XIII. INTERNATIONAL LOGISTICS & SUPPLY CHAIN CONGRESS 2015

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“Maritime Logistics: The New Port Projects of Turkey”

PROCEEDINGS

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PREFACE

It is a great pleasure for us to host the Thirtenth International Logistics and Supply Chain Congress, 2015, in İzmir. The Congress is organized by İzmir University, Logistics Association (LODER) and German Logistics Association Istanbul Chapter this year. The International Logistics and Supply Chain Congress is being arranged generally in cooperation with a Turkish University, an International University and LODER every year.

The main objective of the Congress is to bring together international experts from academic entities and practitioners from the industry, and to provide a platform for presenting and discussing recent developments on the relationship among the logistics, supply chain management and international value chains.

Trade and logistics is the main building blocks of the bridge (supply chains) between the producer and the customer. Supply Chain Management (SCM) and supply chain logistics management give us a wider perspective than logistics alone. Since the supply chain management is a new business management style, supply chain logistics management is the management of logistics activities along the supply chain.

Many companies outsource logistics of their supply chains to the companies in logistics business, and manage their supply chains logistics together. In business logistics, SCM managers fight with logistics costs, in logistics companies, the companies struggle to promote their services to the companies, since logistics activities are the costs of business logistics and are the products of logistics business.

I would like to thank İzmir University for their efforts in organizing this congress. The support of Keynote Speakers of the Congress, Prof.Dr.Adil BAYKASOĞLU; Professor Dr. George DOBORİGİNİDZE and Associate Professor Dr. Tone LERHER are acknowledged and kindly appreciated. We also would like to thank all invited speakers, all the authors as well as the scientific and organization committee members and the reviewers for their enthusiasm, time and expertise.

I thank to TUBİTAK for their contributions. Thanks to Dr.Ulviyye AYDIN, Dr. M.Hakan KESKİN and Burak ÖÇLÜ who did a lot of organizational works.

Finally, we would like to thank everyone who has contributed for making this congress a reality and a success.

Mehmet Tanyaş
Vice President of LODER

ANALYZING TURKISH MARITIME INDUSTRY FROM A CLUSTER PERSPECTIVE

Ceren Altuntaş Vural[1], Aysu Göçer[2]

***Abstract** – The increasing speed and the wide-spread complex network of global trade enforces the maritime industry to adopt a strong logistics focus. As a consequence maritime industry players are required to acknowledge their critical roles on global supply chains that are competing at the network level. This article makes an attempt to analyze the maritime cluster in Turkey with reference to Porter's diamond model and develops some insights regarding the competition dynamics in Turkish maritime industry. In order to fulfill these aims the article tries to identify various players of Turkish maritime cluster including shipyards, ports, shipping agencies, ship brokers, ship consultants, shipping service providers and ship equipment manufacturers which interplay over several factors. The existing activities between these actors are tried to be systematically detected by analyzing maritime industry reports. The interaction and relationships between these players are tried to be explored with the help of a focus group study and in-depth interviews that were conducted with the representatives of major players active in Turkish maritime cluster. As a result of the study, the factors forming the basis of the maritime industry cluster in Turkey are outlined, and important drivers for industry survival and growth are provided. The dynamics as well as the determinants of competitive advantage within this cluster are identified based on Porter's diamond model. The findings provide important insights to practitioners especially in terms of synergy exploitation, opportunity exploration and strategy building. Findings are also highly relevant for public bodies that seek to find ways to promote highly competitive industries in order to have larger shares from world markets. Last but not the least, the results may provoke new research that explores maritime supply networks, horizontal integration in maritime services, alternative distribution channels in business-to-business services, innovation and synergy in industrial clusters are expected to generate interesting and fruitful findings for industrial marketing area.*

Keywords –Maritime Industry, Cluster Theory, Turkey, Turkish Maritime Cluster, Porter's Diamond Model

1.INTRODUCTION

Since Porter's [28;29] introduction of the Diamond Model as a source of regional and national competitive advantage, cluster studies have gained significant attention from both policy makers and researchers. The interaction between the four determinants of the model are assessed to discover the potential clusters for nations which will lead them to international competitiveness at the end. Although it seems like a paradox for proximate environment of a company to gain importance in a rapidly globalizing world trade where transportation costs are decreased [14], statistical evidence states that globalization fosters centralization instead of widely spread activites around the world [1].

Maritime industry has its share from clustering. Actually this industry has a natural propensity for geographical agglomeration especially for shipbuilding or yachting sub-sectors. However location proximity is not enough to be become a cluster that facilitates competitiveness. Divisibility of processes, transportability of the

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final product, long value-chains, diversity of competencies, importance of innovation, volatility of markets are all seen as necessary and sufficient conditions for clustering [34].

Maritime industry is an important industry for Turkey where 86.4 % of foreign trade in tonnage and 55.24 % of foreign trade in value is carried by seaways [15]. Many global players in shipping agency or port industry have invested in Turkey to get a share from the sector. It is a critical industry that has close connections with the foreign trade performance of Turkey and therefore it has a potential to contribute to national competitiveness. However, to the best of the authors' knowledge, Turkish maritime industry has not been analyzed with a cluster perspective until now. It is considered to be important to discover if the industry has a potential to form a competitive cluster and also it may produce important insights to take measures on if the industry lacks clustering advantages.

Porter's [28;29] Diamond Model has advantages in evaluating clusters, identifying their strengths and weaknesses and discovering industries that have more potential to become clusters [9]. Therefore this model is chosen to assess Turkish maritime industry as a cluster. Firstly the determinants of Diamond Model are reviewed together with existing clustering research based on Porter's model. Then Turkish maritime industry was analyzed by reviewing the reports published by three national associations representing maritime industry: Turkish Chamber of Shipping, Turkish Shipbuilders's Association and Port Operators Association of Turkey. A focus group analysis with Turkish Chamber of Shipping's Izmir office management board was followed by five in-depth interviews with maritime industry representatives in order to explore the existing situation of Diamond Model determinants in Turkey. Conclusions and further research recommendation is proposed.

2. DIAMOND MODEL AS A SOURCE OF COMPETITIVE ADVANTAGE

2.1. The Dimensions of Diamond Model

Diamond model of Michael Porter [28] is based on the competitive advantage of nations that is produced by inter-connected home-based clusters supporting each other. Porter [29: 213] defines clusters as "geographic concentrations of interconnected companies, specialized suppliers, services providers, firms in related industries and associated institutions (for example universities, standards agencies and trade associations) in particular fields that compete but also cooperate". The school bases its ideas on Porter's Diamond Framework on Figure 1 which represents the four mutually reinforcing sources of competitive advantage.

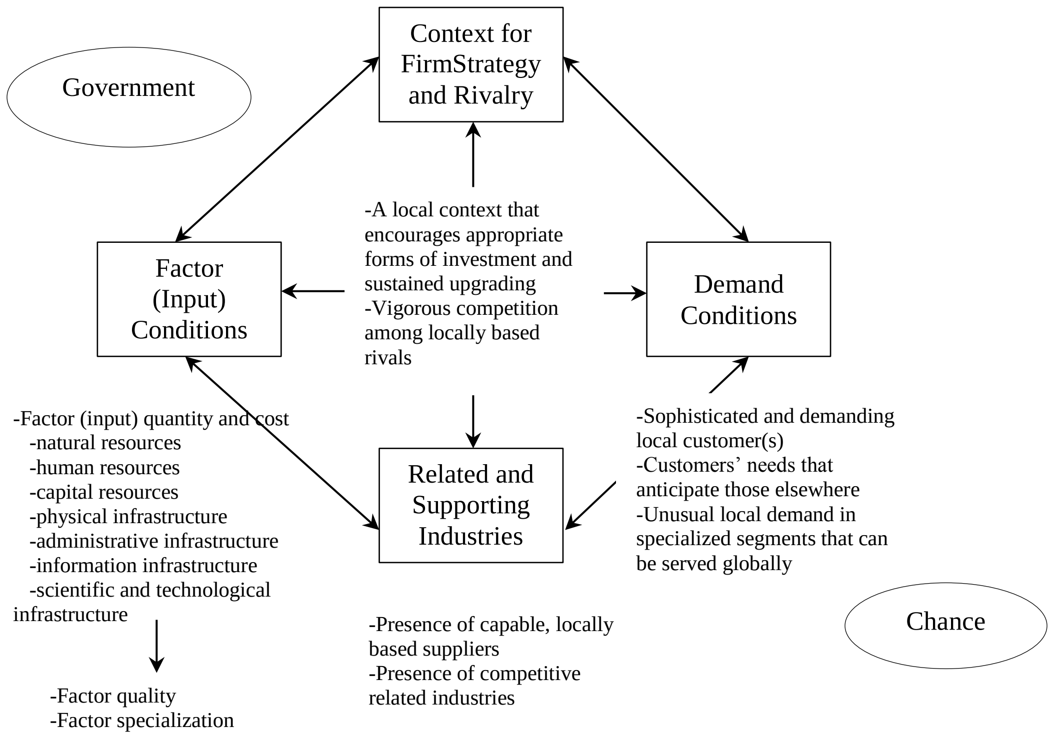
The factor inputs are composed of both tangible and intangible factors of production. Although some of the factors are mobile, there is a certain part which is specific to a region. In order to achieve competitiveness within the cluster, these factors should be improved in terms of quality and specialization. Porter emphasizes the importance of specialized factors like innovation capability or knowledge sources specific to a location (like a patent right or know-how of research and development institutions within the cluster) for sustained competitiveness.

Firm strategy and rivalry refers to the rules, intensity and the governance of rivalry within the cluster and is one of the strongest determinants of a cluster. According to Porter, local rivalry is highly influential on the productivity of a cluster because if the rivalry is imposed from a distant market, the flaws in the local production may be compensated with the longer distance of the competitor. However, a strong local rivalry would reinforce the companies in the cluster to innovate, to reduce their costs and increase the quality of production. Clusters also shift the focus of local rivalry from lower total cost or possession of physical assets to innovation potential and specialized skill generation.

Demand factors are important determinants in terms of achieving economies of scale and encouraging new firms to invest in the cluster. However, these outcomes are related with the size of the demand markets. In addition to these, Porter argues that the sophistication of local demand stimulates the level of quality and innovation potential of clusters. This sophisticated demand may also lead the way for the cluster to serve global markets in different segments as well so it serves as an essential knowledge source.

The last factor is the existence of related and supporting industries. These are evaluted from vertical and horizontal perspectives. The vertical perspective focuses on the existence of competitive suppliers that support the production processes. The horizontal perspective focuses on the presence of companies that produce the same products or services. The presence of these companies would decrease the costs due to shared capacity or motivate innovations due to pressure of rivalry.

Figure 1. Sources of Locational Competitive Advantage



Source:[29]: 20.

There are various impacts of clusters on competitiveness [29]. Clusters provide better access to labor markets, supplier markets, institutions, public goods and specialized information and this increases the productivity of individual companies within the cluster. They also generate complementarities by supporting each other on better performing parts. Local rivalry inside fosters constructive competition in terms of increased quality and innovation. Companies inside a cluster gain a better understanding of market needs when compared with isolated enterprises. Clusters also attract new business due to the established supplier-market relations, available factors of production and positive feedback.

Firms act depending on the inter-connected determinants of their environment. Ability of firms to innovate and upgrade depends on the information that they can seize from their proximate environment, the skills and abilities that they can pool from the inputs they reach, the market characteristics and rivalry structure that encourage and facilitate innovation and suppliers that provide technological know-how. There are two external factors of diamond model, namely government and chance. Government can improve or impede locational competitive advantage with its ability to facilitate the investments for factor production or its authority that can control rivalry conditions. However its main role should be a catalyst for the successful and healthy inter-relations of diamond determinants instead of an involver to markets and clusters. Chance may take place in the form of true accidents, wars, natural disasters or sudden and unexpected changes in currencies. Nevertheless chance shouldn't be seen independent from the diamond determinants and the existing environment. The events that trigger the accidents are generally caused by the environmental elements [28].

2.2. Clustering and Diamond Model

Clusters are defined as “localised sectoral agglomerations of symbiotic organisations that can achieve superior business performance because of their club-like interaction take place between competitors or complementary players” by Reference 34 [p. 850] who also underline that they are not the result of a coincidence or natural concentration of companies that are located around raw material resources but do not interact with each other. Actually the economic school of thought [e.g. 22] approaches clusters as a means for achieving economies of scale by sharing the same resources. The industrial district school [e.g. 33; 3] on the other hand takes a social economy perspective and combines the advantages of selective specialization, lowered transaction costs, trust, shared culture and societal embeddedness in clusters. Porter’s [28; 29] strategy school emphasizes the innovation potential raised by the regional synergy in a cluster. The Institute for Strategy and Competitiveness extends research on regional clusters by analyzing statistical data related with employment, economic development, wages, colocation and patents [9].

There is plenty of research on regional development that uses Porter’s Diamond Model to assess industrial clusters. The model is originally based on the export statistics of many developed countries such as Denmark, Italy, Japan, Singapore, etc. and it was also applied to German printing industry, American patient monitoring equipment industry, Italian ceramic tile industry and Japanese robotics industry as case studies [18]. The model has been tested on many different countries and industries as well which lead to some advancements. For instance in a study testing the Diamond Model determinants’ impacts on innovativeness and performance finds interesting evidence on German high-tech manufacturing firms and knowledge-intensive service firms. Although locational determinants such as factor conditions and related or supporting industries have favorable impacts on cluster performance, demand conditions and strong local rivalry seems to have negative results at the firm level [12]. Reference [11] uses the model’s variables in order to analyze the competitiveness of UK higher education industry. Reference [6] compares and contrasts cluster schools’ propositions with supply chain management’s principles by focusing on New England cotton textiles industry.

The model is not without its critics though. The fundamental opposition to Diamond Model’s propositions is about its extant focus on home-base economic activity for enhanced competitiveness. Reference [31] criticizes the model’s application to Canada by referring to the country’s exports activities and multinational enterprises’ (MNE’s) activities outside Canada. A new model that incorporates both domestic and international factors is proposed which is called the double-diamond model [32]. With the recognition of MNEs and different characteristics of different nations, it is contended that *different diamonds need to be constructed and analyzed for different countries, and these diamonds often require integration and linkage with the diamonds of other economically stronger countries thus creating a double diamond paradigm*. [18: 46].

This double-diamond framework was applied to Korea and Singapore by Reference [25] and to Canada by Reference [18]. Reference [19] used both of the models in order to explore how a nation and an industry sustain its competitiveness even if it loses its advantage in labor conditions by taking Korean apparel industry as an example. Reference [8] analyzed Irish dairy industry, popular music industry and software industry and found evidence for Porter’s critics based on MNE success rather than his original model. In addition to these efforts, some extensions of the Diamond Model were proposed and applied to cluster managers for assessing their competitiveness [20] and seven different industry groups based in Maine, USA [9].

Cluster studies in maritime industry are rather new when other industries are considered. One of the earliest studies analyze Port of Antwerp’s competitive advantage based on both Porter’s Diamond Model and the alternative double-diamond model [17]. Malaysian maritime industry’s competitiveness was assessed with a Delphi method using Porter’s approach [27]. A comparative analysis was applied to Spain, Germany, the Netherlands and Norway for proposing a differentiation framework of maritime clusters in these countries [24]. Reference [7] assessed if Greater Dublin Region has a potential for forming a cluster when compared with the internationally recognized maritime clusters. Finally Norway’s maritime industry was analyzed with a cluster perspective in order to assess its clustering potential and evidence was found for detoriating cluster conditions [4]. This study tries to make a contribution to this part of the literature by analyzing Turkish maritime industry with the Diamond Model perspective and assess if the industry holds the potential for becoming a cluster that would foster regional and national competitiveness.

3.THE MARITIME INDUSTRY IN TURKEY

Turkey, with its land surrounded by sea at three sides and geographical sensitivity bridging Europe and Asia, is an important player in maritime industry worldwide. Its convenience and importance in geography makes maritime transportation a common mode for the trade of dry cargo, liquid cargo, lorry cargo, and container shipments, and enhances maritime tourism for cruises or yachts. This also increases the role of ports and enhances different areas of operations related to maritime industry in Turkey, such as ship building, repair and maintenance, yacht industry, supply industry, or aquaculture products industry.

In order to outline the progress of maritime industry in Turkey, industry reports of Turkish Shipbuilders' Association for 2014, Port Operators Association of Turkey for 2013, and Turkish Chamber of Shipping for 2013 were reviewed. A general look into the numbers shows that maritime industry is becoming increasingly important with %90 of world trade and %86.4 of Turkish foreign trade realized by seaway [15]. Based on Turkish Statistical Institute data, although 86.4% of Turkish foreign trade volume was carried out by sea, only 11.4% of Turkish foreign trade volume was carried by road, 0.5% by rail, 0.4% by air, and remaining 1.3% by others in quantity terms, whereas in value terms, 55.24% Turkish foreign trade volume carried out by sea, 23.24% by road, 0.68% by rail, 11.28% by air, and remaining 9.56% is by others.

Based on European Union's official statistical website Eurostat, Turkey is fifth country in load handling by maritime transportation in 2011, with 359 million tones [37]. On the other hand, Turkey is also improving its port capacity in the last years. Based on reference [37], there are 172 ports in Turkey, 22 of which are public ports, 23 of which are municipality ports, and 127 are private. The capacity of Turkish ports is 11.085.000TEU for containers, 276.851.862 tones for main cargo and dry bulk load, 148.900.782 tones for liquid busk load, and 3.674.800 units for lorry. Port Operators Association has 56 members by 2013, which lead the operations in port industry in Turkey, and manage 87% of all container capacity as well as 84% of all cargo capacity in Turkey. Besides, RO-RO transportation in Turkey has increased by 6% in 2012, and reached 348.000 vehicles, while Port Operators Association members handled 73% of them by 253.000 vehicles. Turkish port industry also gives importance to green activities, and aims to support sustainability at all fields and activities. Therefore, ship recycle is another operation which is accepted as green industry by International Maritime Organization. In Turkey, there are 21 ship recycle companies operating in Aliağa. Besides, based on Ministry of Transport, Maritime Affairs and Communications data, there are 800 ship agencies in 24 cities in Turkey by 2014, which is counted as 994 when branch offices are included.

To summarize, although 2008 was the year of a slight decrease in maritime industry due to global crisis, the recovery was soon observed by 2013, which came by the biggest values at almost every area of operation. The amount of global shipments in world trade is doubled in the last twenty years, with raw material, production and market related search of companies worldwide. 1995's 5 billion tons of shipments by seaway became 10.5 billion tons in year 2014, which was expected to increase by 4% in 2015. Despite this increasing amount until 2013's, the growth was not as expected in 2014, especially when compared to the last years' success. Maritime industry in Turkey, with more than 2500 scores in the freight market, set its record in export amounts in ship building, as well as reached 16 billion DWT in repair and maintenance in 2013 [15]. However, in 2014, freight was fall in price, and ship export amounts remained the same with no growth. This has pushed the industry to lower the costs. In parallel to the data provided by Baltik Dry Index (BDI), the decrease observed in freight prices in 2014 continued also in 2015. BDI, showing dry bulk freight prices, is accepted as a pioneer and reputable indicator in maritime industry worldwide. Internal and external dynamics in maritime industry affect the index closely. High demand in dry cargo shipments indicates a growth in world trade, which also brings an increase in freight prices. As BDI shows average prices in freight, an increase in the index raises the expectations towards a revival in world trade and growth in world economy. However, freight prices rely not only on economic activities, but also indicate shortfalls or surplus in ship tonnage amounts. Therefore, the evaluation on freight prices should consider various statistical data and dynamics including world transportation volume, new ship orders, weather conditions…etc.

Therefore, the trend in 2014 now proposes to follow a more deliberate policy in 2015 by the industry players in Turkey.

4. METHODOLOGY AND SAMPLING

An empirical research methodology was applied that aims to systematically observe the reality regarding the unit of analysis through five senses [5]. The exploratory nature of the study requires qualitative methods that collects data from few subjects but investigates the variables in great depth [35]. As the purpose is to discover if the maritime industry in Turkey is clustered with the principles of the diamond model approach, qualitative research design is more appropriate for evidence gathering. Therefore focus group methodology was adopted for the first step of this research. In order to confirm the findings gathered from the focus group session, five structured face-to-face interviews were held with other representative of maritime industry in Turkey.

In qualitative studies, the aim is to explore a complex subject deeply rather than generalizing a specific point to a large population. Random sampling is a sampling method that can be used on normally distributed large samples and in research that aims generalizing the research results [23]. Judgmental sampling, on the other hand, depends on the researcher's expertise in terms of sample choice. Within this expertise framework, the samples that have specific expertise or experience related with the subject are chosen purposively in order to reflect the population as exactly as possible [10]. Therefore the focus group participants and the interviewees were selected based on judgmental sampling principles.

Focus groups are mainly used to collect data in exploratory research especially for previously unexamined topics [26]. They produce new ideas or recommend new dimensions on the unexplored topic that the researchers wish to understand by gathering people who share similar backgrounds, interests, characteristics or expertise needed to generate ideas on the discussion topic. They are also used in underlining the different perspectives or approaches that evaluate the same issue. For reaching more effective outputs with desired variety and low fragmentation, it is suggested that the size of focus group samples should be between six and ten [30]. Groups sized between 4 and 6 are called mini groups and they are considered better in terms of discussion quality and larger time devoted to each participant [16].

Turkish Chamber of Shipping is the umbrella organization for the maritime industry in Turkey. The chamber tries to bridge and bond shipping agencies, maritime tourism companies, ports, ship builders and other supply organizations with governmental bodies. Lobbying, training, awareness raising, policy generating are among fundamental activities of this institution. Considering its representative power of Turkish maritime industry, a focus group session was organized with the board of Chamber of Shipping's İzmir branch.

The results of the focus group session were backed up with five semi-structured interviews. This methodology was essentially important for our study in order to probe the issue in details and provide rich data [13]. The semi-structured interview is in between fully structured and fully unstructured interviews where the researcher prepares some open-ended questions that initiate the session but the research process can be extended with other questions as well [2]. Also the researcher is free to change the sequence of questions, extend the discussion on selected topics or encourage the respondent in order to analyze the topic of interest in more depth.

Judgmental sampling was again selected in order to determine the interviewees. They were selected from the main sub-sectors of Turkish maritime industry which were also identified by the focus group participants. The sub-sectors of selected interviewees and the details about the interview sessions are listed on Table 1.

Table 1. Sample of Semi-Structured Interviews

Interviewee	Sub-Sector	Date	Duration
1	Ship building, ship maintenance and repair, also a representative of Turkish Ship Builders' Association	20/08/2015	40 min.
2	Freight Forwarding and Logistics	25/08/2015	50 min.
3	Ship Management and Intermodal Transportation	25/08/2015	40 min.
4	Port Management	26/08/2015	50 min.

5	Shipping Agency	28/08/2015	35 min.

Focus group session took place on 11 August 2015 at the Chamber of Shipping’s office in Alsancak, İzmir, Turkey. It lasted for nearly 70 minutes and every participant had an equal chance of contribution to discussions. Both in the focus group session and interviews a total of 8 questions were asked. The first question was asked for identifying the sub-sectors of maritime cluster. The other 7 were asked to explore the situation related with diamond model determinants including government and chance. The last question was asked in order to reveal the respondents’ assessments about the performance of Turkish maritime cluster.

5.FINDINGS AND DISCUSSION

5.1. Focus Group Findings

The focus group participants were contacted after their routine board meeting session. They were briefed about the principles of focus group methodology. Two different question forms were distributed, one asking about their profile information and the other listing the session questions to enable them take notes. The moderator got permission for recording the session which was transcribed by the two researchers afterwards for further analysis. The profile information regarding the participants can be found on Table 2.

Table 2. Profile Information of Participants

Participants	**1**	**2**	**3**	**4**	**5**	**6**
Age	40-49	40-49	40-49	40-49	50-59	40-49
Occupation / Title	Maritime Business Adm./ Owner	Maritime Business Adm./ General Man.	Captain/ Coordinator	Captain/ General Man.	Mechanical Engineer	Maritime Business Adm./ General Man.
Tenure at current company	14 years	15	13	10	30	24
Tenure at the sector	20 years	22	19	26	36	24
# of employees	10-49	10-49	>250	50-250	1-9	10-49
Age of organization	11-20	11-20	21-30	>30	21-30	11-20
Foreign partnership	No	No	Yes	No	No	No
Sector	Ship Supply	Freight Forwarding	Container Shipping Agency	Pilot and Tug Boat Services	Yacht Supply	Container Shipping Agency, Brokerage, Bulk Shipping, Freight Forwarding

Following reference [21]’s methodology for focus group data analysis process, the transcripts of the session were analyzed manually through decoding and interpreting the participant quotes. For the interpretation of this structured data, the important thing is not to focus only on individual quotes but to derive analytical results throughout the relations between quotes and the examination of group interaction [30]. Data was analyzed question by question under these principles.

Question 1: Who are the members of Turkish maritime industry? Which sub-sectors should be included?

There was a general consensus about the answer of this question. The leading engines of maritime industry were listed as Ship Management, Port Management, Ship Building and Yatching and Marine Tourism. All other sectors were considered under the heading of Supporting Service Providers.

Question 2: Please evaluate the factor conditions depending on the sub-sector that you represent. (Here a list of factor conditions were given such as qualified labor, access to R&D results and information, access to capital, access to infrastructure and transportation networks)

It was discovered that while some of the sub-sectors were suffering from lack of qualified work force, others enjoyed a large pool of employees. The problem here is about the match between the required capabilities and the qualification of employee candidates. For example there is plenty of work force as seamen or office workers for freight forwarders. Captains, ship building engineers and mechanical engineers are trained at undergraduate programs. However, ship supply organizations, ports, marine tourism or ship broking sub sectors face problems regarding the work force. Most of them are trained at work so require a lot of on-the-job training time for specialization. Also they lack the required personal skills for the relatively demanding structure of shipping business in terms of working time and working conditions.

R&D has a partial impact only in ship building but it is considered to be insufficient. The service businesses do not have a budget and consequently a function that undertakes R&D. For shipping agencies marketing department acts like a business development agent, researches for new markets and leads the shipowner for opening new services. For ship suppliers, there is an international and a domestic association through which organizations are able to reach information. NACE seems to constitute a barrier against access to information because there are problems in its application. It causes troubles with statistics and with a chain impact this causes a decrease in international funds devoted to shipping sub-sectors. In general access to information is dependent on people that undertake that specific business. If they insist and look for it, they are able to reach information through personal networks.

More visible parts of maritime industry such as ship building or ports have more favorable conditions in terms of capital access. Ship suppliers also enjoy being considered as exporters because they can easily reach EXIM Bank credits and government support for international fairs. However shipping agencies or forwarders are depending on their own resources for capital. Especially freight forwarders are acting as financiers for exporters and importers who demand long term payments. Therefore they face difficult conditions in between shipping agencies and shippers or consignees.

The infrastructure opportunities are bound with insufficient and low-developed transportation network. The roads are limited and the traffic is jammed. Multimodal transportation faces a lot of barriers due to transportation and customs problems. Warehouses and bonded warehouses are plenty. Especially ship supply companies own their own bonded warehouses so they seize the power of holding inventory. They also own their own cold chain equipment therefore they are better off in terms of infrastructure.

Question 3- Please evaluate the market conditions and customer demand with reference to the sub-sector that you represent.

The brokerage, freight forwarding and shipping agency sub-sectors are not able to develop customers. They only try to get extra market share from their competitors so they try to reach the available market. The demand in these sectors can be called derived demand and the real demand is generated from import export markets. Marine tourism’s market demand is directly related with national economy and also directly related with the country’s tourism potential in terms of natural resources. Natural resources and climate are favorable in Turkey but economic situation is rather volatile. For ship supply industry the Turkish providers are able to seize on 30% of the market despite having the most important straits in the world, Bosphorus and Dardanelles. The rest of the market is supplied from other countries located on the Mediterranean coast. Shipowners’ nationalities are also important in supplier decisions. They tend to buy from their home countries instead of buying from abroad.

Question 4- Please evaluate the related and supporting industries in terms of price, quality, proximity etc.

Shipping agencies are not able to select their main suppliers like ports or like vessels. They have to select one available in the market. This part of maritime industry has an oligopolistic structure with few players holding the majority of the market. In terms of road transportation, plenty of suppliers are available at different prices and quality levels. In marine tourism there are larger opportunities in supplier selection especially in terms of marinas but if the yachter is located at a specific region with limited marinas then this causes a problem. About yacht supply the majority of supply is imported and it is hard to find domestic suppliers. Ship suppliers use both imported and domestic suppliers depending on the price. They buy some durable foodstuff or meat from abroad but buy technical equipment, handware, fresh food and conserves preserves from Turkish suppliers. Freight forwarders buy the service from shipping agencies and sell to shippers but they are not very powerful against agencies. They rather function as a financier organization in between.

Question 5- Please evaluate the firms structure and rivalry for the sub-sectors that you represent.

There is almost no cooperation in many of the sub-sectors in maritime industry between competitors. The competition is tough and mainly price-based. For instance in ship supply industry there are very small-scale companies that do not fit with international quality standards. But because of their smaller scales they have lower costs and therefore they are able to quote lower prices. The larger companies try to protect themselves by participating in international standard organizations and adhering to some standards. They become approved suppliers by becoming members in such organizations. A modest example of cooperation might be observed in ship supply based on common benefits. Ports are continuously encouraged for cooperation and specialization in different types of cargo handling. But their propensity to provide services for every cargo type prevents efficiency and specialization in port industry. For freight forwarders the services provided are almost the same. These providers can be divided into three classes of foreign globals, large Turkish forwarders and small-scale forwarders. Foreign globals and large Turkish forwarders have a chance to survive with lower profits based on their larger international networks. However the smaller ones are not very reliable. There is a strong competition based on prices and payment terms which is dangerous for financially weaker firms.

Question 6- Please evaluate the impact of government on Turkish maritime industry.

In general government support seems to be nascent for maritime industry and in some cases government seems to act impedingly. For example the taxation on Turkish flag for both commercial cargo vessels and for yachts is totally discouraging marine tourism and development of Turkish fleet under Turkish flag. This is also dependent on the perceptions surrounding marine tourism in Turkey. Yachting is generally perceived as a habit for the wealthy and the government acts hesitant to support such a sector in terms of subsidies or lowered taxes.

Another problem is related with state authority. For instance fish farms are coastal facilities and they are established by Ministry of Maritime, Transport and Telecommunications but their management is left to Ministry of Agriculture. This completely changes the approach towards fishing industry policies.

Foreign policies of the government are also very influential on Turkish maritime industry due to Turkey's strategic location. Coastal trade is immediately affected by international conflicts. Additionally direct adoption of EU laws and regulations cause problems because they are not applicable in Turkish business context.

Government seems to be supportive in some sub-sectors of maritime industry but this requires strong lobbying activities. Government support and encouragement is not the results of a macro strategy but rather the result of individual efforts. Ship suppliers or agencies find ways to survive especially with reference to their lower costs but the producer sub-sectors such as ship builders are in deep need of government support.

Question 7- Please evaluate the impact of chance on Turkish maritime industry (like changes in foreign exchange rates, war, natural disasters, sudden changes in technology etc.)

Foreign exchange rate volatility directly influences exports and imports which ends in lowered demand for maritime transport. Strikes at neighbor ports create advantages for Turkish ports. For marine tourism chance is very important as war or conflict at the country directly decrease the demand for the sector. A similar situation in another Mediterranean country on the other hand becomes Turkey's chance.

Question 8- Please evaluate Turkish maritime industry as a cluster and assess the interaction between the members of this cluster. Do you think that Turkish maritime industry contributes to Turkey's national competitiveness?

Maritime industry is a natural cluster. For example Turkish ship builders and yachting industry are located at Tuzla, Yalova and Ereğli because this is more beneficial for their effective operations. Agencies are clustered in Izmir, Istanbul and Mersin. Ports are clustered in Aliağa and in Ambarlı but a cluster mentality is missing. Ship supply industry provides equal service with European counterparts in terms of price and quality but face barriers in terms of service speed. Turkey is not a fully mariner country despite its locational advantages. The shares received from global bunker and ship supply markets are very low. Infrastructure is scarce for especially ports and marinas. Specialization is not available. There are significant problems about cooperation and coopetition especially because of cultural reasons and traditional approaches. Bureaucratic procedures should be decreased and subsidies should be introduced. Turkey's maritime industry performance is not sufficient.

In general focus group data provided evidence for the lack of a clustering mentality in Turkish maritime industry. However the results were tried to be supported with in-depth interviews with representatives of different sub-sectors in order to discover similarities and differences. The next section summarizes these results.

5.2. Semi-structured Interview Findings

Semi-structured interviews with five experts from different areas of business provided rich insights from their individual perspectives. This contributed as well as supported the focus group discussions, and let this research to develop a more generic content on the findings regarding the clustering approach of maritime industry in Turkey. The discussions of the experts and their main points of emphasis with respect to the determinants of competitive advantage based on Porter's diamond model are summarized in Table 3.

The interviews with various maritime industry members outlined that, in the business area of their industry, some differences do exist in terms of the determinants of competitive advantage. Almost all members evaluate industry competitiveness to be very extensive. Based on their role in the industry, the interviewee of the port indicated that competitiveness is solely based on price.

On the other hand, factor conditions are mentioned to be very limited in terms of skilled labor availability, except on the shipping agency side. Especially in the port side, there is the emphasis of unavailability of skilled blue collar employees. They further mentioned that blue collar employees do not want to work in the field operations, and try to move to white collar, most probably due to low salaries or demotivating human resources strategies. This is the same for freight forwarders, who express their areas to be one of the less preferred business branches in maritime industry in Turkey. Besides, the need for specialized employees is mentioned frequently by almost all of the sides. On the other hand, R&D activities are mentioned to be very poor in the industry, and information sharing is very limited. On the ship business side, the interviewee mentioned that information is available, but knowledge on which information to access and how, is limited. Supporting this point, the shipping agency respondent also mentioned that information is dispersed at different members with no integration, and therefore not accessible. Supporting this point, the interviewee of the freight forwarder also stated that central information is not available, whereas dispersed information is available only by price. Therefore, they face problems in responding to their headquarters' requirements related to information and data in the market. They further mentioned that there is the misled of information in the market; e.g. available in million dollars, not in tons. Interestingly, they emphasized language as an important problem of information available in the market. Furthermore, capital accessibility in the industry is mentioned to be available. But, the accessibility is evaluated to be better for international members relative to the Turkish members. The interviewee on the ship business side additionally mentioned that capital accessibility is based on relationships, whereas on the freight forwarder side based on trust. On the other hand, infrastructure is mentioned to be very insufficient, problematic and weak by almost all members. Only the interviewee from Turkish Shipbuilders Association mentioned that infrastructure is not limiting their operations.

Supplier and related industries are evaluated to be highly varying in quality by the interviewee of the port, especially depending on the area of expertise. In general, supplier market with qualified standards is evaluated to be very limited, especially in inland transportation, while limited numbers of qualified suppliers are mentioned to be expensive. This qualified supplier unavailability is mentioned to be a negative aspect hindering the competitiveness. Besides, the cost pressure on the suppliers is also emphasized, causing quality related problems in supplier operations. Shipping agency and freight forwarder further mentioned that new entrant suppliers are expected to be better qualified due to increased expectations of industry members.

In terms of the demand conditions, the market is mentioned to be in downtrend, slowing down with prices and shipment quantities getting lower. Especially, freight forwarder industry is mentioned to be very challenging with easy access to the freight forwarder market, which raises unfair and unqualified business offering low cost and low qualified service in the market, harming the business of qualified but costly players. However, the interviewee from the shipping agency evaluated Turkey as a very promising and attractive market in terms of the global players.

Besides, governmental support is evaluated to be unsatisfactory, with incentives to be increased and regulations to be adopted to benefit the industry in general.

The industry is also discussed to be highly dependent to external conditions, with luck factor closely affecting the entire business performance.

Determinants of Competitive Advantage	Port	Shipping Agency	Ship Business	Freight Forwarder	Turkish Shipbuilders' Association
Strategy, Structure, Rivalry	• Price based competition	• Extensive competition	• Extensive competition	• Extensive competition • Unfair competition	• Competition without collaboration
Factor Conditions	• Skilled labor limited • R&D activities poor • Infrastructure very limited and problematic • Information sharing limited • Capital accessible	• Skilled labor available • R&D activities very poor • Information sharing and trustworthiness limited • Capital accessible for international agencies • Infrastructure limited	• Skilled labor not available • High demanding generation • R&D activities poor • Information sharing limited • Capital accessibility depends on relationships • Infrastructure limited	• Skilled labor very limited • R&D activities very poor • Information not available, or not accessible • Capital accessible for internationals • Infrastructure limited	• Skilled labor not available • Specialized labor limited • R&D activities very poor • Information available • Credit opportunities satisfy big shipyards • Infrastructure not limiting the operations
Suppliers & Related Industries	• Suppliers highly vary in quality based on the area of expertize	• New entrant suppliers better qualified	• Lack of qualified suppliers	• Qualified suppliers not available, but improving in quality	• Supply market very limited
Demand Conditions	• No growth	• Turkey as a promising market	• Market in downtrend	• Market is in downtrend • FF market becoming too challenging	• High fluctuations in demand • Industry is slow
Government	• Infrastructure support not satisfactory • Incentives not sufficient • High governmental payments	• Governmental activities not sufficient • Regulations block the market	• Governmental support limited • Government investments not sufficient	• Governmental laws are not sufficient to control the irregularities in the market	• Project based incentives • Tax related incentives limited
Luck	• Not very important • Extraordinary examples rarely happen	• Highly dependent on external factors	• Uncontrollable events • Industry highly dependent on external factors	• Uncontrollable events	• Highly dependent on external factors
Clustering in Turkey	• Turkish trade to be increased • Competitiveness negatively affect cluster approach • Commercial focus exits	• No clustering • Collaborative acts limited • Players not integrated • Decisions independently given	• Based on relationship network • Self-focus approach • Opportunistic acts	• No clustering in Turkish maritime market	• Turkey with competitive power • Competitiveness of the industry weak in Far East

CONCLUSION

The main purpose of this study was to explore and discover the interactions between the main determinants of maritime cluster in Turkey and also to explore if these interactions supported a “clustering” effort in terms of enhanced competitive advantage. Focus group analysis results show that the different sub-sectors of Turkish maritime industry are apart from each other. Even in the same sub-sector cooperation is observed very rarely. Factor conditions seem to be problematic in some areas but the main problems are related with market conditions and the rivalry inside the industry. Market conditions are derived from global trade markets and this structure does not facilitate a business development opportunity for the industry. Rivalry is significantly based on price and this has very negative impacts on industry players. Coopetition is hardly observed. Government does not have an encouraging role for maritime clustering. Instead, the governmental procedures hamper the markets and create new problems for the industry members.

The interviews with five different areas of business in the industry further supported the discussions raised in the focus group. In the interviews, Turkish maritime industry is emphasized to be non-clustered, with disintegrated players independently giving their decisions. Especially, competitiveness is discussed to be negatively affecting the clustering approach triggering opportunistic acts and self-focus approach, as well as the relationship network is further mentioned to be dominating the business in general. Factor conditions are mentioned to be very limited, and suppliers or other related industries to be yet not sufficiently qualified as per the international standards. Besides, although access to capital is stated to be available for global players, the challenges related to Turkish companies are discussed to be highly limiting their business performance. On the other hand, while market is assumed to be in downtrend recently, it is foreseen to be promising in the near future. Although luck is mentioned as an important determinant supporting competitiveness, governmental support is commonly mentioned by almost all interviewees to be still necessarily required to be increased.

To summarize, Turkish maritime industry carries some characteristics of clusters in its various sub-sectors like locational proximity or shared resources. However within the competitive advantage framework, the cluster’s diamond model determinants do not have an effective interaction with each other. Therefore it is concluded that Turkish maritime industry requires a wider cluster perspective for gaining a common competitive advantage in international markets. However this study’s results are limited with the methodology employed. Further studies are recommended that use quantitative research methods like surveys of analytical models for generalizing the results and prioritizing the areas that should be improved initially. Sample should be enlarged to all regions of Turkey for a more precise picture.

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SHIP INVESTMENT STRATEGY IN CURRENT MARKET: *"HOW A MARITIME COMPANY DRAGGED INTO FAILURE?"*

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Abstract - *Ship investment within purchase and sale decisions is the main determination of a maritime company's strategy. Volatility of economic indicators in maritime transportation as merchant fleet capacity on supply side and cargo trade demand create a risk for ship owners, operators and managers. Time charter rates always have been variable according to type of ships and supply-demand balance of maritime transportation. Specific transportation in dry bulk, chemical, oil-product and LPG/LNG tankers and container vessels needs specific strategies for a maritime company so that it can continue its trade operations without any failure story and protect the entire asset. In this study, quantitative methodology has been used and regression analysis of between last 20 years' shipping market indicators such as world fleet capacity and ship values as per specific ship types and charter rates in market including Baltic Exchange Indices has been carried out. Significance of the analyses results will reflect a "Projection" for construction of a ship investment strategy for the upcoming years. This strategy will be a bridge in order to pass into the new phase of shipping market where the uncertainty is structured on. Since by the new players come into the market, generating the own ship investment strategy will place no more a "Should" and pave the way to a "Must". This paper is aimed to summarize the whole strategy and the importance of innovative decision-making which may open a new door on evaluating market risks and generate a competitive advantage for a maritime company on the "No risk no profit" conjecture.*

Keywords: Ship investment, shipping market, time charter, ship value

INTRODUCTION

Ship investment and decision-making are placed at the most strategic stage of ship owning, operating and management companies. There have been many variables which are depending on specific to segments of maritime transportation on the ships' prices side. Some companies become successful and while some get failed. It is mostly seen that the companies which have an exact strategy on ship investment and managing cost efficiency have become more successful competitors in maritime transportation [1]. Strategic ship investment policies when the ship prices and freight market rates get decrease keep an important role on development of a company. On the operational side investment also gets help to increase shipbuilding market, flagging issues and cash flow between countries [2]. There are specific segments such as bulk carriers, product tankers, chemical tankers, crude-oil tankers, LPG/LNG tankers, general Cargo vessels, container vessels, heavy-lift ships, Ro-Ro vessels and supply vessels as well as all constitute different market rates. The size and frequency of the fluctuations in the ships' sale/purchase and chartering market suggest that investment decisions of the companies have visibly influenced from the international trade market such as grain, industrial and petroleum production [3]. Therefore, difference between market rates within different type of ships creates more volatility and the risk of companies increases. Many studies have been revealed with dynamic behaviour of ship prices and conditional volatilities in maritime economics literature. Traditional approaches for modelling ship prices have examined correlations between many variables such as newbuilding vessels, newly ordered vessels, demolition rates and freight values and bunker prices [4-5]. However, management strategies are not calculated in previous studies as specific to ship types which are mostly owned vessels like tankers, general cargo, container vessels and bulk carriers.

Shipping of different cargo types and freight rates have influenced average market rates and assisted to calculate an index by Baltic Exchange Maritime Council. Baltic Dry Index (BDI) is used for dry cargo transport and freight rate

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estimation while Baltic Tanker Index (BTI) is used for crude oil and dirty tanker freight rates estimations. Besides, freight and charter rates of container vessels are indicated according to Baltic Container Index (BCI). For instance, Baltic Dry Index is defined as the assessment of average price to ship raw materials like coal, iron ore, cement and grains between fifty different shipping routes as variable to different ship sizes. This makes BDI as a leading indicator of economic activities since it involves events taking place at the earlier stages of global commodity circles [6]. Not only specific to dry bulk carriers, all Baltic Indices have some factors which have impact on variability. Commodity demand, ship supply, seasonality, bunker-oil prices, port congestion, canal capacities and geopolitics affect charter rates of vessels and directly to Baltic Indices [7]. Therefore, it keeps an important role for maritime companies to establish a strategy for investing, chartering and operating their ships.

Whereas the global side is so complicated, local ship owning and managing companies also are affected from this volatility due to the fact that the shipping is international. Providing the analysis based role model will help to develop shipping companies not to be entitled as *"Fish owners"* instead of *"Ship owners"* [8]. It is very easy to fail in shipping while becoming successful is very hard going. Therefore, this study reveals the need for a specific management strategy for ship owners, managers and operators including review of current market reports and analyse them in a simple methodology. Overall aim of the research is to maintain an illuminative process in order to make global maritime companies more competitive in global maritime industry.

METHODS

Time series values of last 20 years world merchant fleet capacity and average ship value rates in USD by per Gross tonnage (GRT) and ship types have been searched for significance with simple regression analysis method. The regression analysis has been performed between both these variables as the world merchant fleet capacity was dependent and ship prices was independent variable. The data has been collected as secondary data from Clarksons and UNCTAD databases. As a secondary method of the research, ship time charter rates and Baltic indices such as Baltic Tanker Index (BTI), Baltic Dry Index (BDI), Baltic Gas Index (BGI) and Baltic Container Index (BCI) which are specific to ship types have been explained within descriptive literature and latest market reports. Time series of world seaborne trade and world merchant fleet including specific cargo's freight rates also have been analysed descriptively. Time series have been used to explain with shipping market volatility in order to estimate the future market condition and prevent internal and external risks for a maritime company.

FINDINGS

The analysis is commenced to indicate significance and distribution of time series of World Merchant fleet and average ship values as first. According to results of Anderson-Darling normality test, both variables have been found normal distributed with a confidence of 62.26% and places above the confidence limit of 50%. Below Table 1 shows results of distribution test:

Table 1. Distribution results

Sample Size:	21	1st Quartile:	1022997.276
Mean:	1281544.302	Median:	1234227.189
Geometric Mean:	1245863.319	3rd Quartile:	1555522.872
Minimum:	863667.45	Interquartile Range:	532525.5963
Maximum:	1749221.533	Range:	885554.083

Both dependent and independent variables have been entered into E-views 8 statistical package software with least square method and regression tests have been carried out. Auto correlation between variables and linearity including multicollinearity tests have been performed in order to explain significance level of the regression. As it can be seen in simple regression table 2, the model was found to be significant with a probability value of (p=0.01942) at $\alpha = 0.05$ and null hypothesis is rejected (Table 2). 20 years' time series of 21 variables were chosen as the sample of the analysis. As per supported with 0.71 R-square value and Durbin-Watson statistical results, it is seen that the analysis does not have auto-correlation. The model has a Durbin-Watson value of 2.23 including an average of Akaike, Schwarz and Hannan-Quinn criteria also tested. 2.23 value of Durbin-Watson statistics show that auto-correlation is found under the limits of 2.28-2.30 and the hypothesis is assessed as significant. The result of single regression analysis as in the following table 2:

Table 2. Simple regression analysis results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2266945.871	0.0561515	9.210385	0.0000
Average Ship Value	-434.257026	0.0015635	2.033237	0.01942

R-squared	0.043609	Mean dependent var	90.61852
Adjusted R-squared	0.6660377	S.D. dependent var	62.57220
S.E. of regression	0.54010	Akaike info criterion	11.10210
Sum squared resid	508831.5	Schwarz criterion	11.14515
Log likelihood	-747.3920	Hannan-Quinn criter.	11.11959
F-statistic	4.131952	Durbin-Watson stat	2.231126
Prob(F-statistic)	0.001942		

Equation (1) of the model has been indicated as follows:

$$yi = 2266945.871 - 434.2570264\, xi + \varepsilon i \quad (1)$$

As per above model, average ship values have significant impact on world merchant fleet capacity for the latest 20 years. As the ship values decrease, world tonnage increases in a positive way with an inverse ratio. It can be predicted that when the ship values get decreased, sale and purchase activities will increase and the effect of increasing sale and purchase activities will assist ship owners, managers or operators to purchase new vessels in order to increase their total assets in the market. Despite the model shows that this future prediction can be supported with average ship prices and merchant fleet capacities, there are also some external variables such as freight rates, exchange rates, bunker prices, demolition rates, flag decision and political issues. However, this model only is used for estimation of the relation between average ship prices and world merchant fleet capacity excluding external variables.

DISCUSSION

Even the model summarizes a counter-relation between ship prices and world fleet tonnage, also world seaborne trade value and world fleet tonnage should be evaluated in a descriptive method. According to below figure, the world demand for cargo ships and the world Supply, which is the world fleet size, can be seen by years. This is called as "*Evolution of finance*" for maritime sector. In the first times of cash period, it is seen that there was no real need to borrow from any authority and existing cash on the market was plenty. However, the only problem was finding profitable investments. In charter back period, large corporations with growing cargo volumes desperately needed bigger ships and were willing to give long-term charters to get them. Independent owners used these charters as security to finance new buildings, which they registered under low-cost flags of convenience. Bankers, who now had access to the expanding Eurodollar market, were happy to offer very high advances against the security of a time-charter and the mortgage of a ship. By the end of the 1960's about 80% of the independent tanker fleet was on time charter and highly leveraged. In the bubble phase, owners commenced ordering ships on their own accounts in order to get profit from volatility of the spot market. However, bankers considered ship mortgages to be sufficient collateral and disregarded time charters. This banking strategy broke the link between supply and demand. In 1980's which is called distress period, the world bank took shipping risk into account and changed the perspective. In the last phase which is convalescence, bankers and owners had to practice "*Rehabilitation*" and it becomes unknown where it is needed for new investments in this high volatile market. [1-10-11].

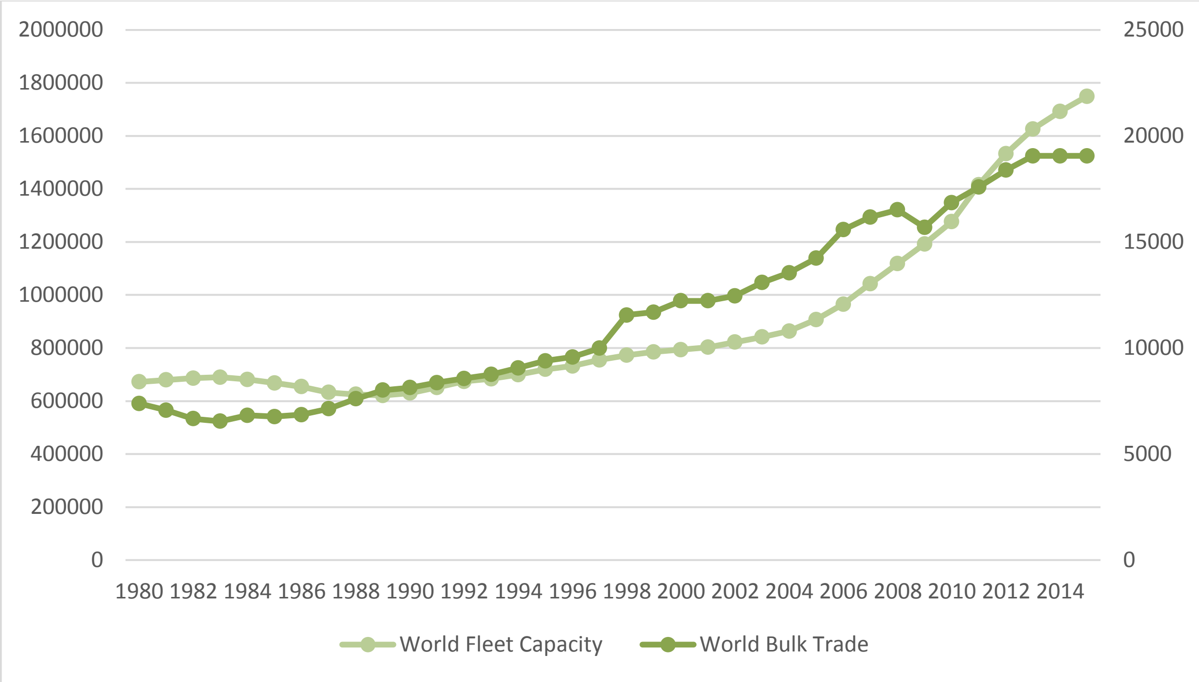

Figure 1. Evolution of ship investment activities (UNCTAD, 2014 & Clarksons, 2015)

1980 to 1982 period world fleet capacity was in a slight decrease while the bulk trade keeps almost same. Since by 1984 up to 1996 world fleet capacity commenced to increase by decreasing ship prices due to high technologies and cheaper labour costs. Within the years of 1996 and 1998, world fleet capacity has a pick up to most of the last ten years period. Since the world seaborne trade is slightly increased, end of 2000 to 2002 freight rates decreased in a moderate way like a shipping crisis start-up. However, world seaborne trade commenced to increase very fast within 2005 and 2008 and the ship owners preferred to invest in new ships in order to take advantage from increasing freight rates in all segments. To analyse more briefly, latest 10 years' time charter rate averages of Panamax and Cape size of bulk carrier segments and Very Large Crude Carrier (VLCC) on tanker segments have been summarized in below figure 2 [12]:

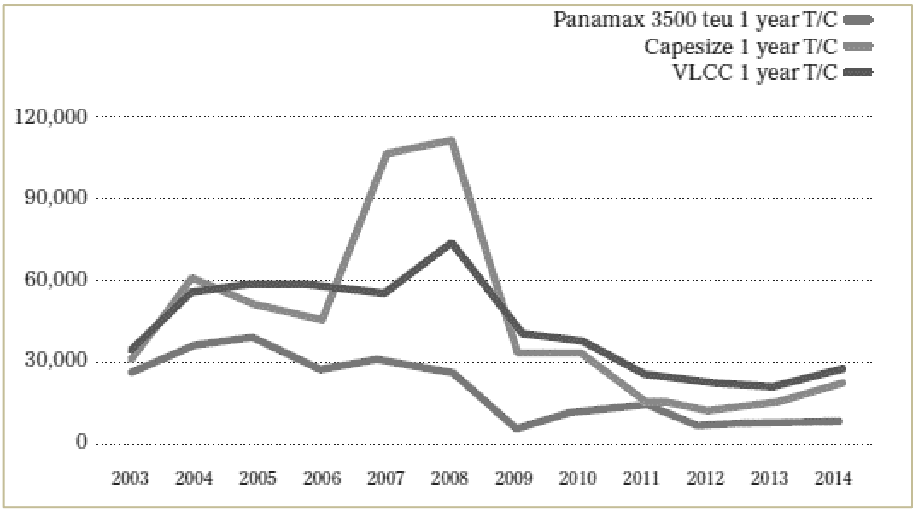

Figure 2. Time Charter Rate per day 2014 (In US Dollars)
(Source: Clarksons, 2014)

At a glance of shipping market, it is seen that 2008 is the most important year for this evolution due to the global shipping crisis. Prior to 2008, ship investments were widely available as the industry was experiencing a period of sound growth and historically high shipping rates. Many shipping companies expanded and placed long-term orders for large numbers of new build vessels. From 2003 to 2008, the new build market was raised until the new ordered ships became a worth more than $800 billion. The half of the orders placed between 2007 and 2008, when vessel prices were at their peak [9]. Banks loans were easily accessible, up to 80 percent of loan to value for new vessels, leaving little margin for error in vessel values. Most of the new vessels were scheduled for delivery in the years immediately following the financial crisis of 2008 [13]. The global recession brought about by the economic and financial crisis produced a completely new scenario. After 2008, the slow growth of global demand for goods on one hand, and a new supply of vessels entering the market on the other, sent charter rates plummeting in most markets. As a result, ship values also collapsed, causing the shipping industry to struggle with losses, loans defaults and bankruptcies. Added to this was the need to find financing for new build vessels under yard contracts that could not be assigned or cancelled.

While a crisis situation occurring, ship prices and values also change rapidly due to decreasing Time Charter rates per day data. By the decreasing ship values, either total asset of small ship owners become little until they become can not pay the bank loans of the vessels. Therefore, small companies prefer bankruptcies, while on the other hand the investors choose to purchase these ship owners' vessels. These both has been a sharp line between success and failure in the maritime management. Investors become active owners and would usually provide the companies with strategic and managerial support to create value and resell at a higher price. Value creation in private equity is primarily based on achieving increased growth and operational efficiency in acquired companies. In this difficult shipping context, many private equity funds have seized the opportunity created by tight credit markets and historically low vessel values to invest in ships and shipping companies.

As well as ship building prices is affected from commodities and raw materials, freight rates also are influenced by major economies' economic growth. According to International Monetary Fund's (IMF) current report, 2015 looks set to become another challenging year for several of the major economies. It is estimated that the global economy will expand by 3.5% in 2015. The European, Japanese and US economies are expected to experience stronger growth than in 2014, while expectations for the Chinese economy continue to point to a gradual slowdown in the growth rate. The IMF expects global trade to grow by 3.8% in 2015, which would be an improvement of 0.7 of a percentage point relative to 2014. If these forecasts are met, it will have a positive effect on demand for maritime transport [14]. Therefore, by the decreasing gross domestic protection, freight rates might be in a decrease due to increasing ship supply. On the other hand, shipping is facing new and stricter environmental requirements, some of which apply globally, while others apply only regionally. The requirements concern in particular emissions of hazardous substances from the consumption of fuel and purification of ballast water. The rules have taken effect in some areas, but most of them will be phased in over the next five to ten years. Substantial investment is required to meet these requirements, and that may be a challenge to financially stressed shipping companies. The environmental requirements may also partially affect prices of older vessels, because often it will not be financially viable to make the required investment to install new technology in older vessels [15].

As described in the model when the ship prices begin to fall, ship owners tend to invest new ships in order to catch up the trend in shipping trade popularity. However this creates an over-tonnage situation in global and due to stable industrial production of raw materials, shipping freight indices begin to decrease. This has always been a cycle of shipping market so that weak management companies can be eliminated and the market rates can be high. When looking at current market in August 2015, it is seen that BDI is in a decrease and dry bulk freight indices also decreasing fast. While the crude oil and British oil (Brent) prices are decreasing very fast, tanker vessel supply stay on a slight increase which might cause not to meet the demand side [16-17]. However, ship owners still prefer to invest on bulk carrier vessels instead of tanker vessels which is seen more feasible in lowest ship prices. On container side, the status is slight different. Container fleet management is very complicated on its logistics and operational activities including freight forwarding works. Also there are very big competitors in the sector which have the largest and crowded fleet in the world. Thus, tanker and bulk carrier management are relatively less complicated than container fleet management. Nevertheless, tanker vessels' management needs the most sophisticated technical management when compared with bulk carrier and container vessels. Within all these descriptive and quantitative analyses of regression, supporting possible strategies will be explained as conclusion.

CONCLUSION

Shipping sector is accepted as a volatile and risky sector. It constitutes many types of ships and ship managements whether including strategic management is existed or owners' perception tend to only popularity. Ship owners might be in different motivations on decision making of long-term or short term chartering commitments or investing new ships. In contrast, some ship owners, managers or operators turn the volatility and decreasing prices into advantage to earn more money and widen their total assets. Sometimes managers invest in ships not only specific to their technical knowledge, trading strategy and development of world gross domestic product. Ship owners are a diverse group of players, of all shapes and sizes with different aims and motivations and backgrounds in different regional business cultures. Certainly, they are motivated by the desire to be profitable rather than loss making but how they seek to make their profits will be a variable. This causes that the owner of a socks factory can be an owner of bulk carriers even though he/she has never experienced any kind management of merchant shipping trade for "*Catching up the popularity*" philosophy which causes accumulation of ship supply side within decreasing of freight rates. Companies must be established on more specific and innovative infrastructure including a well-studied feasibility calculations and shipping market researches. As per this study, it has been lightened that even slight decrease in world trade and industrial production exist, ship building costs get such decrease either. The model also shows the counter-effect of average ship prices and world fleet capacity. Therefore, market cycles, time charter rates and commodity prices must be well examined before a maritime company do investments. It is recommended for further studies, supply and demand side's regression can be combined with Baltic indices, freight rates and time charter rates per annual. Specific freight rates and ship prices' analyses can generate more sophisticated equations which will be helpful for ship owners while their attempt to ship investments. In conclusion, untimely and unsearched investments can be only the circumstances of "*Shipping vogue*". Ship owners, managers and operators must follow the global market and develop new strategies on shipping investments in order not to experience "*Failure*" in their further trade activities.

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A CAPABILITY ANALYSIS OF MARITIME TRANSPORTATION FOR HUMANITARIAN LOGISTICS

Ayşenur Şahin-Arslan[5], *Mustafa Alp Ertem*[6]

Abstract *− Transporting relief supplies quickly to the disaster area is a crucial step of humanitarian logistics. Land and air transportation are mostly used in responding to disasters. On the other hand, waterways are used in global trade and have the advantage of transporting more weight while connecting to other transportation modes for the last mile delivery. Using maritime transportation for humanitarian logistics is a vital topic, but has not been studied thoroughly. In this study, we performed a capability analysis of maritime transportation for a successful humanitarian operation. Maritime transportation is analyzed using the characteristics of port activities in terms of accessibility, modal share, port structures, equipment, resources and coordination of national and international stakeholders. This study presents maritime transportation capabilities and characteristics from the point of humanitarian logistics view as a guide to future researchers and practitioners.*

Keywords − Capability analysis, Humanitarian logistics, Intermodal transportation, Maritime transportation, Ports

INTRODUCTION

Either natural or man-made, disasters are a reality of human life. Regardless of the precautions taken, humanity will continue to suffer from disasters exceeding the relief capacities. As one of the four phases of disaster operations management (i.e., mitigation, preparedness, response, recovery), response phase relies on sound transportation infrastructure. Unfortunately, transportation infrastructure is usually damaged by disasters. In order to reach disaster victims, alternative means for transport is needed.

One alternative mode to land transportation and air transportation in humanitarian response is maritime transportation. Maritime transportation is used heavily in today's trade. Seaborne trade is reported to have a share about 75% of all merchandise trade in the world [14]. Most of the long distance transportation is handled by some form of maritime transportation, either from origin to destination solely by waterways or by a combination of other transportation modes. Relief items handled in the preparedness phase of disaster operations management is not an exception to this large share of maritime transportation in today's trade. On the other hand, maritime transportation during response phase requires more in-depth investigation because of the rapid and ad-hoc nature of humanitarian operations.

A few studies can be cited on using maritime transportation for humanitarian logistics. Tatham and Kovacs [15] analyse ways to apply sea-basing concept of military applications to humanitarian logistics. Bemley et al. [16] investigate secure port recovery after a natural disaster by repairing navigation aid tools. Wilberg and Olafsen [8] developed a simulation model adapting the distribution network of a commercial logistics company to IFRC (International Federation of Red Cross and Red Crescent Society)'s relief item distribution network utilizing vessels and ports.

Using maritime transportation for humanitarian logistics is a vital topic, but has not been studied thoroughly. The objective of this study is to list the capabilities of maritime transportation for a successful humanitarian operation. Turkey is a special case for using maritime transportation in humanitarian logistics, because of the geopolitical location and vulnerability of our country. Therefore, we gathered statistics about Turkish ports reporting their area and equipment capacities in responding to a disaster. The paper is organized as follows. Next section discusses the components of maritime transportation. Later, we present a capability analysis for humanitarian logistics using maritime transportation. Turkish port capacities are reported in the fourth section for their possible use in humanitarian logistics. Finally, we conclude with our findings.

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CHARACTERISTICS OF MARITIME TRANSPORTATION

Maritime transportation is a complex system with its stakeholder relationships and ongoing operational activities. There are several self-reliant actors in this system including governmental and private organizations likely to have distinct viewpoints. Therefore, the components of maritime transportation can be defined by using a "system of systems engineering" approach [1]. Five components of this system are ships, ports, intermodal hubs, users, and waterways ([2][3][4]). Each of these components are independent but interrelated horizontally or hierarchically.

Ships and vessels used in transportation are irreplaceable components of transferring freight from the port of origin to the port of destination using mostly tanker, bulk and container ships. After the ships are manufactured, their regular maintenance should be performed. The ships should be well organized to operate between the ports by planning of their arrival to and departure from the ports. The organization and the operation planning of the ships are very important in maritime transportation system due to its connectedness to the port and intermodal hub components.

Ports are the stations for all maritime activities related to ships taking on passengers and freight cargos. Container loading and unloading, disposal of empty containers, stacking and maneuver activities are performed at the related areas of ports. Moreover, construction of the ports, operation and maintenance of handling equipment, dredging, terminal operations, and administrative activities are performed within the boundaries of a port [1]. The ports also hold empty trucks to transfer the arriving cargo to destination points using intermodal hubs. Container line agents, intermediary companies, customs companies are the main stakeholders at ports.

Intermodal hubs provide the transfer of freight from the port to the final destination via other transportation modes. The capacity of ships for freight is more than the capacity of trains or trucks, therefore, trains or trucks should be ready at the port terminals on time during the loading/unloading processes. If the ports have railway terminals, the freight is transferred to trains since a block train can get up to 80 TEU having more transportation capacity than trucks at once [5]. The warehousing, handling and transportation activities are provided by the intermodal connectors. Railway and highway transportation companies, container manufacturers and owners of container fleets are the primary stakeholders at intermodal hubs.

Transfer operations at intermodal hubs are easier with goods loaded to standardized containers. Generally speaking, containers are defined as large boxes, which are used to transport goods from an origin to a destination. Compared to conventional bulk transportation, the use of containers has several advantages, such as less product packaging, less damage, and higher productivity. The dimensions of containers have been standardized throughout the years, and transport over the sea is mostly carried out by containers on ships. Additionally, trucks or trains can be used to transport containers over land [6]. The container handling and container transportation is used as a base for freights throughout the study. In Figure 1 an example container network is given between an exporter warehouse and a port.

In Figure 1, three modes of containerized intermodal transportation (i.e., highway, railway, and waterway) are depicted. Freight can follow alternative tracks at this network. The containers are first transported to rail terminal by trucks. Then, the freight is placed into the containers and the containers are handled to trains in order to travel to the transshipping port. The containers are transported to main loading port from the transshipping port with small size ships. Lastly the containers are loaded to vessels for their final destination.

The service providers and receivers are the fourth component of maritime transportation system including shippers, owners of ships and vessels, and owners of the freight, port terminal personnel, port handling personnel, governmental, private and non-profit organizations, customs and administrative organizations, international organizations and distributors. These are the users and also the stakeholders of maritime transportation.

The fifth component of maritime transportation system is waterways. Sea, ocean, lake and river transportation can be considered as the types of waterways. River ways are not used much in international trade because of the cost and time disadvantages. The river ways are not developed like the ocean and sea transshipment for the freights in many countries. Similarly, transportation via lakes mostly happens within countries and are not suitable for import/export shipments.

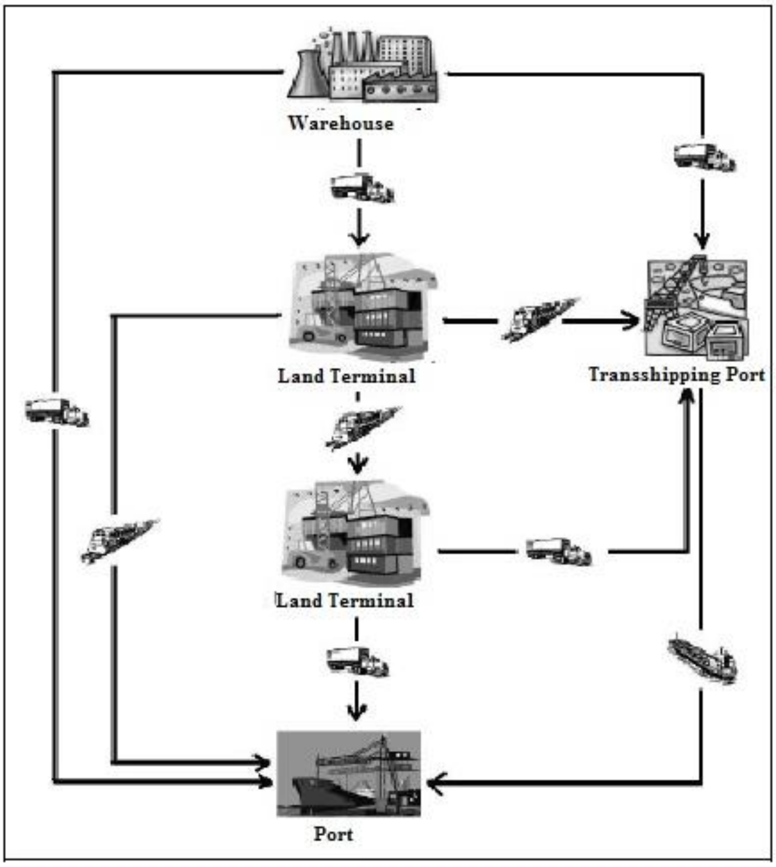

Figure 1. An example intermodal container network, Source: [5]

A CAPABILITY ANALYSIS FOR HUMANITARIAN LOGISTICS

To come up with the capabilities needed for using maritime transportation in humanitarian logistics, we need to have an understanding of the characteristics of humanitarian logistics when compared to commercial logistics. In commercial logistics activities, intermodal transportation is used commonly in order to save time and cost. However, commercial and humanitarian logistics have some main differences even if they may have the same intermodal transportation network and equipment types. In commercial logistics the profit is maximized, on the other hand, saving lives of beneficiaries is aimed in humanitarian logistics. The demand pattern can be forecasted in commercial logistics, but the demand is unknown in humanitarian logistics since the time, quantity and place of the disaster is unpredictable. The transported items in humanitarian logistics aims helping people and can be exemplified as food, water, shelter and evacuating equipment. These products serve the immediate needs for survival and should be treated differently than commercial products in the transportation network [7]. Once a disaster happens, these items are needed immediately, so the desired lead time is almost zero. Therefore, prepositioning these items near possible disaster areas helps in quickly transporting them to the affected areas.

The transportation network of humanitarian logistics is in ad-hoc structure since the network is determined after the disaster and wiped out after the recovery phase of disaster. Disaster characteristics define the flow pattern of goods. For instance, the roads may be destroyed and mostly waterways and airways should be utilized after a flood or an earthquake. On the other hand, waterway and airway may not be used after a hurricane strike, since a hurricane will impede most flights and sailings. Because of the dynamic structure of humanitarian logistics, the transportation network and the required equipment should be determined considering disaster characteristics. The supply network of the goods should also be considered in terms of the intermodal connections. Most of the immediate relief item flow will be from predetermined warehouse locations to disaster prone areas. The available transportation modes between these prepositioned warehouses and possible disaster areas should be determined considering the disaster type.

The frequent use of containers in maritime transportation can be a capability that humanitarian logistics can benefit from. In maritime transportation, when container ships arrive at ports, the containers are loaded/unloaded, handled and stacked. Later, entry/exit and custom services are performed. The container ports can be operated by public or private sectors and the port services are composed of five main operations, which are dock, container yard, container freight station (CFS), gate and other operations processes [5]. The containers are loaded to and unloaded from container ships with cranes at docks. The dock cranes can be gantry cranes moving on a permanent line or straddle carriers with flexible lines. In container yards, the containers usually dwell in order to be handled after entry from gates or exit from container ships. The containers are waited for loading process to ships for some period of time according to loading plans. Moreover, the unloaded containers from landing ships are waited for transfer to terminals from the gates. In container yards forklifts, stowing equipment and reach stackers are used to handle containers.

In container ports, sometimes the containers are opened and the freight is divided for different freight owners having less than container load (LCL) and the empty containers are loaded with different freight owners’ goods in pallets. Forklifts are used in CFCs to load or unload the pallets. The containers come to CFS in order to be loaded to ships and unloaded containers use gates for entry/exit processes. The containers arrive at CFS with towing vehicles on a railway where available. When the discharge process with handling equipment finishes, the entry is completed with the gate operations. The handling equipment used in gate operations are semi-trailers and cranes. The other maritime operations are customs and documents transactions during entry/exit operations.

The aforementioned operations are valid for maritime transportation in humanitarian logistics, too. However, the stakeholders’ relations can change according to the degree of urgency and the place of a disaster. Some of the humanitarian organizations store the relief items in predetermined warehouses close to intermodal hubs. These warehouses have the relief items ready to send to the affected areas when they are needed. The supplier and warehouse operations are performed in preparation phase in order to keep stocks available and up to date. When a disaster strikes, the relief items at these warehouses are transferred immediately with effective transportation modes providing fast response such as air cargos and helicopters. Since the demand is unknown beforehand, needs assessment operations start and the flow of relief items continues with available transportation modes. Because of the uncertainty in demand and the urgency of flows, humanitarian logistics prioritize responding fast to disasters and saving human lives. There must be alternative route plans of other transportation modes against possibility of truck breakdowns, highway destructions or other problems affected by disasters. As a viable alternative to other transportation modes, maritime transportation can play a role in countries with long coastal lines and with high capacity ports.

One type of maritime transportation that might be a capability for humanitarian logistics is Ro-Ro (Roll on-Roll of) lines. This type of intermodal transportation uses highway and waterway and ensures the transportation of container trucks on the vessels. In this type of transportation the time for handling is shortened using special handling equipment. Ro-Ro can be useful in humanitarian logistics approach since it is concentrated on fast delivery of required items to the affected areas. However, Ro-Ro has some disadvantages like requiring special vessels and port places, determined freight type and consumes more fuel than the normal type of vessels.

It is a question for private sector either to be a resource provider of humanitarian logistics or not with its transportation network capacities because of its differences between commercial logistics. This question is studied by Wilberg and Olafsen [8] for the IFRC case. A maritime transportation company specialized in “factory-to-dealer” concept in Sweden is investigated to be a part of the decentralized supply chain of humanitarian logistics using the company’s ocean transportation, terminal and technical services as well as inland distribution. The authors studied replacing the response system of IFRC utilizing aircrafts with on board vessels with determined sailing routes. They see that the company which gives commercial logistics services has the ability of serving also humanitarian organizations with its "mobilized resources". Moreover, established business processes of the company improve the response system as a whole in the simulation model. It is found that the equipment required for humanitarian logistics are common with commercial logistics, since commercial logistics use the equipment for a wide range of handling activities from small to large loads.

The proposed system in Wilberg and Olafsen [8] has not been implemented in practice. The coordination of relationships can be more complex than this simulation model, because of having more than one company providing this service to other stakeholders (local and international governmental and non-governmental organizations (NGOs)). Time might be a straining factor for the stakeholders to transfer the relief items effectively. The customs and administrative operations between ports and other transportation modes take time if the call for aid is at the national level, whereas it is more flexible if there is an international call for aid.

A CAPABILITY ANALYSIS FOR TURKEY

Turkey is surrounded by sea on three sides (i.e., Black Sea, Aegean Sea, Mediterranean Sea) providing strategic export/import ports and several routes to connect Asia and Europe. "The main long distance container shipping lanes between western Europe, the Middle East and the Far East pass through the Mediterranean very close to Turkish ports" [9]. There are fifty ports in base of eighteen port presidencies in Turkey. It is seen that Ambarlı, Mersin, İzmir, Gemlik and Haydarpaşa ports are in the top five of the total maritime transportation in Turkey when they are analyzed according to export/import rates as given in Table 1 and Table 2.

Table 1. Total container handled as import/export in ports, Source: [10]

Port	Import (TEU)	Export (TEU)	Share of export in this port's total handling	Share of this port in total	Cumulative Share
Ambarlı	1,496,650.00	3,023,960.00	33.1%	42.2%	42.2%
Mersin	618,379.00	1,250,873.00	33.1%	17.5%	59.7%
Gemlik	347,142.00	686,245.00	33.6%	9.7%	69.3%
İzmir	335,265.00	695,798.00	32.5%	9.6%	79.0%
İzmit	318,878.00	630,152.00	33.6%	8.9%	87.8%
Aliağa	214,966.00	413,573.00	34.2%	5.9%	93.7%
Antalya	91,146.00	179,351.00	33.7%	2.5%	96.2%
Haydarpaşa	77,283.00	158,700.00	32.7%	2.2%	98.4%
İskenderun	40,341.00	83,207.00	32.7%	1.2%	99.6%
Trabzon	14,766.00	28,742.00	33.9%	0.4%	100.0%
TOTAL	3,554,816.00	7,150,601.00		100%	

In Turkey there are thirteen ports having nineteen container terminals in eleven cities. In Table 1 the import and export handling of containers are given for the top ten ports of Turkey having container terminals. The shares of export for each port are very close to each other. The proportions show that top five ports constitute to the container handlings with approximately 90% of all imports and exports. Table 2 also shows the container capacities of these five ports (in TEUs) and the realized handlings (as loading + unloading). In the last column of Table 2, the capacity usage of the ports are given and all of them are larger than 70%. The 25 logistic warehouses built by AFAD hold 40ft containers, so the remainder of this capacity can be used for humanitarian logistic activities for these relief item containers. These ports are usually used for export/imports so the handlings between ports in Turkey may not be suitable for container transfers. In case of an international call for aid, these ports would be suitable to handle relief containers.

Table 2. Total container handled and the container capacity of top five ports, Source: [10]

Port	Container	Loading	Unloading	Capacity

	capacity (TEU)	(TEU)	(TEU)	usage
Ambarlı	4,905,720.00	1,496,650.00	3,023,960.00	92%
Mersin	1,800,000.00	618,379.00	632,494.00	70%
Gemlik	700,000.00	347,142.00	339,103.00	98%
İzmir	750,000.00	335,265.00	360,534.00	93%
İzmit	900,800.00	318,878.00	311,275.00	70%

The ports are crucial parts of a possible international humanitarian response chain providing space for arriving containers from international relief providers. However, ports should be supported with other transportation modes (highways and railways) in order to make the last mile delivery to disaster areas. Wagons on the railway can handle up to 80 TEU (1600 tons) with block trains as well as trucks also can be transported with their containers (i.e., Ro-La system) at up to 120 km/hr velocity. The block trains are advantageous since they do not stop at intermediate stations. A sample of the block train is given in Figure 2.

Figure 2. A Sample for a Block Train, Source: [11]

The connection between the port and railway is ensured between port of discharge and land terminals. Most of the container ports in Turkey have railway connections (Figure 3). Only Antalya, Gemlik, Trabzon, Rize, Karabiga and Bartın port presidencies do not have railway connections. Among these ports which are not connected by railway, only Gemlik has a large capacity. On the other hand, most of Gemlik's handling capacity is full with commercial logistics.

Figure 3. Railway Connections of Ports in Turkey, Source: [12]

Asyaport (Tekirdağ) and Çandarlı (İzmir) are the new ports having large container handling capacities. These new ports also have railway connections and would be desired for humanitarian activities. Asyaport started its activities on

1 July 2015, but the construction at Çandarlı port dock still continues as of the time this paper is written. A railway connection for Kocaeli Derince port is given in Figure 4. As it is seen on the figure transfers are made to/from block trains at the area between CFS and dock.

Figure 4. Railway connection in land terminal of Derince/Kocaeli port, Source: [13]

Table 3. Capacity of Port Terminals in Turkey

		AREA					EQUIPMENT							
PORT	TERMINAL	Total Container Stock Area (m2)	Terminal Capacity (TEU)	CFS Area (m2)	Stock (m2)	Stowage Capacity (TEU)	Dock Crane	Mobil Crane	Straddle Crane	Container Dock Crane	Tow Truck	Fork lift	Spreader	Stacker
Ambarlı Altaş	Marport Terminal	340,000.0	1,900,000.0	17,425.0	4,477.0	24,685.0	10	5	41	18	92	8	12	-
	Mardaş Terminal	330,000.0	1,305,720.0	197,107.0	4,161.0	25,110.0	19	11	8	14	30	-	-	14
	Kumport Terminal	402,115.0	1,700,000.0	10,000.0	6,700.0	30,270.0	7	8	20	32	51	25	10	21
Haydarpaşa TCDD	Haydarpaşa TCDD Terminal	-	-	55,000.0	-	52,800.0	9	6	18	17	-	38	-	-
Aliaağa	Nemport Terminal	88,300.0	549,000.0	-	-	-	12	14	19	20	-	-	-	20
	EgeGübreTerminal	283,000.0		-	-	-	-	-	-	-	-	-	-	-
İzmir	TCDD Alsancak Terminal	-	-	-	-	-	5	12	10	29	-	21	-	-
Antalya	Ortadoğu Terminal	-	-	86,800.0	80,000.0	-	-	9	-	-	-	-	-	-
Bandırma	BandırmaTerminal	215,569.0	350,000.0	8,000.0	110,000.0	4,195.0	-	9	-	3	5	5	-	-
Gemlik	Gemlik Terminal	70,000.0	600,000.0		11,500.0	-	14	7	-	-	22	25	-	15
İskenderun	Limak Port	-	1,300,000.0	3,600.0		-	-	3	-	17	-	25	-	5

	Assan Port	-	250,000.0	1,600.0	3,720.0	-	-	4	-	7	8	-	5	2
İzmit	Derince TCDD Terminal	-	800.0	-	-	-	5	41	10	-	-	21	-	-
PORT	TERMINAL	Total Container Stock Area (m2)	Terminal Capacity (TEU)	CFS Area (m2)	Stock (m2)	Stowage Capacity (TEU)	Dock Crane	Mobil Crane	Straddle Crane	Container Dock Crane	Tow Truck	Forklif t	Spreader	Stacker
İzmit	Evyap Terminal	-	450,000.0	-	-	-	-	-	-	-	-	-	-	-
	Yılport Terminal	46,000.0	450,000.0	-	-	-	6	-	-	-	-	-	-	-
Mersin	Mersin Terminal	350,000.0	1,800,000.0	220,000.0	-	-	7	7	-	25	84	67	12	18
AsyaPort	AsyaPort Terminal	-	2,500,000.0	-	-	-	11	-	33	-	-	-	-	-
Trabzon	Alport Terminal	-	-	-	13,000.0	-	-	-	-	-	-	-	-	-
Samsun	Samsun Terminal	100,000.0	250,000.0	7,000.0	50,000.0	-	11	14	-	6	7	8	3	-

The information of equipment in ports for container handling and container stock is given in Table 3. The data of Table 3 is obtained from the official websites of the ports so the dashes mean that type of information is not available for that port. The obtained data were not standard and may not be up-to-date for some ports, since several ports have different website layouts and many of them belong to private port operators. In the first column, the port name is given along with the terminals of the port in the next column. In the third column, the total container area is given in m^2. The terminal capacity is given in the fourth column in TEUs for containers. In the fifth and sixth columns the CFS and stock area capacities are given. In the seventh column, the stowage capacity of the terminals are given for the terminals where data are available. In the last eight columns, the equipment availability of the terminals are provided such as dock, mobile, straddle and container dock cranes, tow trucks, forklifts, spreaders and stackers. As it is given in Table 3, the largest container port capacity is on three terminals of Ambarlı Altaş Port with 37% of all Turkish ports' capacity. The second largest container capacity is on Mersin and İskenderun Port. Actually Asyaport has 2,500,000.00 TEU container capacity but it has just started operation and has not realized its real demand yet.

CONCLUSION

This study aims to highlight the suitability of using maritime transportation for humanitarian logistics. Maritime transportation is employed heavily in international trade and has established procedures for handling all of the transport related activities. Components of maritime transportation are explained. Using these components, a capability analysis of maritime transportation is accomplished. Turkish ports' handling area and equipment capability analysis is performed by gathering data from various port web sites. Use of containers is emphasized in this study because of its speed and standardized operations. Using maritime transportation is especially important for Turkey because of the recent investment of AFAD to 25 logistic warehouses holding 40ft. containers. It can be concluded from this study that maritime transportation has the capabilities that are required for use in humanitarian logistics. This study is a first step to highlight the literature gap on using maritime transportation for humanitarian logistics and a humble start for future work.

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IMPLEMENTATIONS OF SHIP FINANCE SYSTEMS IN THE WORLD AND A FUTURE STUDY FOR TURKISH MARITIME INDUSTRY

Ayse Asli Basak[7], *Erkut Akkartal*[8]

Abstract - *Maritime transportation has been the key point of international trade since ancient times and has the biggest ratio in global trade environment in recent years. Either the maritime transportation has significant role on international trade or, being a part of this transaction via financing of ship investors is also significant. The purpose of this study to reveal basic systems of "Ship finance" which has placed at utmost level of ship investments since the first commencement of sea trade. Analyses of Variance concerning some country-based and global financial indicators such as Baltic Exchange indices, GDP per capita, seaborne trade volumes and own fleet capacities will lighten up that how countries may turn ship finance issue into an "Opportunity" to develop their own maritime economy. Government based financial institutions and private funding companies are existed nowadays and both have advantages and disadvantages on the side of country's development. However, as different from other maritime-advanced countries, Turkey still have neither a government based nor private companies on ship financing. The absence of a national ship finance system makes Turkish ship owners and investors to tend to finance their investments via foreign commercial banks and/or financial corporations. The paper includes indicating the best and most compliant ship finance model for Turkish maritime economy within evaluation of whole risks such as shipping market crises, owners' and government's perceptions. Possible consequences of this paper is to display how to be a developed economy especially for those of which surrounded by seas and, to be a "Reproducer" candidate of global economy with new policies which will open the door to becoming a pioneer economy.*

Keywords – *Shipping, ship finance, shipping market crises*

INTRODUCTION

Maritime transportation is compromised as one of the branches of the global supply chain management and constitutes a transportation ratio of more than %90 in international trade [1]. Shipping of goods and services intra-industries creates a more volatile market for shipping companies including an effect of finance positions in maritime trade. Where by the resources become necessary for ship investments, ship finance issues appear as the next stage for a ship owner, operator or manager and therefore, ship financing is defined as a method of raising funds whereby risks are mitigated by the resistance of various forms of collateral, and charter fees serve as the principal source of repayment [2].

Ship finance is constructed on a bottom line of any deal is that a bank or some other lender advances money to a ship owner to assist the owner to build a new ship, buy a second hand ship, convert-repair-alter a ship or refinance existing indebtness secured on a ship. Due to the fact that shipping is a cyclical and uncertain industry, ship finance issues on banks and ship owners' side became more sophisticated in global maritime industry [3]. In most maritime advanced countries such as Germany, Denmark, Netherlands, United States and newly; China and South Korea as emergent side, have their own financial ship funding systems as being private and/or government supported corporations. However, as opposite in Turkish maritime industry, ship investments are mostly financed by foreign banks or financing corporations due to Turkish banks' perception on Turkish ship owners as with their high risky rates. Volatility of shipping market causes some difficulties on the ship owners and investors' side due to tightness of global demand. As cost pressures and service demands escalate, ship owners and bankers or financiers are collaborating strategically to share resources and

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information while also realizing economies of scale [4]. However, for Turkish ship owners or investors, there is a "*Self-Dealing*" position against possible crises and most of Turkish ship investors who are to be ship owners tend to lend money from foreigners and therefore a huge amount of cash flow in ship investment are remitted into foreign banks or funds as re-payments. Capital payments dominate shipping companies cash flow and decisions about financial strategy are among the most important that their executives have to make. For this reason alone ship finance deserves a special place in the study of shipping economics [5]. It is reported that the operation of merchant ships contributes about US $ 380 billion in freight rates within the global economy, equivalent to about 5 % of total world trade and this amount cannot be negligible, when Turkish economic growth is considered [6].

The main effective component of the ship finance is the shipping market. It is seen that 2008 is the most important year for this evolution due to the global shipping crisis. Prior to 2008, shipping finance was widely available as the industry was experiencing a period of sound growth and historically high shipping rates. Many shipping companies expanded and placed long-term orders for large numbers of new build vessels. From 2003 to 2008, the new build market was raised until the new ordered ships became a worth more than $800 billion. The half of the orders placed between 2007 and 2008, when vessel prices were at their peak [7]. Banks loans were easily accessible, up to 80 percent of loan to value for new vessels, leaving little margin for error in vessel values. Most of new vessels were scheduled for delivery in the years immediately following the financial crisis of 2008 [8].

While a quick outlook into different ship finance systems in the world, many models are seen which are suited to the financing of ships, and numerous different ways of structuring these models by means of commercial banks, ship mortgage banks, investment and merchant banks, finance houses, brokers, leasing companies and shipbuilding credit schemes [4]. By the aim of the research, special characteristics of Turkish shipping and finance will be explained with supportive analyses so that the best role model can be determined for Turkish shipping market.

METHODOLOGY

Countries have been determined between the most maritime advanced countries and also developing countries which have specific ship finance system neither have not. Since the data is metric, regression analysis was used in order to reveal the relationship among variables. Liner ship connectivity index, existence of ship finance regulations and deadweight tonnage of total merchant fleet of countries were selected as independent variables. Gross National Product (GNP) was dependent variable. Exploring funding styles of ship finance systems seeks answers to the role of financial corporations in shipping as a specific loan management for ship investments in the world, more effective systems for current global shipping market, funding system's practicality to recover current ship investments for Turkey within an evaluation of Turkish maritime economic policies and further implementations can be used if a ship funding system established in Turkey.

DATA

Among totally 58 countries which are placed in merchant shipping sector, 37 of them were selected. Total fleet capacity data has been taken from UNCTAD data centre and GNP values taken from World Bank [9]-[10]. Since some of the countries have unusual flag regulations on owner taxes which is called *"Flag of convenience"*, they are excluded from the study. The countries such as Panama, Marshall Islands and Malta mostly include the big part of ownerships as foreign affiliates. For example, Greek ship owners prefer to fly Panama flag instead of Greek Flag on their ships due to low ship owning taxes [6]. On the other hand, first regression analysis has been carried out between all of the variables of liner ship connectivity index, existence of ship finance regulations, deadweight tonnage of total merchant fleet and GNP of countries. However the results have shown that the most significant model can be determined between variables of deadweight tonnages of total merchant fleet and total latest GNP of countries. Therefore, regression analysis in this research has been supported with sketch regarding these different countries' ship finance systems including literature review and some descriptive analyses. Basic components which affect the shipping financial structure have been also analysed with comparing the market statuses and effects of the mentioned indicators on ship finance have been searched. These both quantitative and qualitative methods will assist to find out the best ship finance model for Turkish maritime sector and future suggestions which can be additional to support best ship financial model for Turkish maritime industry. A final evaluation for development of Turkish economy has been carried out within the financial condition, possible risks and ship investors' perception in Turkey.

RESULTS

As the first step to model analysis, before performing regression analysis, normality tests have been carried out. Kolmogorov-Smirnov and Shapiro-Wilk tests have shown that variables are normal distributed as shown in Table 1 below:

Table 1. Normality tests

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
GNP	,103	37	,200*	,948	37	,085

As all the independent variables regressed on GNP, only total deadweight tonnage of merchant fleet of countries was displayed to be significant. After performing the diagnostic tests of the regression analysis, regression analysis was performed by enter method which can be seen in below Table 2:

Table 2. Method that shows entered/removed variables

Model	Variables Entered	Variables Removed	Method
1	Total_fleet_volume[b]	.	Enter

a. Dependent Variable: GNP

Then, assumptions of the regression analysis were tested. Linearity, heteroscedasticity, auto correlation and multicollinearity assumptions were satisfied by appropriate tests as the results in Table 3 and Table 4. As displayed in ANOVA table, model was found to be significant (p=0.041) at $\alpha = 0.05$ and null hypothesis rejected (Table 3).

Table 3. ANOVA table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1343506336,151	1	1343506336,151	4,495	,041[b]
	Residual	10460442945,405	35	298869798,440		
	Total	11803949281,556	36			

a. Dependent Variable: GNP

b. Predictors: (Constant), Total_fleet_volume

Table 4. Significance of coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0,173	,334		7,063	,000
	Total_fleet_volume	,140	,066	,337	2,120	,041

a. Dependent Variable: GNP

Moreover, regression coefficient was significant at $\alpha = 0.05$ which was given in Table 4 above and the overall summary of the model is as in Table 5 below:

Table 5. Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
				R Square Change	F Change	df1	df2	Sig. F Change	
,8544[a]	,73	,63	1,85118	,74	4,495	1	35	,041	1,972

a. Predictors: (Constant), Total_fleet_volume

b. Dependent Variable: GNP

Below model in Equation (1) has been displayed in Table 4 as well:

$$yi = 23{,}619.17 + 0.1397xi + \varepsilon i \tag{1}$$

(0.3344) (0.065)

Besides, $R^2 = 0.73$ and Adjusted $R^2 = 0.63$ with $n = 37$ (Table 5).

The above model shows that, given the deadweight tonnage of merchant fleet of countries, GNP can be predicted for the future national budget plans. Of course, there are many variables affecting GNP. However, in this study, the causality between GNP and fleet tonnages has been dealt with. Analysis has been performed by statistical software package SPSS 20.0.

DISCUSSION

Despite the analysis shows significant results on merchant fleet capacity and GNP side, there are still some assumptions on the countries like United Kingdom, Greece and Norway. While these 3 countries were excluded from the analysis, $\rho\ value$ shows a result of 0.02 which is more significant than the overall analysis of 37 countries. When the main reason was searched, it was found that these 3 countries have been placed at the most maritime advanced countries since the ancient times of maritime merchandise. Among all 37 countries, Germany, United States, Japan and China have one of the most own-flagged fleet capacity which means total GNP is increased directly proportional by the national fleet capacity. The countries such as Panama, Marshall Islands and Malta have been excluded from this research due to having the biggest ratio of world merchant fleet which are totally owned by foreign ship investors. The huge size of their fleet affected the analysis in a negative way. Therefore, only national owned flagged capacities assist to indicate the economic level of countries.

Generated model also have been affected by many variables which the most important one is global economic crises. Sensitivity of this model against crises in global maritime economy must be descriptively analysed. More than most other forms of finance, ship finance is international. The financing of large ocean going ships are undertaken by banks all over the world, by no means just owners in their own country. On the contrary, and certainly for larger ships and larger owners, one is more likely to find, for example, an American bank, acting through its London office, lending to a Greek-controlled owning company and securing itself on a Liberian registered ship. There may be a degree of patriotism but if a foreign bank can offer better terms, then owners, accustomed to international dealings in the everyday operation of their ships, will not be troubled about dealing with foreign lenders [11].

Some examples of the countries that have own ship finance, investment and maritime trade strategy can be descriptively seen by last 20 years' time series in Figure 1:

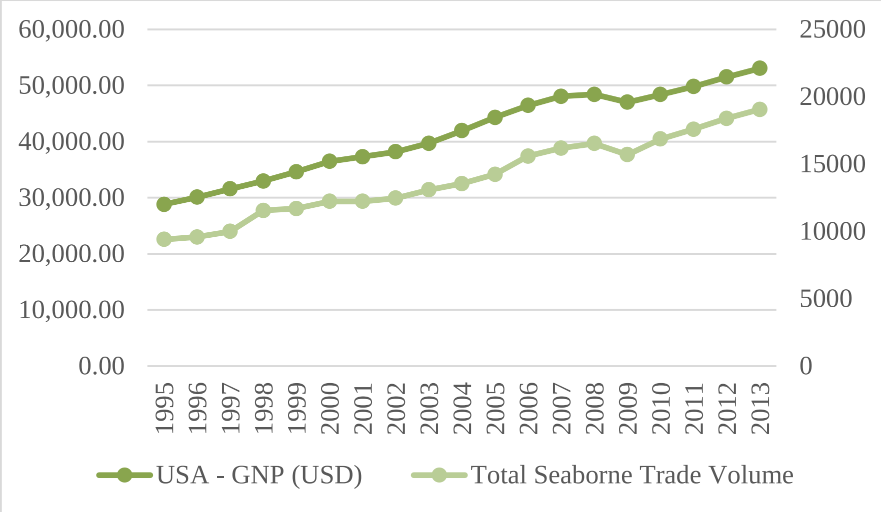

Figure 1. Time series of total GNP and seaborne trade volume of United States [9].

Figure 1 shows that own national ship investment policies and enlarging seaborne trade assist total GNP to increase for United States. However, it is also seen that during global shipping crises in 2008, GNP of United States also began to decrease in a linear way. While comparing with Turkish economy it is found a slight complicated that seaborne trade increasing and decreasing frequency is very low. Therefore, it may be one of the effects that GNP in Turkey have not increased as much as the United States.

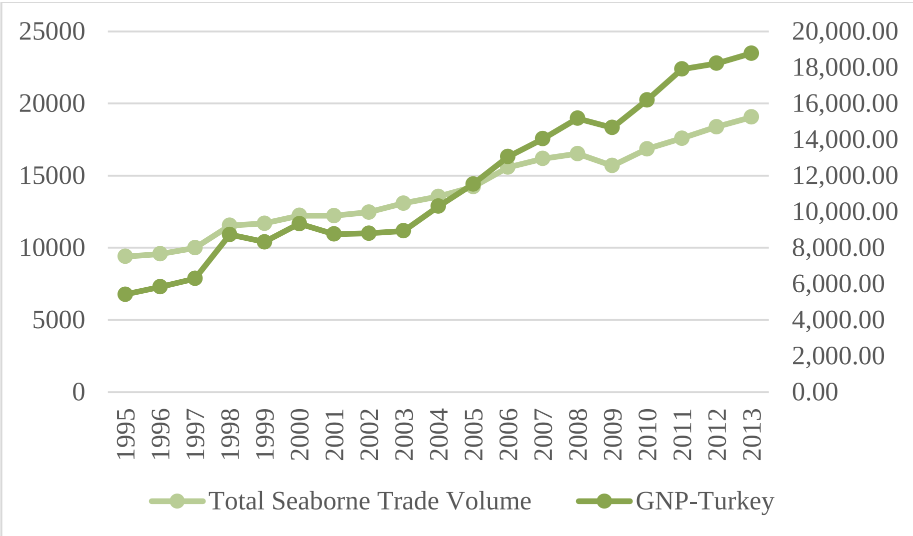

Figure 2: Time series of total GNP and seaborne trade volume of Turkey [9].

As per described in introduction section, many of countries have different types of ship finance systems, the most known funding system is German "*KG System*" which is partly supported by government but managed as a private corporation. German KG funds own 1,700 ships, many of them container ships leased to Denmark's Maersk Line, Switzerland's Mediterranean Shipping Company or other big lines. Flows into the funds have plummeted since the 2008 world economic crisis forced ship managers to lay up many KG funds' ships and turn to investors to pay the ships' storage costs. German ship owning companies are mostly family-owned private businesses such as Turkey that manage the operation of ships on behalf of KG funds. The companies own only a small stake in each fund and are paid a fee for their management services [12]. One of the other popular funding system is Danish Ship Finance which is semi-percent supported by government and keeps its successful position in such volatile sector with comprehensive policies covering more than 500 vessels in its loan [13]. In China and South Korea also governments support to ship funding with incentives, however management is performed by financial institutions [14]. If Danish and German "*KG*" fund systems are compared, it is seen that "*KG*" system has been approved that it would be affected very much when a governmental control is not included in the financial system. Danish ship finance system is a good example that government controls all the financing process against a cause of possible crisis in shipping market of the country. Both systems can be used with a "*Win-win*" motto by the owners and financiers' side; however the mortgages of the ship investments will be well evaluated according to market risks.

Since the commencement of ship finance systems, Turkey could not have been a key player in shipping sector with its financial infrastructure. Increasing value of industrial production and demand to transportation bring out together the importance of shipping sector. In 1970s, there were "*Cash-flow*" ship owners in Turkey and the total assets were depending on the richness of that operator. By the 1980s and 1990s, a Turkish governmental ship owning company "*Deniz Nakliyat*" was the key player in worldwide maritime transportation and was being fully managed as a Turkish company. However, the world was changing in other hand. Industrialization became very important for a country and government could not handle to manage all fleet vessels by its own and specialization became necessary. Since 1990s, shipping market in worldwide became very volatile due to high value of import and export either for Turkey. "*Deniz Nakliyat*" could not bear this volatility and sold many of their vessels to private ship-owning companies in Turkey [15].

Since by the private shipping companies were arisen, there had been occurred a big opening to necessity of financial resources, too. Turkish flag ownership was become very difficult to handle high volume of taxes and lack of financial resources in Turkey and this made them to tend to foreign banks, equities and funding companies. Ship investments which are financed by foreign companies are still an unsolved problem for Turkish economy so that the money of Turkish ship owners go to a foreigners and this is an equivalent situation to import. When a ship investment's value is considered, it is seen that ship prices are very high which are counted as million dollars. Some Turkish banks such as "Deniz Bank" and "Koc Finans" were financing Turkish ship owners' new-building investments. However, due to bankruptcies of the companies or late payment backs of Turkish ship owners made these banks not to prefer Turkish ship owners for ship mortgages and credits. If a Turkish ship owner is only specific to ship owning operating and managing without any other related companies such as factories or shipyards, it becomes very difficult to stay on their feet against shipping market crises. Above restricted situation can be summarized in below Figure 3:

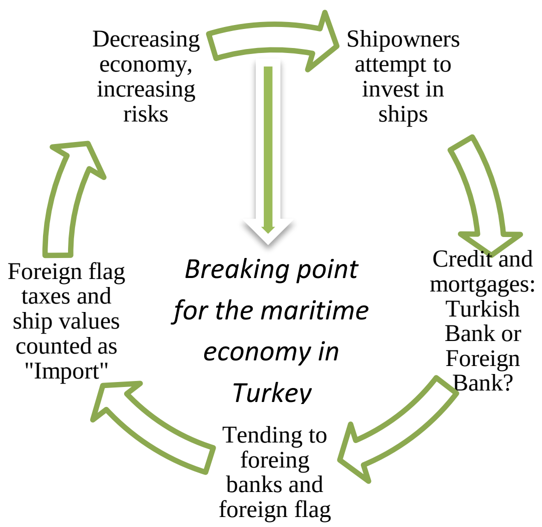

Figure 3: Cycle of ship investment and market in Turkey

While the big fleet vessels owning companies are important, small shipping companies also very significant for especially liner sector. However, due to the over numbered of these ship owning companies, make the increase of risks of back payments while a possible financial crises. Therefore, a collaboration of these companies under one hand management may decrease the risks and become on a very standing position in the economy even to the shipping crises. On the last few months, a new regulation has been approved by the government that small shipping companies which have old vessels and sailing in continental will have an incentive for scrapping their vessels and finance them for new-building vessels from Turkish shipyards in order to renew vessels and improve quality of the Turkish fleet. However, on the big size of vessels' owners' side especially for bulkers and tankers, still there is a lack of financial resources due to a lack of a governmental support and incentive. Rectifying of this absence will be explained in conclusion section of this paper.

CONCLUSION

Shipping finance consequently continues to grow, and the world shipping industry has responded to demand for its services. But, shipping markets are cyclical and notoriously volatile, and today's unprecedented markets are unlikely to continue for ever. The role of private equity funds and government incentive ship finance institutions appears fundamental for the growth of the sector and could affect its development in several ways, including through the consolidation and vertical integration of transport services. This would call for improving the efficiency of the sector and building more financially sound companies. While the investment horizon in foreign ship finance companies and/or banks is typically between three and ten years. Within the evaluation of worldwide ship finance systems and current market condition in Turkey, it has been found that it is necessary to provide incentives as governmental to ship owners in Turkey in order to increase economic level by decreasing the import rates which caused by foreign flagged ship investments. If Turkish maritime industry has its own ship finance system either government supported or private corporations, maritime economy would be more certain and powerful with national investors. National based ship finance might also increase Turkish flagged vessels in world merchant fleet and assist Turkey being a "*Reproducer*" country within world maritime activities. By the aim of this research, best model for Turkish economy is indicated as Danish system which is more useful by supportable positions of government via controlling the financial status. Also, a "*One-hand management*" policy can be developed and supported as specific to ship types, segments and their tonnages by gathering all small ship-owning companies under one management. Ship financing in Turkey must be evolved in order to adapt the current market conditions in worldwide. A new structure of mortgaging the ships can be constructed according to ship types and market statuses against possible bankruptcies of the companies. Further follow-up mechanism with special financial analyses must be also prepared to decrease high risks of volatile market and to prevent ship owners' failure due to lack of knowledge. Competition within ten years' period will increase rapidly as it has already commenced by the end of 2014. Turkish ship owners' perception must be changed to more informative and technological solutions either with maritime authority in Turkey as incentive.

For further studies it is recommended that total merchant fleet capacities can be an indicator in order to predict the economic level of country and therefore, must be considered for development of the national economy. As the shipping market is not smooth and becoming more fast-paced day by day, this study unfolds a new way to seriously consider the necessity of taking an action for ship and maritime trade investments in Turkish maritime sector in order to be successful in world shipping. As much as a country's own maritime investment capacity increases, the risks of economic collapse can decrease either in global. Due to the fact that the volatility always existing in maritime sector not as smooth, it is time to become more skilful on to ship finance in order to improve Turkish economy.

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EKO(L)LOGISTICS: A CASE STUDY OF BEING BOTH GREEN AND COMPETITIVE

Ayşegül Karataş[9], *Esra Dil*[10]

Abstract *– Environmental concerns have increasingly taken place in the strategy development process of logistics service providers as a dimension. Taking its roots from the developed countries, "green logistics" began to be applied by the international companies located in developing countries. Being one of those, Ekol Logistics tries to be not only competitive in terms of service quality and costs but also sustainable and environment friendly. Furthermore, it seems quite successful in balancing them. The environmental enforcements resulting from operating intensely in European Union and serving mainly to powerful automotive firms seem to be perceived by Ekol as incentives to be more sustainable and competitive. By the help of intermodal transport, Ekol reaches Europe by sea without being exposed to the problems of transit documents. In addition, it saves greenhouse gas emission by reducing kilometers in land. Such environmental implications made Ekol the owner of the Eco-performance Award in 2012 and the owner of "Sustainable Logistics Company" title which is verified by the Bureau Varitas and UTİKAD. As a result Ekol's strategies are worth examining closely.*

Keywords *– Green logistics, Sustainability, Intermodal Transport, Environment*

INTRODUCTION

According to Rodrigue et. al. (2001:7) "It is not a question whether or not the logistics industry will have to present a greener face. Pressures are mounting from a number of directions that are moving all actors and sectors in the economy in the direction of increasing regard of environment. The issue is when and in what form it will be realized." After decades from these sentences were mentioned, we see that logistics service providers are focusing in this issue closely. The basic motivation of these companies may be the regulations, the customer pressure, social responsibility or institutional legitimacy or combination of these. But it is obvious that although green operations seems to be more costly relative to those of non-green, logistics service providers try hard in order to find out either cost reductive green implications or at least competitive as the others in terms of costs. Because the sector is highly price sensitive.

Ekol Logistics is one of the green logistics service providers having the slogan of "*Logistics for a better world".* Both growing consistently with acceptable profitability and carrying off environmental awards, show that it found out a way of realizing its slogan. In this respect, Ekol's way of doing business is worth analyzing.

LITERATURE REVIEW

The literature has increasingly focusing on the ability of firms to ease the environmental problems by making resources less wasteful thus more sustainable, while retaining the basic system of capitalist production and consumption (Lai and Won, 2012:278). In this respect, logistics industry has been closely evaluated by the researchers. Because transportation causes pollution, noise and congestion. Thus, an efficient use of transport resources which aimed at the selection of vehicle types, the scheduling of deliveries, consolidation of freight flows and selection of type of fuel can help to mitigate these problems (Ubeda et. al. 2011:44).

As a concept, green logistics is concerned with producing and distributing goods in a sustainable way taking account of environmental and social factors. Green logistics activities include measuring the environmental

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impact of different distribution strategies, reducing the energy usage in logistics activities, reducing waste and managing its treatment (Sbihi and Eglese, 2007:99).

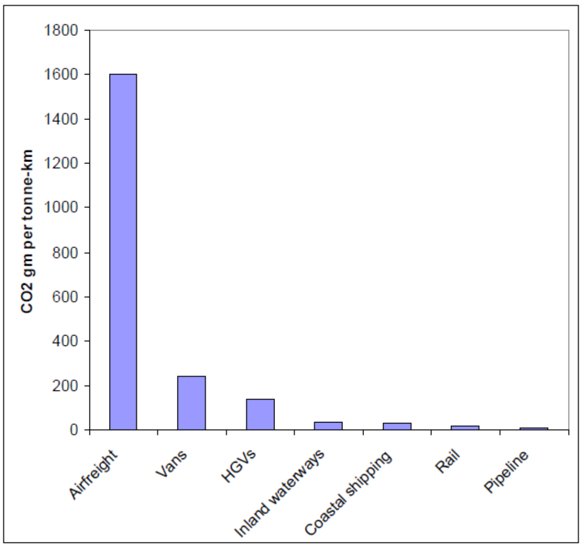
Rodrigue et. al. (2001:9) says that there are three forms which make green logistics possible. First, the environmental improvements may come from the industry itself which is called “bottom-up approach”. Secondly, greenness may be imposed on the logistics industry by government policies which is called “top-down approach.” And lastly, the combination of these is possible. It is possible to see that all these approaches take place in the world, depending on the government policies and the development level of the country. Rodrigue argues that globalization and global logistics has in many instances harmed environment by encouraging governments to compete on international market by lowering environmental standards in certain countries while maintaining higher standards in rich countries. In the case of Ekol, located in a developing country but serving to multinational companies and operating in both European Union (EU) and Turkey, the situation is a bit complicated. Because there is merely no environmental regulations in Turkey but EU impose very restrictive environmental standards. Namely, in the White Paper (2011:6) , EU declares that by 2050, emission will be reduced 60% while the transport grows. All the standards are precisely determined, ready to be implemented. So that, not only the European companies but also those operating in EU, will come under intense pressure to cut their greenhouse gas emissions in an effort to achieve very ambitious carbon reduction targets at national, EU and global levels, over the next few decades (Mckinnon, 2010:1).

In the case of Turkey, it is also possible to see green logistics implications. Why do the companies conduct environmental implications although they don’t have to? Because the environmental conscious companies either reduce costs or gain intangible benefits such as image and reputation enhancement (Rodrigue et.al, 2001:10). In addition, the customer pressure is also seems to be an antecedent of green logistics. A research applied on Chinese manufacturing exporters showed that the customer pressure for environmental protection encountered by a Chinese manufacturing exporter is positively related to its implementation of green logistics management (Lai and Wong, 2012:275).

Whether it comes from bottom to top like in the case of Turkey or top to down in the case of EU, the green logistics implications are alike. These can be categorized as below:

- Shifting freight from modes with relatively high carbon intensities such as air and road, to those with much lower carbon emissions such as rail and water-borne services can substantially decarbonizes freight transport operation (McKinnon, 2010:3)

Graph 1: Emissions from Freight Transport



Source: McKinnon, A. (2007). CO2 Emissions From Freight Transport: An Analysis Of Uk Data. In Logistics Research Network-2007 Conference Global Supply Chains: Developing Skills, Capabilities and Networks.

- Improvements in the operation, loading and maintenance of freight vehicles will reduce automatically the total kilometers needed to deliver a given quantity of load. Consequently the reduction in total kilometers will provide environmental benefits due to the reduction in fuel consumed and consequent pollutants (Sbihi and Eglese, 2007:111). The vehicle routing and scheduling concerns the determination of routes and schedules for a fleet of vehicles to satisfy the demands of a set of customers (Sbihi and Eglese, 2007:110).
- Waste management: waste avoidance, reuse and recycling (Rodrigue et.al, 2001:9).

METHODOLOGY

In this study, data were collected from both the primary and the secondary resources. The news about Ekol Logistics' activities, its web site and logistics reports are some of the secondary resources included to the research. Apart from these, three interviews, which took about thirty minutes each, are conducted with the director of research and development department of, director of intermodal transportation and the expert of RORO transportation in 03.02.2015. Content analysis is applied to the data collected.

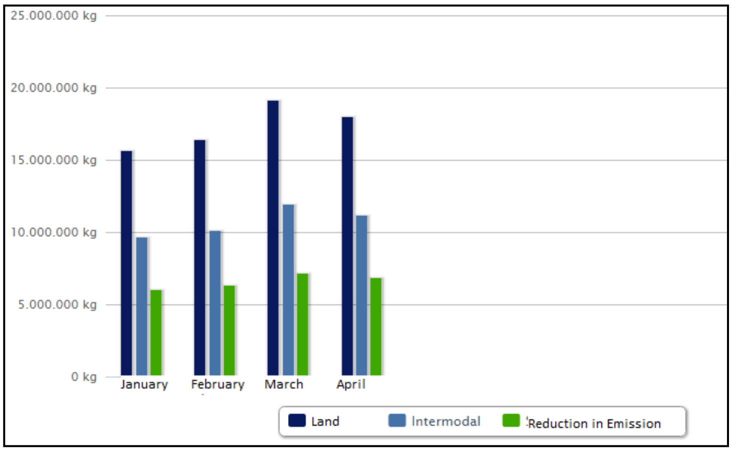
FINDINGS

<u>Company Profile:</u>

- The company was founded in 1990 by Ahmet Musul (Ekol, 2007-2014).
- Current partnership structure is 62% Ahmet Musul and 38% AD Invest (Özsalih, E. 2015).
- 2012 revenue is, 284,4 million EU; 2013 revenue is 367,2 million EUR; 2014 revenue is 403,7 million EUR (Ekol, 2015b).
- 3940 employess in Turkey and approximately 1400 employees in nine European countries (Ekol, 2015a).
- 400.000 m^2 warehouse in Turkey and 100.000 m^2 warehouse in Europe (Ekol, 2015d).
- Fleet: 5 RORO, 740 tow trucks and 2900 trailers.
- Customer Range according to the revenue: 38% automotive, 14% manufacturing, 13% service, 12% textile, 24% other sectors (Ekol, 2015b).

<u>Green Lojistics Activities:</u>

1. <u>Intermodal Transportation:</u> Ekol started RORO trips between Haydarpaşa and Trieste ports with its modern vessels called Hatche, Paqize, Qezban and Fadiq, three days a week with 60 hours trip time (Ekol, 2015c). Trailers arriving in Trieste by Ro-Ro are carried to Germany and Czech Republic by a block train dedicated to Ekol. In addition, another vessel called Ashe began to serve between Alsancak and Sete once a week with 48 hours trip time (Ekol, 2015c). When the intermodal transport from Haydarpaşa to Köln is taken into account, Ekol saves 823 lt fuel, 2221 kg CO_2, 5.8 kg NO_x, 0,08 kg particles by not using 2420 km of land route in only one trip (Özsalih, 13.03.2015). When we consider that a tree approximately absorbs 22 kg CO_2 in a year, it can be easily understood that the saved amount is huge. The savings of Co_2 emission of Ekol are reported on a monthly base on its website. The savings of 2015 are as follow:
   Graph 2: CO_2 Emission reduction amount in 2015



Intermodal transport is welcomed by the customers also. Because Turkey is not a European Union member and logistics, being a service, is out of the Customs Union scope. So the trucks need a transit document in the borders of European Union member states. However, free transit documents are both limited and their delivery depends on the decisions of the governments of each member state. The price of the paid transit documents also varies from country to country. Thereby, there is no standard (Şener, 15.08.2014). For example, in the end of 2013 a transit crisis occurred in the customs of Bulgaria. When the promised free transit documents were not delivered, Turkish trucks had to wait in borders for days (http://www.a24.com.tr/haber/bulgaristan-ile-sinir-krizi-23604071.html?h=19, 31.01.2014). On the other side, the paid ones are very expensive and decrease the competitiveness of both the shippers and the Turkish logistics providers. As a result, the new way of transporting goods to Europe, makes the customers feel more comfortable in terms of delivery time and cost. Because of the reliability and greenness, intermodal provided a competitive advantage to Ekol, causing an increase in the market share (Eşber, 2015).

2. Carbon Foot Print: Carbon foot print is defined as the amount CO_2 and other carbon compounds emitted into the atmosphere by the activities of a person, company, country, product etc. In 2013 Ekol managed to have ISO 14064-1 Carbon Footprint Verification (Özsalih, 2015). Ekol calculates not only its own carbon foot print but also each of its customers' although not legally required. By this way, it can measure and control its own emission. On the other hand, this application supports its customers' green activities. In this point, it will be useful to remind, approximately 40% of Ekol's sales come from automotive companies whose origins come from developed countries where environmental issues take place in laws. But these multinationals seem quite serious about environmental issues, trying to do more than required. As a result, they can use the reports prepared by Ekol in their own evaluations. By the way, Ekol prepares these documents by the help of the ERP based program, called Quadro. This program is continuously improved by the engineers working in R&G department.

Motor Quality: In Ekol's fleet all the trucks have EURO 5 motors since 2012. These motors cause less green house emissions than its alternatives except for EURO 6. In Turkey even in 2014, only the 53% of trucks have EURO 5. EU prepares to have EURO 6 obligatory in rural areas. So, although Turkey tags behind in terms of regulations, operating in EU, Ekol has to behave according to EU regulations. Supporting this, intermodal director of Ekol says that, "If you don't have Euro 5, there are areas where you cannot get in, such as Paris." (Eşber, 2015).

This issue becomes more complicated when we think that automotive companies which Ekol provides logistics service, are also its suppliers from which it buys its trucks. So that renewing its fleet, is somehow a great favor to its suppliers.

Having a R&D department: It is possible to reduce both the costs and emissions by reducing the traffic needed to move a given quantity of freight (McKinnon, 2010:4). R&D department works on this. The director of this department summarizes it like this: “More loaded vehicles and less vacant kilometers with effective planning” (Özsalih, 2015).

ISO 14001: It is a certified environmental management system. This standart is formed in order to minimize the environmental pollution. It doesn’t keen on what is produced, but how is produced. Ekol managed to have this certificate in 2009 with lilyum warehouse and enlarged in 2011.

Green Office : Ekol joined in the Green Office program of World Wildlife Foundation (WWF) in 2010 and had the diplo. This program includes waste management, savings in paper and electricity. WWF helps the companies to create their own environmental office management systems.

In Ekol, the waste is categorized and the appropriate waste is recycled such as paper, on the other hand the inappropriate waste such as medical waste is removed. But the amounts of all the categories are reported. So that Ekol can control these amounts. For example, in 2012 1.2 million tones package waste was sent to recycling. In 2013, 2.1 million tons of package is recycled. The remains of the cafeteria are sent to the animal shelter.

Ekol also reports its own energy consumption yearly for water, natural gas and electricity. With the improvement done in the electricity servers, 76% saving was realized. The employees also are educated not not use energy needlessly.

With all of these implications, Ekol R&D department director says that “we did merely nothing except for paper works in order to take Green Office Diploma.” (Özsalih, 2015).

Environmental Social Reponsibility: Ekol uses the fon earned from the waste recycling in order to plant trees. İzmir Urla Memorial Forest (2012), Manisa Salihli Memorial Forest (2013) and İzmir Urla Kadıovacık Memorial Forest are examples.

IN LIEU OF CONCLUSION

Ekol seems to find a better way of doing business for both environment and profits. But the question is “Is it possible for the other companies to find a way like Ekol?

Maybe the intermodal transportation is the most creative and most affective environmental implication of Ekol. But what was Ekol’s basic motivation in this improvement? If there hadn’t been any problem in the borders of Europe, would Ekol still have invested in ROROs?

In addition to these, we see that something seems very irrevelant like transit documents or Customs Union, may lead to the environmental implications. There can be any other examples of this situation?

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DOES IT HAVE TO COSTS SAILING GREEN?A STRATEGIC MANAGEMENT ANALYSIS ON A MERCHANT SHIP

Şaban Emre Kartal, Yasin Arslanoğlu

Abstract- Even shipping is known as the cleanest mode of transportation, shipping activities worldwide became important source of pollution. According to 2007 figures, only the sailing merchant ships around the World emitted CO2 as much as Germany did. Recently, growing awareness for environmental protection brings the concept of green logistics management for maritime firms and has emerged as an important strategy to reduce pollution. Most of the environmental protection regulations and related equipment's, brings extra expenses to firms almost in all sectors. In this paper, some of the mandatory and optional Green Shipping Activities (GSA) and regulations for shipping firms are classified. It is tried to answer one very frequently asked question of, does all greening applications have to bring extra commercial pressure on commercial firms? Do these GSA may cause strategic advantages or benefits for maritime firms?

Especially volunteer GSA are tried to identify by using SWOT table, and assessed between each other by help of one very basic decision support method; AHP, providing and benefits for an imaginary ship. Some most important GSA are selected from literature and assessed by using expert decisions.

Keywords - Shipping companies, Strategic Management, Green shipping, SWOT, AHP

INTRODUCTION

Shipping activities pollute the World in many aspects. Differing form range of a small fishing boat to giant cargo carriers of modern world, marine transportation vessels are considered as a source of pollution for environment [1] [2]. Unlike the sailing ships of history using wind as power source, or the ships propelled by rows using man power, fuel using ship engines cause pollution in different ways. Exhaust gases are given out from main engines and also auxiliary ones like electric generators. From the first power driven ships using coal as fuel to today's LNG consuming ships, main engines always produce greenhouse gases like Co2, NOx or other in different amounts and in different ratios [3] [1]. Exhaust gases are not the only polluter originated from ships. Modern engines also consume lubricating oils which generally mix with bilge water of ships. Also residues of fossil based fuels called as sludge is also a very common polluter for marine environment. Even ballast water carried on board the cargo vessels for balancing the empty ships may be listed as an important source of pollution, causing micro-organisms in various types, sea plants and also fish to be carried to different locations of the planet via, and be a treat to the marine ecosystem [4]. Regarding the pros&con, there is a vast literature for the relation between the environment protection and the marine transportation.

Maritime transportation is not the solely industrial activity polluting the globe, and in almost all of the greening activities of various sectors there is a cost. This cost may sometimes be larger than to undertake, in some cases greening activities may increase the reputation and the brand value of the firm and so on. There may also be some other initiatives and privileges for greening activities in order to push commercial firms for these kinds of activities as well as maritime sector [5].

In shipping industry these kinds of rules and the regulations are generally directed to firms by IMO in a mandatory way. Due to international, off-shore nature of commercial shipping organizations, international powerful agencies like IMO are strongly needed. It is always difficult to know the responsibilities and the legal obligations evolving a maritime commercial vessel which especially flies a flag of convenience, having a crew of various nations and being operated from a completely different (generally from a developed-Western country) land [6]. For example, considering a ship with flag of convenience like Panama, Liberia, Cyprus and also Malta, being operated and directed commercially from London, manned with Filipinos, Indians and Russians and so on [7]. As well, consider the same ship navigating between ports of call of World, visiting many different flag states with different rules. So, the international, mandatory set of rules and regulations like Safety of Life at Sea (SOLAS), Marine Pollution (MARPOL) and International Ship and Port Security (ISPS) gains importance in this much stakeholder, multinational structure. IMO declares new regulations and liabilities globally, in which the maritime nations force their companies and ships to follow. These set of rules and regulations are generally aiming to protect the global environment, accordance with new requirements, human needs and on-going trends like global warming, huge amount of garbage's to handle and air pollution [8]. Especially MARPOL aims to protect the marine ecosystem. As well as imposing some new set of rules and regulations, this convention may also require different devices like garbage incinerators for reducing the solid waste quantity on-board or ballast water management which handle and process the ballast water in order to neutralize and eliminate the transfer of microorganisms between World oceans [9]. However companies may also adopt some different equipment's that not only save the environment, but also contributes to company profitability which may be described as the main goal for a commercial firm [10]. Like adopting modern sail systems to ships in order to support ship propulsion for decreasing fuel consumption, or bunkering ships with less carbon emission resulting natural gas in form of liquid form-commonly known as LNG [11], [12] [13], [14]. These greening applications are not only limited with some new equipment's and modern devices, they may also contain some approaches and principles. For example, ships may sail under the navigating speed which they can reach. Process called as the slow steaming causes an important reduction in fuel consumption which founds place in existing literature with its affects [1], [3]. As seen above these kinds of applications are subject to free will and the profitability decisions of maritime companies, at least for the moment. So, being familiar with these systems and devices, the maritime decision makers must make their decisions, which will eventually play an important role on firm's commercial future because some of these devices will cost to its user as well.

This paper intent to give brief information about these volunteer GSA and asses their effects on their users. For this reason, some of the GSA's are identified briefly in the following chapter and after, using SWOT analysis, these Strengths or Weaknesses as the internal factors–and Opportunities and Threats as external outcomes occurring from them tried to be evaluated by asking maritime industry workers.

GREEN SHIPPING ACTIVITIES

Green shipping activities may be classified in to two different categories according to their level of applications. More clearly, the main international rule maker, which is directly constitutes a part in United Nation; the International Maritime Organization -IMO- generally set-up mandatory rules and regulations for ships. Almost all flag carrier vessels have to obey these rules under its flag administrations responsibilities against UN. However some these regulations are quite old and well-known like SOLAS (safety of life at sea), MARPOL (marine pollution) and ISPS (international ship and port security), IMO may set up new regulations and amendments in these rules according to needs. So, time to time, maritime firms may face new mandatory set of rules. Most of them are provided under MARPOL chapters, which are actually intended to protect the environment in different aspects. MARPOL brings strict regulations against pollution of seas from oil, garbage and exhaust gas pollution. Even ballast water which is carried through the oceans should be specially treated according to new regulations [15].

However in this paper, it is not focused on this kind of mandatory regulations which are directed from MARPOL and IMO which the ships have to obey. Instead, it is intended to see the approach of maritime experts, who are the last users of volunteer GSA. As the volunteer or the optional GSA's, like described above, the ones which companies does not have to purchase, set-up and use for the time being. Aim of this approach is to calculate, if there were a conflict or concurrency between GSA and the benefits of maritime firms. Greening applications in almost all sectors, generally brings extra expenses, however by increasing demand for a green environment may change this attitude for the goodness of the world environment indeed. New carbon taxes and awarding mechanisms for environmental friendly services are on the agenda of policy makers [16]. The applications here used as material like modern sails, online communication services, slow steaming and LNG utilization are completely on the long term strategic decision plan of a maritime company for the moment, which means, company will decide if it will be profitable and better for his own. Off course, IMO or other policy makers may bring these kinds of applications as mandatory but for the moment they are optional, or known as so.

1. Using Modern Sail Systems.

Ships have been sailing at World Oceans for ages and the wind was one of most important propulsion force for human being for a long time. Even the most important trade routes were shaped according to winds of oceans. Even today, people are using wind powered yachts and small leisure crafts, mostly without commercial reasons. But today the people are again trying to use this green power for their commercial needs with modern sail systems on board of merchant vessels. Old sailing ships inspire the modern ship designers and the latest technology leads for the new design of application of different sail systems. SkySail is the most popular one in market. Several papers are issued about utilization of modern sail systems [11], [12], [17]. Having their own operating, auto-control mechanisms, with their unique design; they may costs much for their owners.

Figure1. Ship with Modern Sailing Systems

2. Using LNG as Fuel.

Liquefied natural gas (LNG) is now being area of usage in almost all industrial activities. Bunkering the commercial ships with LNG is now a new trend in shipping industry [18]. There are several factors that push firms to change their fuel to LNG but the most important one is of course the price of material [19]. Off course, burning LNG as the main fuel in main engines for ships is a new trend, so the most of the merchant ships are not ready for this. There has to be made some important changes in engines and bunker systems for the volunteer ships, which means cost. Environmental protection policies like exhaust gas emission reduction regulations may play a major role in this transition.

3. Slow Steaming.

Going fast will be a reason of choice for ship charterers, but it will also increase the fuel consumption. As well, consuming less fuel also brings an important advantage for ship operators and charterers. There is an optimum speed described and declared for almost all ships that is the profitable for sea-going activities. But ships may sail above these speeds because of commercial pressure. Also, even this optimum fuel consumption in optimum speed may be reduced by slow steaming according to many papers and research, sailing under this speed will reduce consumption of fuel [1], [3].

4. Equipping Ships with Solar Panel.

Conventionally, ships use their own generators for their electric needs in ports and also in anchorages. These generators also conventionally use diesel oil as fuel, which causes GHG emissions and pollution as well. Any attempt for shutting down these units, with supplying the electrical needs of vessels may contribute to the environment. However, every vessel may not be appropriate and ready for solar panel installation due to flat space needs, or other technical requirements', investing in solar panels which will produce electric to support the ships can be listed as a GSA.

5. Cold Ironing.

As a new, unconventional application, process of shutting down the main engines and also electric generators of a ship, while the ship is berthing at ports is called as "Cold Ironing" in the literature [20]. As stated above, shutting down the generators will stop the emission of GHG from ships and eventually will contribute to environment. Not the all, but some of the modern port facilities around the World are ready for this application and providing electricity for berthed ships as a port service, off course against a charge, cost. Also the existing, old ships have to invest to prepare their systems for cold ironing.

6. Using Electronic Communication Systems Instead of Paper.

Online communication systems onboard avoid utilization of paper and save an important amount of paper in ships. Also usage of ink and cartridges for printing out plenty paper may be counted as an important contribution to environment. Moreover, the transportation of these printed International Safety System (ISM) documents to operating companies also means consumption of fuel and money as well. These kinds of online systems will avoid all this kind of spending's, but also may bring an expense of satellite internet connection for the ships, which is normally more expensive from the normal land based connection prices.

GSA	***In literature***	***Effects***
Modern Sail Systems	11, 12, 17	Less fuel consumption
LNG as fuel	13, 14, 18, 19	Less Co2 emissions
Slow Steaming	1, 3	Less fuel consumption
Solar Panels on board	-	Less fuel consumption
Cold Ironing	20	No fuel consumption in ports
Online Communication Systems	-	Reducing usage of paper

Table1.Summary Table for Volunteer GSA

METHODOLOGY

SWOT Analyses

SWOT analysis has an important area of usage in the literature. Analyzing the environment of firms within a constantly changing environment is vital [21]. The abbreviation SWOT standing for Strengths, Weaknesses, Opportunities and Threats provides an image of the internal and the external condition for a firm [21], [22]. Describing the internal and external environment, the method is widely preferred technic in analysis of commercial firms [23]. Even there are some contra opinions and concerns about the usage of the tool, it has found a wide area of utilization until now [24]. Also with its simple usage method and easy of application, the technic is capable of being used as hybrid, together with other methods [22], [25].

In this research, the GSA criterions are tried to be listed as a SWOT table. The internal factors like Strengthens and weaknesses and also external one like Opportunities and Threats arising from the nature that is far beyond, or on which the company has little affect are illustrated. Obtaining criterions, expert opinions are used as an important source of information. Merchant marine students, at the last semester of their education, having oceangoing watch-keeping officer license holders or the candidates, which all have been worked on board of merchant vessels for 12 months as a part of their education has been chosen as experts in this study. It was an opportunity to find a number of this high level students at same place for consideration and also their opinions. Off course the literature was examined and several web sites were searched for obtaining criterions.

AHP

Analytic hierarchy process (AHP) is a well-known, multi criteria decision-making method, which is widely used in scientific literature for many different problems [26]. First, Saaty has described this process method for solving a decision making problem, based on numerical comparisons between criteria's [27]. Pairwise comparison of criteria's are required by decision makers, which calculates the relative priority weights of each factor within the SWOT table [28].

Combining the both methods of SWOT and AHP, here in this paper it can be said to use a hybrid method.

As a reciprocal matrix of weights, information gathered from pair-wise comparisons are shown as the criterion aij.

$$\mathbf{A= (aij)} = \begin{matrix} w1/w1 & w1/w2 & \ldots\ldots\ldots & w1/wn \\ w2/w1 & w2/w2 & \ldots\ldots\ldots & \\ \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots & \\ wn/w1 & wn/w2 & \ldots\ldots\ldots & wn/wn \end{matrix}$$

After consistencies of calculations must be calculated and tested using the formula,

CI = (lambda max – n) / (n-1)

Then, the control of; CR = CI / RI; must be carried out, where CI is consistency index and RI is the random index (RI) obtained for a random matrix of n, and CR is the consistency ratio [27], [28]. The general rule is that CR ≤ 0.1 must be obtained for consistency [28].

Pairwise Comparison of Criteria's

Criteria's are compared to each other by asking experts from maritime sector, who has been identified in part 3.1. Also a questionnaire form has been prepared, both together using the expert decisions and from the literature, for obtaining criterions and the same experts used for the assessment of the criteria's as well.

STRENGTHS

- 1- Reducing the main running costs,
- 2- Increase the readiness level of a vessel, by reducing the need of supplies
- 3- Increase the comfort level in vessels, increase crew loyalty.

WEAKNESSES

- 1- Increase the first installation costs,
- 2- Increase the maintenance expenses,
- 3- May need extra crew for applications,

OPPORTUNITIES

- 1- Increase the customer demand,
- 2- Advantage against increasing fuel prices in long term,
- 3- Chance of tax reductions or privilege's for green shipping, like carbon stock market.

THREATS

- 1- Incompatibility of applications for ship,
- 2- Ongoing trend of decrease in fuel prices,
- 3- Increasing price of GSA's

Table2. SWOT Table for total GSA's applications on board.

S –(STRENGHTS) Priority of the group ; ***0,35***

		Total Priority of Factor
1	*Reducing the main running costs, ; **0,40***	***0,14***
2	*Increase the readiness level of a vessel, by reducing the need of supplies ; **0,40***	***0,14***
3	*Increase the comfort level in vessels, increase crew loyalty ; **0,20***	***0,07***

W-(WEAKNESSES) Priority of the group ; ***0,13***

		Total Priority of Factor
1	Increase the first installation costs, ; ***0,33***	***0,04***
2	Increase the maintenance expenses, ; ***0,33***	***0,04***
3	May need extra crew for applications ; ***0,33***	***0,04***

O- (OPPORTUNITY) Priority of the group ; ***0,38***

		Total Priority of Factor
1	Increase the customer demand, ; ***0,43***	***0,16***
2	Advantage against increasing fuel prices in long term, ; ***0,43***	***0,16***
3	Chance of tax reductions or privilege's for green shipping, ; ***0,14***	***0,05***

T- (THREATS) Priority of the group ; ***0,14***

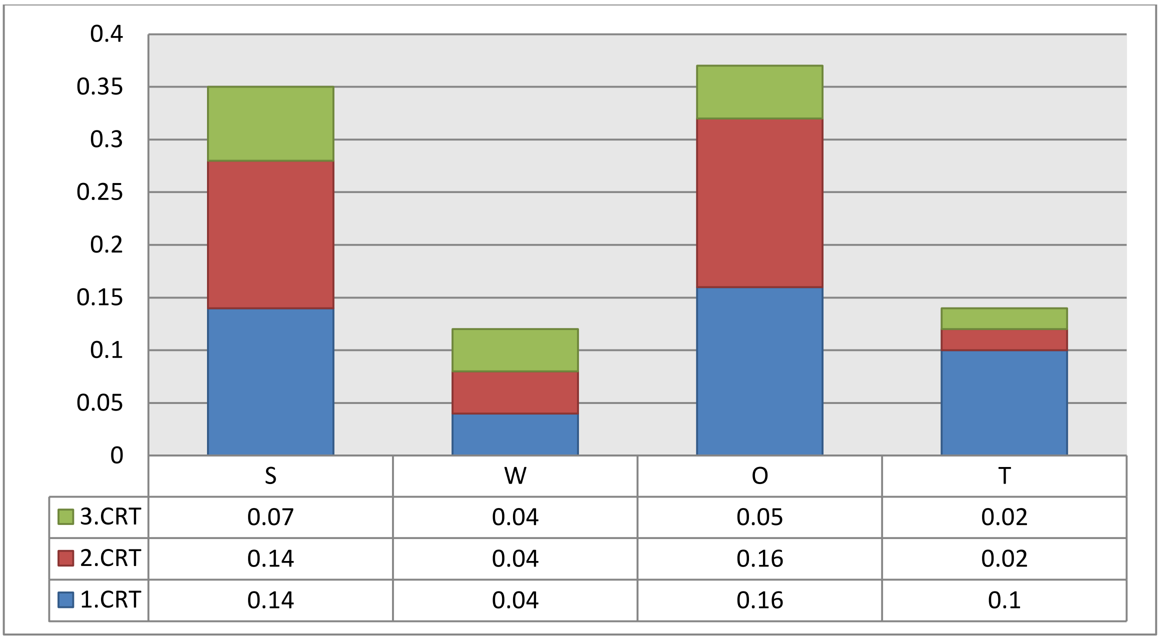
Factor		*Total Priority of*
1	Incompatibility of applications for ship, ; **0,71**	***0,1***
2	Ongoing trend of decrease in fuel prices, ; **0,14**	***0,02***
3	Increasing price of GSA's, ; **0,14**	***0,02***

Table3. Weights of Criterions, for per criteria and the sum for the group.

Comments & Conclusion.

A hybrid approach has been utilized together with SWOT Analysis and AHP approach, both which are preferred by many researchers. They have also been used together to give holistic results with different data. Methodology and both the methods have been described in previous section. In this paper we used expert decisions both for obtaining the criteria's in SWOT matrices and also for weighting the same criteria's according to expert decisions.

The results are clearly illustrated with the tables and graphs. Without making analyses and giving strategic decisions regarding the investment plans for a maritime firm, it is intended to show some important factors and their relative importance, also by grouping them in this paper.



Graph1. Weight distribution's for criteria's for each group.

- OPPURTUNITY Group has the biggest share among all with *0.38*, showing that the GSA will eventually result in benefits from external factors. As seen from the results , the, more customer (charterer for the ships) demand for the shipping companies and the advantage aganist increasing fuel prices having the same *0.43* share within the group, are the most important benefits.

- STRENGHTS , with *0.35* share also shows that shipping firms will be positively affected with these GSA, when compared to that negative groups of WEAKNESSESS and THREATS.
- Reducing the running costs and help keeping ships ready without supply, have the same important shares of *0.40* within the STRENGHTS.
- WEAKNESSES and the THREATS having share of *0.13* and *0.14* respectively. It is also good to see that negative factors having small shares. In these group of assesments, incompatibility of these kind of applications, especially like modern sail systems which may require external support and an important amount of investments seems to affect the decisions.
- It is also hope full to see low share of Increasing price of GSA's factor as a THREAT, which shows that there is a trend of being feasible for these applications.

Greening in almost all industrial activities is a rising trend and it should be considered very importantly due to increasing pressure of human beings on nature. Maritime logistic firms, in which there is big competition on market share, are also an important source of pollution on earth. Luckily, there is greening approach and also a legal pressure for firms in this sector. Volunteer applications are gathered from the literature and assessed by the maritime practitioners in order to see their degree of importance, so called weights with two famous methods, in a hybrid way.

Shares of factors and groups of them given in tables and graphics for the GSA's for the maritime firms. Considering commercial firms, it is always good to remember the main goal of making profit. But also the same GSA's may lead to better commercial results in this sector.

It is good to think that both commercial concerns and the environmental protection issues are not conflicting, but is it true always?

How much incentives and supports, or terrifying penalties are required in order to keep our World cleaner?

In this paper, it is tried to how that if GSA may also benefit for the maritime companies, and how they can manage this.

It may be a good area of study for future to check the rate of return for these kinds of investments.

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SELECTION OF EFFECTIVE GREEN SUPPLY CHAIN MANAGEMENT STRATEGIES IN ELECTRONICS INDUSTRY USING AHP APPROACH

Sevda Sargın[11], Gül Esin Delipınar[12]

Abstract – Companies' main aim is to maximize their profit in order to survive in the market. Fast production can quickly be converted to money. However, serious environmental problems may be created at the end of the production process, since the green supply chain management activities haven't usually taken into account by many firms. Green supply chain management has become more important and challenging topic in industries to keep the environment sustainable. It might increase the costs but it is a necessity in order to protect the environment when earning money at the same time. This paper identifies, by using AHP (Analytic hierarchy process) technique, the seven main criteria, green purchasing, green manufacturing, green distribution, green packaging, eco design, green environment and reverse logistics in green supply chain management of the companies in Turkey of electronics industry. According to this technique, main question will be the finding the best strategy, for the firms by considering mentioned criteria for green supply chain management. For this purpose, a model is generated from literature reviews and data is collected from structured questionnaires from managers in the electronic industry. After the inspection of the main criteria in the electronics industry, the results are presented.

Keywords- AHP, electronics industry, green supply chain management, sustainability

INTRODUCTION

Nowadays, there is a fierce competition between the companies. From the production view, producing the large sum of products is used to be the main goal of the firms in the past. The supply chain function is significant, however the firms must also consider the reflection of these activities to the environment. Supply chain management includes the activities such as procurement of raw materials, design of products, manufacturing of products, marketing of products in the end of the supply chain, connecting the product with the end-user. If these activities are not managed well, they can cause great threat to the ecosystem [2]. Today, by the laws and regulations, firms also consider the protecting the environment to provide sustainable world for the future. They started to introduce environmental programs in to the organizations all around the world. [10].The main goal is not limited to controlling the pollution for the environment. Protecting the environment taking the necessary precautions by considering green strategies is also an essential issue in supply chain management. In other words, green supply chain should take into account the environment with production, product design and delivery of the product to the end user. Green purchasing, green manufacturing, green distribution, green packaging, eco design and reverse logistics are important criteria for firms to gain competitive advantage in green supply chain management.

Some firms with newest developments outsource their supply chain operations, such as purchasing raw materials or components or components from suppliers to form supply chain network. If firms plan to form green programs, parallel to their own functions, they should also consider other partners in supply chain network as well. Supply chain managers; consider both traditional performance criteria and environmental criteria known as green supply chain management (GSCM). [9]

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This study’s main goal is to provide an insight for electronic industry in Turkey on how to choose the best strategy with the seven main criteria green purchasing, green manufacturing, green distribution, green packaging, eco design, green environment and reverse logistics in supply chain management. Many firms are aware of the green programs, but most of the environmental factors may not be considered or applied.

In order to decide the relationship and interaction between criteria and strategy alternatives in decision making model, this study uses *AHP (*Analytic hierarchy process) technique. AHP links all levels of the hierarchy. This makes it easy to measure how one criterion influences the other criteria and their alternatives. [12]. Then decision makers form pair wise comparison judgements in the hierarchy to decide priorities for the alternatives [12].

LITERATURE REVIEW

Green Purchasing

Green purchasing considers environmental issues, including canceling the waste, recycling and reusing, replacing materials without changing the content of product. It includes purchasing products and services that are less damaging to the environment. [12]. Firms evaluate the suppliers according to green competencies, green image and green management abilities. [1]. They form environmental standards in purchasing policies involved the suppliers selections, evaluations, relationship development to choose their supplier.[10]. Effective way to deal with environment issues is concentrating on waste prevention and controlling the source with green purchasing. Green purchasing, can decrease materials which damages the ecosystem, by substituting dangerous products for recycled or reused materials. [4]

Green Packaging

Packaging has several objectives: protecting and handling the product, informing the customers about the content of product and promoting the brand. [3]. Decreasing the amount of waste, recycling and reusing the packages are the main goals of the firms which are following the green supply chain management. Packaging of products is necessary for the sustainable environmental program. Suppliers can use biodegradable or returnable high density polyethylene pallets, moisture absorbing packaging. Apart from these environmental advantages, green packaging may be considered as adding extra costs, but it creates economic value, such as decreased disposal and liability costs. [4].

Green Manufacturing

Green manufacturing is producing the goods with techniques which save energy, and safe for environment. It also includes recycling, re-manufacturing [2]. The concept of green manufacturing includes re-manufacturing, use of environmental friendly materials, recycling, and pollution reduction. Key factors may be followed in production process, the amount of energy and resource utilization, green degree of energy, the amount of hazardous wastes and the reuse times of hazardous wastes [12]. The firms’ main aim will be how to increase the existing production process and decreasing the generation of toxic or harmful substances.

Green Distribution

Transportation modes are essential issue in green supply chain management. Green distribution channels, transportation modes, control systems, just in time production affects the both direct and reverse logistics channels. Gasoline type, frequency of transportation, distances to customers, packaging properties (weight, shape and material) influences the green distribution performance. [6] In green distribution, the main aim is to design a more efficient transportation system and minimize the amount of carbon emission in distribution. [8]

Eco Design

Eco-design (design for environment) refers to activities which reduces the negative environmental effects of goods throughout the life cycle. Green design is about risk management, product safety, pollution prevention, resource conservation, and waste management. It also includes energy savings, design for disassembly, reuse and recycling and innovation capabilities. [10]. Eco-design requires non-renewable materials, affects environment less, links consumers with environment. Eco-design also involves energy savings, reuse and recycling, design for disassembly, abstaining from toxic substances and increasing innovation capabilities [2].

Environmental Management

The core function of environmental management is to keep the beneficial natural resources and maintaining its efficiency and quality. It is a process in which environmental sources and its effect is governed. Environmental management includes raw materials, emission control, resource recovery and recycle of waste. [11]. It consists of policies, procedures and audit standards for regulating operations and it manages waste materials or emissions. [7]. Environmental management concentrate on decreased levels of 'environmental pollutants'. Environmental responsibility may be given to general managers; they can support environmental training to non-environmental workers. [14]

Reverse logistics

Reverse logistics consists of the activities reusing products and materials. Remanufacturing activities, reusable packaging, recycling of materials can be given as an example. In recycling, used products or materials are collected from production area. If needed, dismantling the materials of product, in this case product loses its original function. On the other hand, in reusing the materials of product, materials of the product are disassembled and it doesn't lose its original function. [6]. 'Activities of reverse logistics, include collection, combined inspection/selection/sorting, reprocessing/direct recovery, redistribution, and disposal'. [13]

GREEN SUPPLY CHAIN STRATEGIES

Risk based strategy

Firms, which decide to follow this strategy, expect its suppliers to obey environmental requirements. The aim of this strategy is to decrease the level of risk by passively accomplishing environmental programs.[1]. This strategy is followed when the firm keeps minimal internal environment sources or has just started to contemplate about supply chain greening program [5]. Industries which follow this strategy cannot originate competitive advantage and cannot gain economic benefits from this strategy. Additionally, environmental programs are not presented and expectation is that there won't be any innovation in the end. [11]

Efficiency- based strategy

This strategy is related to efficiency improvements in specific approaches. In addition to economic benefits, this strategy also concentrates on waste reduction and efficient resource use [1]. The efficiency based strategy links environmental performance to operational processes. It also needs high level of engagement among supply chain partners. This strategy is more elaborated than the risk- based strategy, but not sufficient in product design, material substitution, or innovation [5]. However, it can be advantageous since it minimizes the costs. Because it does not provide knowledge-intensive environmental management activities mentioned above (product design, material substitution or innovation, it is considered technically weak. [11].

Innovation based strategy

This strategy aims to train suppliers to educate suppliers to follow the newest environmental regulations. It follows newest trends of green supply chain management and invests company resources according to these trends [1]. It also helps industries to form their products from product life cycle view, and provide tough environmental rules and regulations to their suppliers and give the required training to adjust operational processes to follow newest environmental regulations. Companies which choose this strategy, should have professional environmental expertise, and should mix green activities, such as green design, sustainable procurement to make better processes. Firms should make more investments to resources and manage capabilities to green management. [11].

Closed-loop strategy

This strategy links environmental performance to the entire supply chain management. It requires both the suppliers and firm to collaborate and develop specialized knowledge and technology. [1].This strategy refers to its basic form as ‘reverse logistics’ and at end of loop includes reusing the materials such as re-manufacturing or recycling. Important examples are disposable cameras, reusing of printer cartridges. [5]. It is the most complicated type of green supply chain management strategy. Firms which choose this strategy need high levels of control on return of used products. It might be hard to keep track of products assigned products, because of too many channels. Based on these causes, firms, putting this strategy in effect, can also form economic, operational and environmental performance [11].

RESEARCH METHODOLOGY

In this study, from multi- criteria decision making methods, analytical hierarchical process (AHP) method is used in order to choose green supply chain management strategy selection.

AHP method is found by Thomas Saaty in 1965. After, in 1971 it is used by American army to calculate probability planning problems. It became prevalent between 1974- 1978 [16].

AHP uses both objective and subjective criteria, and compares, measures them. It analyzes and compares criteria or different alternatives with criterion in pairs. It uses scale of absolute numbers and changes individual decisions to ratio scale weights. The results can be compared and ranked in order for deciders to make a choice. [17]. because this method, both considers numerical and non-numerical, it is easy to use, flexible and applicable to complicated problems. [15]

This research data is collected from six firms and forty two logistics and supply chain managers working in electronics sector at Turkey. Survey questions are asked to experts in sector, and the results are evaluated by AHP method.

Four main strategies are chosen to be evaluated in electronics sector. Risk-Based (RB), Efficiency- Based (EF), Innovation Based (IB) and Closed Loop (CB). Four criteria are selected as follows: Green Purchasing (GP), Green Manufacturing (GM), Green Distribution (GD), Green Packaging (GPC) Eco- Design (ED) and reverse logistics (RL).

In figure 1, hierarchy model is given. According to the survey results, results are evaluated in pairs. While, comparison matrix is used, scale in figure 2 is also used.

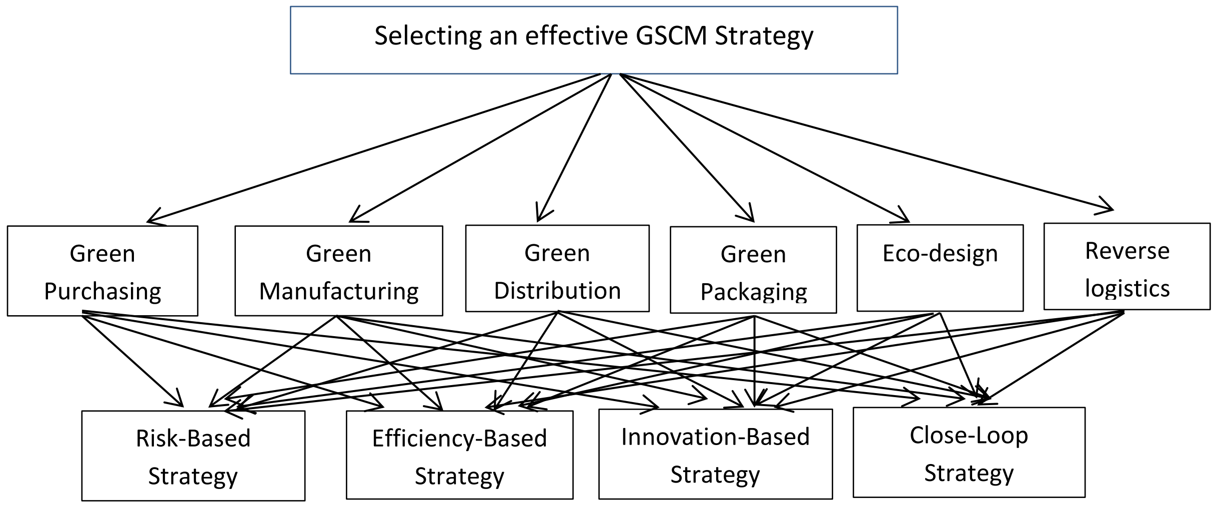

Figure: 1

This scale below gives the information about which criteria is more important than other. This scale gives the value of importance according to from least to most importance level.

Figure 2: Scale for the pair wise comparison (Saaty 2001)

Preference number		Linguistic term
1	:	Equally important
3	:	Weakly more important
5	:	Strongly more important
7	:	Very strong important
9	:	Absolutely more important
2, 4, 6, 8	:	Intermediate values

After the survey results are evaluated, in three steps, different criteria are reviewed between different alternatives. Comparisons in pairs are determined and following results are found at the end of this research.

Figure 3: Criteri a

Alternatives	Eco-Design	Green Purchasin g	Green Productio n	Green Environmenta l	Green Distributio n	Green Packagin g	Reverse Logistic s
Risk-based strategy	0,06	0,43	0,10	0,07	0,07	0,08	0,05
Efficiency-based strategy	0,12	0,19	0,17	0,15	0,14	0,14	0,10
Innovation-based strategy	0,26	0,19	0,27	0,29	0,25	0,24	0,21
Closed-loop strategy	0,56	0,19	0,46	0,49	0,54	0,54	0,63

CRITERIA	
Eco-Design	0,12
Green Purchasing	0,36

Green Production	0,12
Green Environment	0,23
Green Distribution	0,03
Green Packaging	0,10
Reverse Logistics	0,03

In the second step, criteria are reviewed between each other, weighted averages are given above.

At the end, according to each criterion, weighted average and criteria weight are multiplied and the results are found below.

Figure 4:

	Eco-Design	Green Purchasing	Green Production	Green Environmental	Green Distribution	Green Packaging	Reverse Logistics	
Risk-based strategy	0,01	0,16	0,01	0,02	0,002	0,01	0,002	0,20
Efficiency-based strategy	0,01	0,07	0,02	0,03	0,00	0,01	0,003	0,16
Innovation-based strategy	0,03	0,07	0,03	0,07	0,01	0,02	0,01	0,24
Closed-loop strategy	0,07	0,07	0,06	0,11	0,02	0,06	0,02	0,40
	0,12	0,36	0,12	0,23	0,03	0,10	0,034	1,00

MAJOR FINDINGS AND IMPLICATIONS

In this study, AHP method is used in order to guide the supply chain managers to decide supply chain strategies. All the alternatives and each criterion are discussed between each other.

Although there are many rules and regulations exist in electronics sector, not many firms actually apply the green logistics. Firms try to delegate their green responsibility to their suppliers. Survey is applied to 7 firms, which does not resist to innovation and change. Other firms which do not follow green logistics rules and regulations are not added to this study. Firms in this study are global firms which have export and import transactions.

This study is applied to the limited number of firms. Number of companies may be increased or the number of criteria can also be increased.

According to the results, close loop strategy applies to the electronics industry. This strategy is recommended to the firms. Because it is effective strategy, firms can also increase their profitability.

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EVALUATION OF THE LOGISTICS SECTOR IN TURKEY IN TERMS OF ENVIRONMENTAL INITIATIVES

Mübeyyen Tepe Küçükoğlu[13]*, Muhammed Parlak*[14]

Abstract – Environmental issues have a big importance in the logistics sector as well as in the other industrial sectors. There are lots of factors which motivate and also prevent initiatives in and the practices of logistics companies. The aim of this study is to evaluate the current applications of logistics companies in Turkey, to explore drivers and barriers that affect the environmental point of view of companies and future plans regarding environmental approaches. The research in this study is explorative and in order to analyze environmental initiatives the necessary empirical data has been obtained from a survey study among logistics companies which operates in Turkish market.

Keywords – Environmental initiatives, environmental management, green logistics applications, logistics sector analysis

INTRODUCTION

Because of the increasing environmental problems in today's business world, it is not possible to be oblivious to environmental issues. There is a strong awareness from different perspectives such as public authority, government, customers and also suppliers. Pressures from all these sides trigger companies to move to decrease the environmental effects that occur as a result of their operations.

In order to turn environmental problems into business opportunities, the logistics sector plays an important role in establishing and adopting green initiatives [1]. Green logistics initiatives can increase the competitive advantage of companies and help them to contribute to the sustainable development of the environment [2]. According to OECD reports the logistics sector is one of the significant sectors which contribute overall greenhouse gas (GHG) emissions in the world [3] and logistics related activities are the most important contributors [4]. Hence, the logistics area has a great potential for companies to mitigate their environmental impact [5]. Several ways for companies to green their transport and logistics activities including modal changes and intermodal solutions (e.g. efficient use of transport resources), advances in technology solutions (e.g. less fuel consuming vehicles), tools for assessing logistics' carbon footprint (e.g. selection of type of fuel), green transport management (e.g. accurate planning and scheduling, choosing the appropriate vehicle or route, consolidation of freight flows) and green logistics system design (e.g. designing logistics networks) [2-6]. Besides freight transportation, other logistics activities such as warehousing, packaging and reverse logistics focus on minimizing negative environmental impacts [3].

In order to achieve success in green logistics applications it is essential to extend traditional supply chain objectives including ecological objectives. Although this situation creates additional costs and limits the current way of business [4], it is essential for the sustainability of the earth. On the other hand, environmentally responsible practices tend to favor fewer shipments and vehicles, less handling, less packaging waste, shorter movements, more direct routes and better space utilization [5]. With these positive results, green practices also have advantages for cutting costs and increasing profitability in some cases.

This study aims to make an analysis about the Turkish logistics sector taking into account logistics companies' environmental positions. Applying a survey study among logistics companies which operate in Turkey, the main drivers and barriers for pro-environmental attitudes, current green initiatives and future green agenda of

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these companies are generated. This paper is formed from five main parts. After the introduction part, a literature review will be presented. This part is followed by an explanation of the main drivers and barriers of the environmental practices of logistics companies and also their green initiatives. Next, the methodology of this study will be explained. The last part includes the results of survey analysis.

LITERATURE REVIEW

Although, green logistics literature is quite new, there are some significant studies which highlight and focus on some important areas as analyzing different sectors from different countries. Isaksson and Huge-Brodin searched for the current position and development level of green logistics service providers and their green service offers. According to the case study implications, they found that green approaches and integration differ among companies [1]. Wu and Dunn proposed six types of logistics elements to identify certain activities in the supply chain that may interface with the natural environment. These elements include purchasing, inbound logistics, transformation, outbound logistics, marketing and after-sale services [5].

Isaksson mentioned a set of green transport and non-transport focused initiatives [7]. Kim and Han proposed three basic dimensions in order to measure environmental logistics practices as internal environmental management, environmental sourcing and packaging and environmental process design. They analyzed data collected from 129 Korean logistics companies and the results show that proposed model is well suited for measuring environmental logistics practices [3]. Wu and Dunn examined logistics issues with a pro-environmental focus [5].

Karagülle investigated Turkish logistics industry from green business perspective which consists of small and medium sized mostly multinational companies. These companies have an increasing awareness and an active role in environmental protection, waste management and energy efficiency; they review their environmental policies, follow international regulations about emissions and have ISO14001 Environmental Management System [2].

Lieb and Lieb conducted a survey with CEOs of large logistics service providers which are operating globally and classified green initiatives into four categories; administrative, analytical, transportation-related and other category [8]. Byrne et al. conducted an exploratory study by performing a face to face survey among seller and buyers of logistics services in Ireland, in order to analysis attitudes, knowledge and preparedness to implement sustainable logistics. According to the results, they found a varying degree of willingness among organizations to implement environmentally conscious activities [9].

Martinsen and Björklund purposed to develop and apply a tool for identification of matches and gaps between the environmental demands of customers and offers of logistics companies. They found that green demands are lower than offers of logistics service providers in some areas such as transport planning, logistics system design, modal choice and energy data collecting [10].

Lin and Ho conducted a survey on the green practice adoption of Chinese logistics companies to analyze influencing factors, which are composed of technological, organizational and environmental dimensions [11].

Ramanathan et al. focused on the usage of supply chain collaboration for achieving environmental sustainability and developed a conceptual framework to help companies in developing this collaboration. They stated that it is possible to achieve and maintain green supply chains successfully by sharing not only technical information but also green agendas, strategies and wider requirements among all supply chain partners [12].

Björklund and Forslund aimed to investigate the purposes of companies in having environmental performance management systems in logistics and they declared that the most common reason is internal management purposes [13].

DRIVERS AND BARRIERS OF GREEN LOGISTICS PRACTICES AND GREEN INITIATIVES

According to green logistics literature, there are many drivers for logistics service provider companies to make their activities more environmentally friendly. These drivers are split into internal and external factors within some resources. Internal factors are; influence of entrepreneur, company's strategy, environmental management strategies, awareness of top management and employee interest, cost efficiency, improvement of customer relationships and company image. External factors are pressures from outside the organization and include the influence of competitors, customer concern and market demand, government legislation and regulations, standards defined by associations of logistics organizations and influence of suppliers and experts [1-4-7, 14].

Lin and Ho declared that when organizational support, quality of human resources, regulatory pressure and governmental support influence environmental initiatives positively; environmental uncertainty and complexity of green practice effect negatively [11].

From a sustainability perspective, logistics companies face different pressures such as transportation cost pressure and customer side pressures. Customer side pressures include pushing from manufacturers and retailers which have their own environmental objectives [4]. Also governmental regulations are considered to be the dominant forces [14].

Company characteristics can also influence how logistics companies have addressed green initiatives. Company size, (in terms of both employees and turnover) is one of the most important company characteristic expected to influence the adoption of green initiatives [7, 14].

Economic factors (e.g. high costs, long payback period for investments, lack of economic incentives), human resource factors (e.g. lack of skilled staff) and also customers lack of interest present important barriers [1-4-7]. Customers or service purchasers demand logistics services providers care about the environment during core facilities, although they do not mind paying more for this task and evaluate logistics companies according to traditional criterions (e.g. price, quality, timely delivery) [9].

With green logistics activities, companies have the opportunity to achieve reduced operation costs, value creation for customers and long term contribution with limited resources when providing great potential for long time corporate environmental performance [2-3]. Both buyers and suppliers can see that there is value to be obtained through engagement in environmental practices [9].

There are two main domains to achieving environmental improvements; the macro perspective which includes actions taken by governments and legislative authorities and the micro perspective which includes actions taken by companies. In the micro perspective, there are two methods to reduce environmental impacts. These are introducing more energy efficient technology and organizing logistics in a different way [15].

Proposed green logistics service categories mostly consist of consolidating shipments, fuel alternatives, environmentally classified vehicles, a combination of transport modes, the design of logistics system, transport planning, choice of partners, an environmental management system, documented emissions and energy data, logistics innovation, green storage and packaging [7-10-11-14]. Freight consolidation improves vehicle efficiency and some transport modes are environmental friendly as they consume less energy. Good warehouse layout saves operational cost by cutting storage and retrieval movements. Also cross-docking application with careful planning and shared information between channel members improves efficiency and environmental performance by reducing both used warehouse space and movement within the warehouse [5].

Setting specific sustainability targets, establishing committees for overseeing environmental efforts, developing pilot programs directed at reducing environmental effects are some suggestions for green initiatives from administrative side of companies [8].

METHODOLOGY

The data for this study has been obtained from a survey distributed among logistics companies operating in Turkey. These logistics companies carry on logistics activities such as transport, warehousing, distribution, also value-added services such as packaging and labelling, supply chain management services like redesign or management of customers' supply chain. The survey was sent by e-mail to 250 companies and 46 respondents filled in the survey with an %18.5 response rate.

The survey derived from Isaksson et al.'s study [7] includes five sections; company profile, adoption of green initiatives, drivers of green logistics initiatives, barriers to green logistics initiatives, future plans of companies in adopting green logistics initiatives. The questions in the survey include a five-degree Likert scale, ranging from 1(totally disagree) to 5(totally agree).

The company profile section includes both optional and obligatory questions because companies hesitate to answer questions like company name, turnover etc. and may cease answering the survey because of some company-specific questions. This section includes company name, company age, turnover, turnover percentage of company's selected operations, number of employees, geographical scale of company operations, mostly used transportation type, product type of deliveries, information and communication technologies (ICT) used and ICT integration level with supply chain partners which are all necessary questions for a general picture of companies that present logistics sector.

The second section of the survey consists of the adoption of green initiatives and resources of companies. Items in this section are green practices and ICT tools concerning transport and logistics operations and also supply chain.

The third and fourth sections of survey have drivers and barriers on green logistics initiatives respectively. Regarding drivers; stakeholders groups, arguments that have changing effects for each company on logistics, supply chain practices and in ICT. For barriers; companies are asked about the internal and external elements which effect green supply chain adaptation.

The last section has questions that identify future plans of companies about transport and supply chain related green initiatives.

Basically, this study aims to display the main green initiatives, drivers and barriers of green initiatives and future green plans of logistics companies. Additionally, correlation and regression analysis are applied in order to find the relationship between green initiatives and the drivers/barriers. Green initiatives are independent variables and drivers and barriers are dependent variables for regression analysis.

RESULTS AND CONCLUSION

The questions in the first section of survey are used to map out the characteristics of the respondents because there is no specific research for logistics providers in Turkey. The survey shows that 13% of the respondents are entrepreneur or main shareholder or company owner, %4 CEO, %29 logistics/supply chain manager, %4 environmental sustainability manager and %50 employees of other positions. The annual turnover is spread among the intervals ranging from 2-10 M € to 50-100 M €. The respondent companies are active on a local to European market. The surveyed companies are active at different geographical scales. The answers on this topic show that %16 of the respondents were active on the local market, %35 on the national, %39 on the global, and only %13 on the European market. %38 of companies have more than 500 employees. The empirical findings point out that, %35 handle a fairly mix of industrial and consumer goods, %17 handle more than %50 industrial goods, %13 handle only industrial and only consumer goods and %22 handle more than %50 consumer goods (please see Figure 1 below).

The result shows that companies mostly use LAN, WLAN, GPS and barcode as information and communications technologies. %52 of companies have an environmental office or department for green initiatives and %65 of companies currently adopt green logistics management initiatives. At the same time, %91 of companies pay attention to environment issues as a part of overall business strategy. However, %52 of them has a formal and explicit strategy.

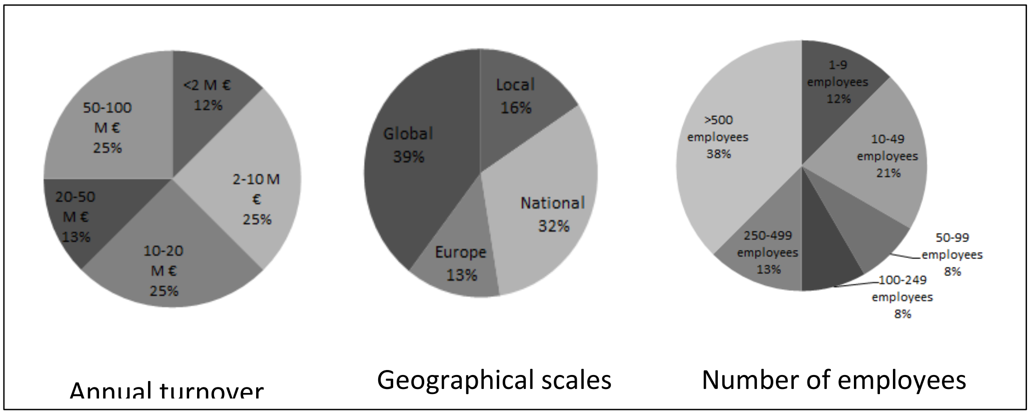

Figure 1. General Characteristics of Logistics Companies

The second section of survey includes usage of transport and supply chain related green initiatives of companies. Some of the initiatives have a higher mean value than the others. Both transport and supply chain related initiatives have mean value greater than 3,0. Regarding transport related initiatives, the most used practice is transport planning management which has 4,6 mean value and ranking of 1. Then come measures to reduce empty running and structural changes to company' logistics system with 4,3 and 4,2 respectively. All items are shown on Table 1.

Table 1. Green Initiatives

		Mean	Std. Dev.	Rank
Transport Related Green Initiatives	Alternative fuels for transports	3,6	1,29	8
	Modifications to vehicle specifications/design	3,8	1,26	6
	Ecodriving	3,6	1,48	8
	Recurrent environmental pilot project	3,3	1,29	9
	Switch to less energyintensive transports modes	4,0	1,12	5
	Greater use of intermodal transport	3,7	1,56	7
	Measures to improve vehicle loading	4,1	1,09	4
	Measures to reduce empty running	4,3	1,25	2
	Transport planning management	4,6	0,98	1
	Structural changes to your logistics system	4,2	1,07	3
	Renewable/green energy	3,3	1,53	9

Supply Chain Related Green Initiatives	Collecting information on energy use/carbon footprint	3,2	1,49	5
	Reduction in the amount of packaging	3,2	1,63	5
	Increase the amount of waste recycled	3,6	1,42	1
	Environmental certification (e.g. ISO 14001)	3,5	1,57	2
	Environmental Management System (EMS)	3,5	1,76	2
	Emission offset programmes	3,5	1,52	2
	Setting a corporate GHG emission reduction target	3,1	1,50	
	Cooperation with our suppliers/partners in order to reach environmental targets	3,3	1,47	4
	Cooperation with customers in order to reach environmental targets	3,4	1,48	3
	Environmental education/training/information for employees	3,0	1,52	6

%52 of the companies which answered our survey have an environmental office or department. That means half of them manage environmental issues via an official department which is responsible from environmental activities of company. Also %65 of companies has been currently adopted green logistics management initiatives.

Table 2. Drivers

		Mean	**Std. Dev.**	**Rank**
Shareholder	Competitors	3,9	1,24	3
	Customers	4,0	1,17	2
	Management	4,4	0,98	1
	Transport/Logistics Suppliers or partners	3,4	1,26	6
	Transport/Logistics Equipment Suppliers	3,5	1,15	5
	Government and public bodies	3,7	1,29	4
	Cost reductions for customers	4,0	1,21	2
Main Reasons	Cost reductions for suppliers/partners	4,0	1,05	5
	Cost reductions within my company	4,1	1,00	4
	Improve customer relationship	4,3	0,87	2
	Improve customer service	4,3	0,87	2
	Increase company's competiveness	4,3	0,87	2
	Increase company's revenue	4,3	0,92	2
	Increase ROI	4,4	0,93	1
	Increase market shares	4,4	0,83	1
	National and EU laws and regulations	4,3	0,92	2
	Economic means of control (e.g. taxes, subventions)	4,1	1,07	4
	Reduce company risk	4,2	0,94	3

According to Table 2, the drivers of green logistics initiatives are separated to 2 groups, shareholder groups and main reasons. The main effective shareholder group is found to be management. This is because company management or top management level and their support is always essential regarding green logistics initiatives as well as other important changes within the company. Main reasons items have higher values greater than 4,0 and these are all important drivers for companies. First two weighty drivers are found as increase of ROI and market shares.

Table 3. Barriers

		Mean	Std. Dev.	Rank
Internal Barriers	High investments costs	4	1,19	1
	Uncertain payback period	3,7	1,24	2
	Lack of financial resources	3,7	1,14	2
	Lack of org.human res. specifically devoted to manage such initiatives	3,3	1,42	3
	Lack of knowledge/skills inhouse	3,2	1,49	4
	Lack of ICT skills internal	2,9	1,40	6
	Lack of ICT skills external	3,0	1,35	5
	High ICT running costs	3,3	1,28	3
External Barriers	Limited access to technology that reduces environmental impact	3,5	1,33	5
	Lack of customer interest	3,2	1,39	7
	Lack of customer support	3,7	1,38	3
	Negative impact on customer supply chain	3,1	1,46	8
	Lack of transport/logistics suppliers’ or partners’ interest	3,4	1,32	6
	Lack of transport/logistics suppliers’ or partners’ support	3,6	1,22	4
	Lack of economic incentives	4,0	1,09	1
	Lack of clear regulations	3,8	1,26	2
	Lack of ICT vendors selling specific product supporting green log.	3,5	0,98	5
	Lack of standards (including ICT standards)	3,4	1,36	6

Barriers, which are shown on Table 3, have lower values than drivers. As internal barrier the most important one is high investment cost of green logistics initiatives and as external barrier lack of economic incentives is ranked as 1. Because of technology based structure of mostly green logistics initiatives, investment cost is quite big barrier for the companies which express a willingness to do something.

Table 4. Planned Green Initiatives

		Mean	Std. Dev.	Rank
Transport Related	Alternative fuels for transports	3,9	1,19	6
	Modifications to vehicle specifications/design	4,0	1,25	5
	Ecodriving	4,0	1,17	5
	Recurrent environmental pilot project	4,0	1,33	5
	Switch to less energy intensive transports modes	4,4	0,93	2
	Greater use of intermodal transport	4,2	1,15	4
	Measures to improve vehicle loading	4,3	1,21	3
	Measures to reduce empty running	4,5	0,98	1
	Transport planning management	4,5	0,98	1
	Renewable/green energy	4,2	1,02	4
Supply Chain Related	Collecting information on energy use/carbon footprint	3,9	1,09	5
	Reduction in the amount of packaging	3,8	1,36	6
	Increase the amount of waste recycled	3,9	1,33	5
	Environmental certification (e.g. ISO 14001)	4,0	1,09	4
	Environmental Management System (EMS)	4,1	1,03	3
	Emission offset programmes	4,2	0,97	2
	Setting a corporate GHG emission reduction target	3,6	1,14	7
	Cooperation with your suppliers/partners in order to reach environmental targets	4,3	1,12	1
	Cooperation with customers in order to reach environmental targets	4,3	1,09	1
	Environmental education/training/information for employees	4,1	1,23	3
	Environmental education for your customers and/or suppliers/partners	3,6	1,49	7

We also asked about the future plans of companies regarding their green logistics initiatives. As current green initiatives, some practices for the future are selected as well which are transport planning management and measures to reduce empty running. Companies are also planning to switch to less energy intensive transport modes. When we looked into supply chain related initiatives, cooperation has a great importance. First ranking is shared between cooperation with suppliers/partners and customers in order to reach environmental targets.

According to correlation analysis between green initiatives and drivers; there is positive correlation between transport related green initiatives (GIT) and some of the stakeholder groups. The biggest correlation is between transport/logistics suppliers and partners and GIT (0,611), then government and public bodies and GIT (0,601). The lowest significant correlation value is found 0,423. Regarding supply chain related green initiatives (GISC) and these stakeholder groups; there is a positive correlation between transport/logistics suppliers and partners and GISC (0,713) which is the biggest correlation value among other groups. The lowest significant correlation value is 0, 334. On the other hand, between owners/shareholders and GIT or GISC there is no significant correlation. For barriers, there is no significant correlation value is found.

We applied a regression analysis in order to find out the influence of drivers and barriers on green logistics initiatives. Looking into correlation analysis results, we applied a regression analysis between highly correlated groups. Transport/logistics suppliers and partners explains %37, 4 of GIT and % 50,9 of GISC and government and public bodies explains % 36,1 of GIT.

In this study, we analyzed the environmental initiatives of green logistics in the logistics sector in Turkey. Because of that, we also investigated drivers and barriers for adopting green logistics. We also inquired into green initiatives and planned initiatives of companies of logistics providers. The survey findings indicate that the transport planning management and measures to reduce empty running which is considered for green initiatives for now continue their importance in the future for the companies.

Because of the economic situation, high investment cost of green logistics initiatives which are an internal and lack of economic incentives which is an external are both having high values as barriers. However, the increase of ROI and market sharing are most important drivers for green initiatives of logistics companies.

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CLOSED LOOP SUPPLY CHAIN OPTIMIZATION WITH INTERNET OF THINGS

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Abstract – Closed loop supply chain (CLSC) optimization is known as structures resulting from the integration of forward and reverse logistics activities which the production and distribution process is carried. The importance of the closed loop supply chain management is increasing by legal regulations, limited energy resources and environmental- financial problems that growing in recent years. However, reverse logistics part of the CLSC is a flow type which is more difficult to make predictions, planning and controls by reason contained uncertainties. This stage, Internet of things system reduces related uncertainties by providing all the life information of the returned product and substantially attenuates the planning of reverse flow activities. In this study, a CLSC is considered that meets demands of the sales&collection center both new and the remanufactured product. Manufacturer has three options (refurbishing, disassembly and disposal) to assessing returned products. A mixed integer linear programming model is proposed for a single type of product is completely modular (automobile, computer, telephone, etc.). The model meets customer's products and components demands based period, maximizes profit consist of different sales revenues and total cost (total production, purchase, transportation and disposal costs) and determines how to evaluate all returned products. The proposed model has been verified with the aid of a numerical example by solving in GAMS software and its performance reviewed with test problems.

Keywords – Closed loop supply chain optimization, Internet of things, Mixed integer linear programming, Returned product management.

INTRODUCTION

Supply chain is a system covering the product life cycle processes of product or service and comprising the entire of passed operations until it reaches to hand of end-customer from raw material, information flow, physical distribution and shopping. Long years, the structures that supply chain management interested and whose flow direction is from raw materials to final users is called forward supply chain (FSC) [1]. However, increasing the flow of returned products to manufacturer made an effective product recovery network design necessary due to government regulations and customers' environmental awareness. This product recovery network must be provided with an integration of forward and reverse flow network known as closed-loop supply chain (CSLC) [2].

Manufacturer in CLSC performs both manufacturing and remanufacturing activities using new parts purchased from external suppliers and parts recovered from returned products. But application rates of different product recovery options such as reuse, refurbishing, remanufacturing, recycling and disposal change constantly due to the amount, quality and time of the returned product is quite uncertain. The uncertainties in the reverse flow make planning of entire chain difficult affecting the forward flow. Since the life cycle information of a product is unknown, inspection and testing become necessary to determine the conditions of returned products and their components. When a component turns out to be nonfunctional after testing, the time and effort made in disassembling and testing that component are wasted [3]. It can also be quite expensive to test all returned products and their components. Internet of Things (IoT) makes returned product management easier reducing or almost eliminating uncertainty in reverse flow.

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IoT is a common worldwide network which in a unique way addressable things / objects created by themselves and the objects in the network are in contact each other with a specific protocol [4]. Use of the IoT has been proposed for various segments of supply chains including reverse logistic. By means of this network, all objects can be monitored and tracked. Radio-frequency identification (RFID) is considered to be the core component and the enabler of such a structure. Although passive RFID tags are sufficient for tracking purposes, active RFID tags with embedded sensors can provide a lot more information about the usage/condition of every single object [5]. Sensor detects the changes in the value of various measures such as temperature, pressure, vibration and humidity and converts the signal to be recorded. RFID tag containing static information such as serial number, model, bill of materials, production date, delivery date of the product is connected to the product and can be updated after the operations such as each maintenance, improvement. Dynamic information such as environmental conditions occurring during use of the product, working time and frequency of the product is recorded with the help of sensors.

The purpose of the study, apply IoT system to deal with uncertainty in CLSC and thanks to the information provided by this system both eliminate costly preliminary inspection and disassembly operations and evaluate and use effectively all returned products. Following the introduction, a literature survey on the issue are included in second section. The considered problem is defined and developed model is explained in third section. Then related model is tested with a numerical example in GAMS package program and obtained results are interpreted. The performance of proposed model is tested with experimental designs in fourth section. And study is terminated with last section namely conclusion.

LITERATURE REVIEW

This section, a literature review related to RSC and CLSC network design problems are presented, then IoT system approach in CLSC problem is given.

Literature Review for the Reverse/Closed Loop Supply Chain Problems

RSC and CLSC which emerged into increasing public awareness. It is provided manufacturer draw attention to their end of life products by legislation. Then the popularization of recycling showed a significant increase in academic studies related to both RSC and CLSC network design and cost minimization approach of manufacturers has been replaced to revenue opportunity approach.

Some of the first comprehensive studies in reverse and CLSC networks were presented by Fleischmann et al. [6], who view reverse and CLSC network planning in three main areas, namely, distribution planning, inventory control, and production planning. In a later study, Fleischmann et al. [7], considered the integration of forward and reverse chains using case studies on photocopier remanufacturing and paper recycling. Their results showed that there is a potential for cost savings if one takes an integrated view rather than a sequential design of forward and reverse distribution networks. Krikke et al. [8], provided an integrated approach using a MILP model for draw attention to a variety of product designs and CLSC. Guide et al. [9], emphasized CLSC for product recovery. Beamon and Fernandes [10] evaluated the decision to open the storage and collection centers by developing a multi-term closed-loop supply chain produced both zero and remanufactured products. Sheu et al. [11], presented a multi-purpose optimization model to maximize the net profit based on both forward and reverse supply chain and showed that the model provides 21% increase net profit of network with numerical examples. Min et al. [12], proposed a mixed-integer, non-linear programming model and genetic algorithm for its solution containing both spatial and temporal consolidation retured products. Jayaraman [13], presented an analytical approach towards to production planning and control for CLSCs with product recovery and reuse. Kumar and Craig [14] studied on Dell's closed-loop supply chain. Pagell et al. [15], examined four general recycling options and their effects. Jun et al. [16], examined the product life-cycle management through three main stages. Which are *Beginning of life*, including design and production; *Middle* *of life*, including distribution, use, service and maintenance; *End of life*, including collecting, remanufacturing, reuse, recycling and disposal. Guide and Van Wassenhove [17], observed complexity of closed-loop supply chain and introduced it with a strong business perspective to reader. They examined this evolutionary process of CLSC network in five stages. Their studies aim to optimize the balance condition of the network using the theory of variational inequalities. Zeballos et al. [18], introduced a scenario-based modeling approach with two-stage, to deal with the design and planning decisions in multi-period, multi-product CLSC under uncertainty.

More recently, Özceylan and Paksoy [19] proposed a mixed integer mathematical model for multi-period and multi-part CLSC network. The proposed model gives optimal values of produced and disassembled products in CLSCs determining the location of factories and retailers. Amin and Zhang [20] proposed a stochastic mixed integer linear programming model for a single-period, multi-period CLSC including multiple plants, collection center and demand market problem. The model taking into account environmental factors and uncertainty of demand and returned product aims to minimize total cost. Zeballos ve ark. [21] addressed general multi-period, multi-product closed-loop supply chain which is structured as a 10-layer network (5 forward plus 5 reverse flows) with uncertain levels in the amount of raw material supplies and customer demands. MILP model proposed to design and planning of the network minimizes the total cost including facilities, purchasing, storage, transport and emissions costs minus the total revenue obtaining from returns. Jindal and Sangwan [22] proposed a multi-product, multi- facility CLSC network in an uncertain enviroment, which includes reuse, refurbish, recycle and disposal of parts. It was proposed a fuzzy mixed integer linear programming model to optimize the location and allocation of parts at each facility and number of parts to be purchased from external suppliers in order to maximise the profit of organisation. Ramezani et al. [23] designed a CLSC including strategic and tactical decisions in fuzzy environment. The model consists of three objective functions including profit maximization, time minimization and minimization of defective parts obtained from suppliers.

Internet of Things Approach to Closed Loop Supply Chain Problem

In 1991, researchers at Cambridge University shared a single coffeepot. The researchers were frustrated by the fact that they would often climb several flights of stairs and find the coffeepot empty. They designed a system that captures three images of coffeepot and transmits the computer about three times per minute. After writing the image capture software and protocols, each researcher was able to see online and in real-time the amount of coffee in the coffeepot on own screen. When it comes to 1993, this practice moved to the Internet began to follow millions of times a day. But this practice because of Cambridge University research department moved to another building was finalized in 2001.This coffee machine created the first proof and example of "Internet of Things" and the existence of dependent objects. Subsequent developments are caused to a very large increase in the amount of data produced by “connected objects".

"Internet of Things" concept is used by Kevin Ashton in a presentation prepared for Procter & Gamble company for the first time in 1999. Where, the benefits of application RFID technology in the supply chain is sorted and proposed to company [4]. Ondemir et al. [24] proposed a mixed integer linear programming model which determined how to process each end-of-life product on hand using static and dynamic data obtained by RFID tag and sensors to meet product, component and material demands and minimizing total cost. Ondemir and Gupta [5] proposed a mixed integer programming model used IoT for minimizing remanufacturing, disassembly, recycling, disposal and storage plans in a demand driven environment. Ondemir and Gupta [3] proposed a linear physical programming (LPP) model which determined how to process each end-of-life product on hand using the product life cycle information provided with RFID tag and sensors to meet product, component and material demands based on the remaining life.

PROBLEM DEFINITION

Problem is related to a manufacturer met the sales & collection (S&C) center demands with new, repaired and remanufactured products. This manufacturer enclose the factory, distribution center and repair center in CLSC. The S&C center sales to customers products which are supplied from the manufacturer and collects unused products from customers at the same time. However, It is not considered the exchange between customers and the S&C center in CLSC network design and modeling. End-of-life product in S&C center are purchased at a price according to the their value level. In this study, there are three recovery options including repair, complete disassembly and disposal to evaluate returned products. In the repair option, damaged components of product are replaced in repair center and then sent to distribution center to meet demands of the S&C center. Disassembly option is complete disassembly of product that imply the every single components is taken out. Qualified component is sold to S&C center to meet its demand, send to the factory to reuse or disposed according to the their value level. Disposal option is when product has not sufficient value level to repair or disassembly disposed directly without undertake any purchase cost and without being any processing. Remanufactured products may includes new components as well as used components. The manufacturer needs to supply new components from the outside to meet the products and components demands and optimize the total production cost or take the right recovery decision for each returned products.

At this stage, IoT is used to provide the product information. Product life cycle information is collected, processed and shared by IoT when company collects return products with different value levels. Manufacturer in closed-loop supply chain network produced smart products placed a DIOT (Device of the Internet of Things), so sensors on DIOT monitor the product during the whole life cycle and the product life cycle data. Meanwhile, any changes in product status can be monitored and stored by DIOT. This informations can be obtained by several types of reader device with a unique electronic product code which written RFID tag on each product and every IoT users can get this information when need it. Thus, the remaining value of each returned product can be evaluated and used efficiently.
For each time period, the following questions must be answered.

1) How many components should be obtained from external suppliers per unit time?
2) Which recovery options should be selected for returned products? (repair, disassembled or disposed)
3) Which components of disassembled products should be reused, sold to meet the demand or disposed?

This given based on the life cycle information which is monitored and collected by techniques of Iot.

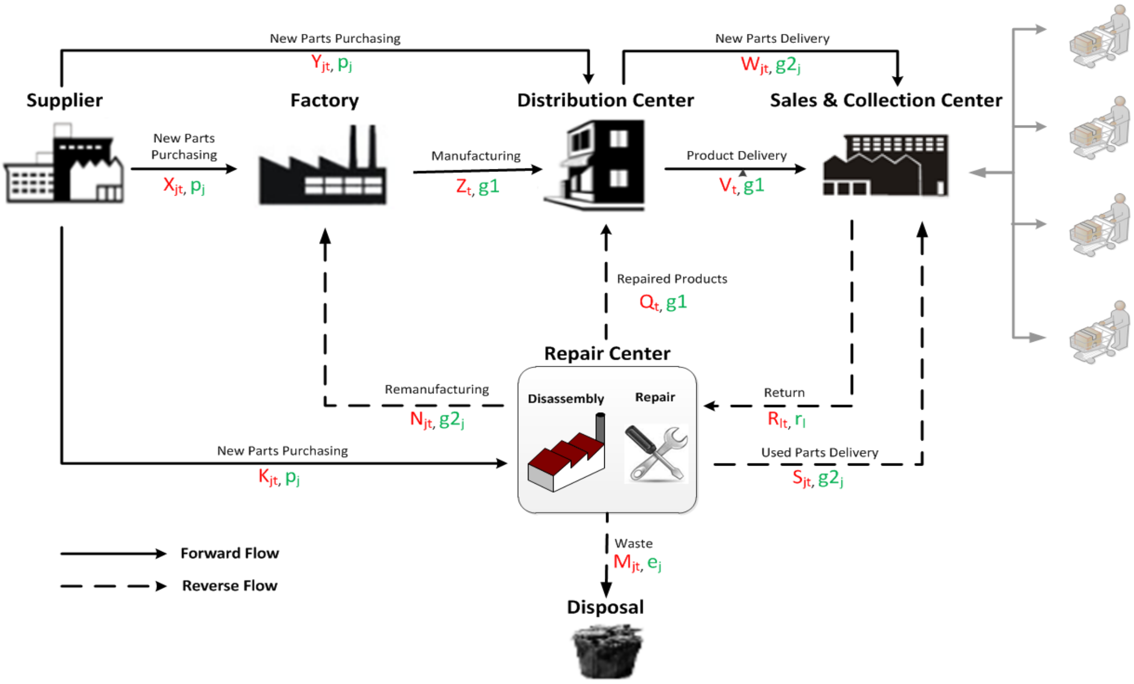

Figure 1: Representational Closed Loop Supply Chain Network

The assumptions of our problem are given below;

1) There is only one productand it is completely modular and life-cycle informations are known.
2) There is no difference between a new product with recovered product and it can meet demand for the same price.
3) The production capacity is sufficient for all product requirements.
4) All cost and sales price information is known.
5) The demand of S&C center are certain and fulfilled for each period.
6) Returned products contains all components including useless components.
7) The components constituting of the product have component importance weights range from 0-1 so as sum of them to be 1.
8) There aren't stock and stock out.

Mathematical Model

Based on the above assumption, a uniform product (automobile, computer, phone, etc.) are determined which is completely modular. The model determines how to process all of returned products to maximize profit for meet the demand. The sets, parameters, decision variables and the model are given as fallows.

Indices

i: Set of returned products ($i = 1, 2, \ldots, I$)
j: Set of components ($j = 1, 2, \ldots, J$)
t: Set of periods ($t = 1, 2, \ldots, T$)
l: Set of returned product value ranges ($l = 1, 2, \ldots, L$)

Parameters

$\boldsymbol{a_j}$**:** *Assembly cost of component j* $\boldsymbol{d_j}$ **:** *Disassembly cost of component j*

e_j: *Disposal cost of component j*
f_j : *Refurbishment cost of component j*
$g1$: *Unit transportation cost of product*
$g2_j$: *Unit transportation cost of component j*
p_j: *Procurement cost of component j from the supplier*
r_l : *Purchasing cost of l-level product from the S*&C *center*
$h1$: *Sales price of product*
$h2_j$: *Units Sales price of new part j*
$h3_j$: *Units Sales price of used part j*
rc_j : *j.component number in a product*
rfc_{jt} :*Amount of refurbished component j in period t*
bro_{ijt} : *1 if component j of the returned product i is quality deficit in period t, zero otherwise*
$\overline{a}_{it}$:*1if returned i purchases in period t, zero otherwise*
R_{lt} : *Amount of used product in the l-level are purchased from* S&C *center in period t*
C_i : *Value level of returned i*
dm_t: *Product demand of the* S&C *center in period t*
dms_{jt} : *Demand for new part j of the* S&C *center in period t*
dmc_{jt} : *Demand for used part j of the* S&C *center in period t*
dem_{it} : *1 if returned i is disassembled in period t, zero otherwise*
rep_{it} : *1 if returned i is repaired in period t, zero otherwise*
Q_t : *Amount of repaired product sending from the repair center to the distribution center in period t*
M_{jt} : *Amount of component j sending from the repair center to the disposal in period t*
K_{jt}: *Amount of new component j procuring from the supplier to the repair center in period t*

How to process of the components is determined according to their value levels. It is provided with binary parameter bro_{ijt}. Accordingly qualified components are refurbished and then reused disqualified components are discarded directly. Where, n is threshold value determined for refurbishing of components.

$$bro_{ijt} = \begin{cases} 1 \quad Component\ j\ \ is\ value\ level\ deficit\ (Disposal) & 0 \le diot_j < n \\ 0 \quad Component\ j\ \ is\ value\ level\ qualified\ (Reused) & diot_j \ge n \end{cases} \qquad \forall i \text{ and } 0 < n$$

All components value levels ($diot_j$) and importance weights of returned products are known. 3 classes (value ranges) are determined for products value levels ($diot_i$) calculated according to this information. C_i (the product value range) is determined as follows. Where, $n_{\mathbf{1}}$ and $n_{\mathbf{2}}$ represents value range limits. Accordingly, information of what recovery process (repair, disassembly, disposal) will be applied for each returned products is obtained.

$$C_i = \begin{cases} \mathbf{1} \quad (Disposal) & 0 \le diot_i < n_{\mathbf{1}} \\ \mathbf{2} \quad (Disassembly) & n_{\mathbf{1}} \le diot_i < n_{\mathbf{2}} \\ \mathbf{3} \quad (Repair) & diot_i \ge n_{\mathbf{2}} \end{cases} \qquad \forall i \quad \text{and} \quad 0 < n_1 < n_2 \qquad \text{(Ondemir and Gupta, [5])}$$

If returned product is purchased in period *t* and in 3. value range, it is repaired. Therefore;

$$\boldsymbol{rep_{it} = 1}\ , \qquad \text{if} \quad C_i \,.\, \bar{a}_{it} = 3$$

If returned product is purchased in period t and in 2. value range, it is disassembled. Therefore;

$$\boldsymbol{dem_{it} = 1}\ , \qquad \text{if} \quad C_i \,.\, \bar{a}_{it} = 2$$

If returned product is in 1. value range, it is discarded directly. Therefore;

$$\sum_{\boldsymbol{t}} \boldsymbol{dem_{it} + rep_{it} = 0}\ , \qquad \text{if} \quad C_i \ = 1$$

The total amount of the component refurbished after disassembly $(\boldsymbol{rfc_{jt}})$ is calculated as follows.

$$\boldsymbol{rfc_{jt}} = \sum_{\{\boldsymbol{i \epsilon I | \bar{a}_{it} = 1}\}} \boldsymbol{dem_{it}}.\left(\boldsymbol{1 - bro_{ijt}}\right)$$

The amount of products repaired in repair center must be equal to the amount of repaired products sent to distribution center from repair center for product demand fulfillment.

$$\boldsymbol{Q_t} = \sum_{\boldsymbol{i}} \boldsymbol{rep_{it}} \qquad \forall t$$

Repaired products are obtained by replacing without an adequate level components in returned products with new parts procured from suppliers. Therefore, new part as the amount of inadequate level components disassembled in repair must be provided to repair center from supplier.

$$\boldsymbol{K_{jt}} = \sum_{\boldsymbol{i}} \boldsymbol{bro_{ijt}.rep_{it}} \qquad \forall j, t$$

Value level deficit components occured during repair and disassembly processes are sent to the disposal center. Therefore, total amount of waste sent to disposal center must be equal to the amount of components are value level deficit.

$$\boldsymbol{M_{jt}} = \sum_{\boldsymbol{i}} \boldsymbol{bro_{ijt}}.(\boldsymbol{dem_{it} + rep_{it}}) \qquad \forall j, t$$

The product value level are calculated according to the component value levels as follows.

$$Product\ value\ level\ (diot_i) = \sum Component\ value\ level\ \ (diot_j)\ \ x\ Component\ importance\ weights$$

Decision Variables

$\boldsymbol{X_{jt}}$ **:** *Amount of new component j procuring from the supplier to the factory in period t*
$\boldsymbol{Y_{jt}}$ **:** *Amount of new component j procuring from the supplier to the distribution center in period t*
$\boldsymbol{Z_t}$ **:** *Amount of product sending from the factory to the distribution center in period t*
$\mathbf{W}_{\boldsymbol{jt}}$ **:** *Amount of new component j delivering from the distribution center to the* S&C *center in period t*
$\mathbf{V}_{\boldsymbol{t}}$ **:** *Amount of product delivering from the distribution center to the* S&C *center in period t*
$\mathbf{S}_{\boldsymbol{jt}}$ **:** *Amount of used part j delivering from the repair center to the* S&C *center in period t*
$\mathbf{N}_{\boldsymbol{jt}}$**:** *Amount of refurbished component j sending from the repair center to the factory in period t*
$\boldsymbol{\bar{b}_{jt}}$**:** *Auxiliary decision variable used to determine value of* S_{jt} *(takes the value 0 or 1)*

Objective Function

Objective function is to maximize the total profit, the total profit function can be given as follows :

Total Profit = Total Revenue – Total Cost **(1)**

1) Total Revenue (TR): Company can perform three different sales for the final products, new components and used parts. Moreover, some of the parts refurbished after disassembly are sent to the factory to remanufacture. These parts can be used instead of new parts and aren't procured from the suppliers, so this section is also taken to be a revenue item. Therefore, TR is composed of four parts as follows.

TR= $\sum_t \mathbf{V}_t.\mathbf{h1} + \sum_t \sum_j (\mathbf{W}_{jt}.\mathbf{h2}_j + \mathbf{S}_{jt}.\mathbf{h3}_j + \mathbf{N}_{jt}.\mathbf{P}_j)$ **(2)**

2) Total Cost (TC): The company is accepted to four different costs including total purchasing cost (TPC), total manufacturing costs (TMC), the total transportation cost (TTC) and total disposal cost (TDC).

TC = TPC + TMC + TTC+TDC **(3)**

Each term is described below.

2.1) Total purchasing cost (TPC): TPC is calculated as the sum of two sections; the first section indicates purchasing cost performed to satisfy new components demand of factory and the S&C center, the second section indicates purchasing cost used products from the S&C center.

TPC= $\sum_j \boldsymbol{P_j}(\sum_t(\boldsymbol{X_{jt}} + \boldsymbol{Y_{jt}})) + \sum_l \boldsymbol{r_l}(\sum_t \boldsymbol{R_{lt}})$ **(4)**

2.2) Total manufacturing cost (TMC): Manufacturing process consists of three sections including manufacturing cost in factory (TMC1), repair cost (TMC2) and disassembly cost (TMC3).

TMC = TMC1 + TMC2 + TMC3 **(5)**

Some of the parts refurbished after disassembly are returned to the factory. Here, if there are missing parts, they are procured from supplier and remanufacturing is performed. If final products produced by repair and remanufacture aren't meet demand of S&C center fully, new product is produced to meet the remaining demand by procure new parts from supplier.

The manufacturing consists of new and remanufactured products in the factory. This cost is the sum of assembly costs of all components from all products that are to be produced.

$$\textbf{TMC1}= \sum_j \boldsymbol{a_j} . \boldsymbol{rc_j} (\sum_t \boldsymbol{Z_t}) \quad \textbf{(6)}$$

Repair is applied to returned products whose value levels are good condition. Repair, e.g. considering for an automobile that requires only simple operations such as replacing the damaged rear view mirror. The repair cost should reflect the cost of disassembling for damaged parts, purchasing and assembly cost for new parts.

$$\textbf{TMC2}= \sum_i \sum_j \sum_t (\boldsymbol{d_j} + \boldsymbol{a_j} + \boldsymbol{p_j}) \boldsymbol{bro_{ijt}} . \boldsymbol{rep_{it}} \quad \textbf{(7)}$$

Complete disassembly is applied to returned products that aren't enough value level for repair but whose components can be reused. Reusable components are refurbished and then sent to the S&C center for meet the demand according to their value level. The remaining parts are sent to the factory for reuse after meet demand of the S&C center. Unusable parts which are in poor condition are discarded. The cost of happening here is the sum of disassembly costs of all components and refurbishig costs of all parts which are in good condition from all products that are to be disassembled.

$$\textbf{TMC3}= \sum_i \boldsymbol{dem_{it}} (\sum_j \boldsymbol{d_j} + \sum_t \boldsymbol{f_j} . (\mathbf{1} - \boldsymbol{bro_{ijt}})) \quad \textbf{(8)}$$

Transportation is dealt with on the basis of products and parts in the model. Final product transportation costs performed to distribution center from factory, distribution center from the repair center and the S&C center from the distribution center are considered equal. In addition, part transportation costs performed to repair center from factory, S&C center from repair center and S&C center from distribution center are also considered to be equal. Accordingly, total transportation cost is calculated as follows.

$$\textbf{TTC}= \sum_t \boldsymbol{g1} (\boldsymbol{Z_t} + \boldsymbol{Q_t} + \boldsymbol{V_t}) + \sum_j \sum_t \boldsymbol{g2_j} (\boldsymbol{N_{jt}} + \boldsymbol{W_{jt}} + \boldsymbol{S_{jt}}) \quad \textbf{(9)}$$

2.4) Total disposal cost (TDC): Unusable components occur in repair and disassembly process. Value level deficit components which will be replaced in repair and which will not be refurbished in disassembly are considered to be disposal and its cost is calculated as follows.

$$\textbf{TDC}= \sum_j \sum_t \boldsymbol{e_j} \boldsymbol{M_{jt}} \quad \textbf{(10)}$$

Constraints

The amount of new components incoming to distribution center from factory must be equal to the amount of the new components outgoing to S&C center from distribution center. Therefore;

$$\boldsymbol{Y_{jt}} - \boldsymbol{W_{jt}} = \mathbf{0} \qquad \forall j,t \quad \textbf{(11)}$$

The amount of products incoming to distribution center from factory and the repair center must be equal to the amount of products outgoing to S&C center from distribution center. Therefore;

$$\boldsymbol{Z_t} + \boldsymbol{Q_t} - \boldsymbol{V_t} = \mathbf{0} \qquad \forall t \quad \textbf{(12)}$$

Some of the components refurbished to be reused after disassembly are sent to S&C center for used part demand fulfillment. As for others, they are sent to factory to be used in remanufacture. Therefore, the amount of component refurbished after disassembly must be equal to the amount of the component to factory and S&C center from repair center.

$$\boldsymbol{rfc_{jt}} - (\boldsymbol{N_{jt}} + \boldsymbol{S_{jt}}) = \mathbf{0} \qquad \forall j,t \quad \textbf{(13)}$$

Some of the components used manufacturing in factory are met by repair center, the others are met by supplier. Therefore, sum of the components procured factory must meet component requirements of factory.

$$(\boldsymbol{X_{jt}} + \boldsymbol{N_{jt}}) - \boldsymbol{rc_j}.\boldsymbol{Z_t} = \boldsymbol{0} \qquad \forall j, t \qquad \textbf{(14)}$$

Product demand of the S&C center is provided with final product in distribution center. Therefore, the amount of products sent to the S&C center from distribution center must be equal to products demand of S&C.

$$\boldsymbol{V_t} = \boldsymbol{dm_t} \qquad \forall t \qquad \textbf{(15)}$$

The S&C center has two different component demands including new and used parts. The amount of new parts forwarded to the S&C center from the distribution center must be at least equal to new parts demand. When company couldn’t meet used part demand completely, remaining part can be completed with new part. Thus, related constraints are formulated as follows.

$$\boldsymbol{W_{jt}} \geq \boldsymbol{dms_{jt}} \qquad \forall j, t \qquad \textbf{(16)}$$

$$\boldsymbol{S_{jt}} + \boldsymbol{W_{jt}} = \boldsymbol{dms_{jt}} + \boldsymbol{dmc_{jt}} \qquad \forall j, t \qquad \textbf{(17)}$$

Some of the components refurbished after disassembly are sent to S&C center for used part demand fulfillment. As for others, they are forwarded to factory to remanufacture. The following constraint provides to give priority to the amount of used part sent to S&C centers (S_{jt}) in distribution of refurbished components for used part demand fulfillment. Therefore, the amount of used part must be as either total amount of refurbished components after the disassembly or used part demand.

$$\boldsymbol{S_{jt}} = \boldsymbol{rfc_{jt}}.\boldsymbol{b_{jt}} + \boldsymbol{dmc_{jt}}.\left(\boldsymbol{1} - \boldsymbol{b_{jt}}\right) \qquad \forall j, t \qquad \textbf{(18)}$$

Numerical Example

The planning model was made in terms of five periods. Each product is made of 10 components. Unit product cost of transportation *(g1)* and product sales price *(h1)* were considered as 10 $ and 1000 $ respectively. Information (value levels) on products and their components are provided by IoT system. Other parameters generated randomly in the specified range are given below.

Table 1: Other parameter values of numerical example

Components	1	2	3	4	5	6	7	8	9	10
a_j	4	4	4	3	1	5	6	6	4	1
d_j	2	2	2	1	2	1	2	1	1	1
e_j	1.14	1.22	1.49	1.41	1.20	0.62	1.28	0.79	0.86	1.34
f_j	2	1	2	2	1	1	2	1	2	1
$g2_j$	1.72	1.81	1.85	1.87	1.94	1.88	1.92	1.78	1.83	1.86
p_j	11	15	13	14	8	9	11	12	13	7
$h2_j$	13	16	16	15	15	11	15	14	16	14
$h3_j$	3	3	4	4	3	3	9	6	4	5
rc_j	1	2	3	3	2	1	4	3	4	2
Component importance weight	**0.08**	**0.16**	**0.08**	**0.07**	**0.15**	**0.13**	**0.07**	**0.05**	**0.06**	**0.15**

Table 2: The demand values related to components

	Zero part demand (dms_{jt})					Used part demand (dmc_{jt})				
Component	**Period 1**	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 1**	**Period 2**	**Period 3**	**Period 4**	**Period 5**
1	72	106	91	108	81	43	56	53	58	26
2	112	120	91	70	90	40	29	41	49	40
3	92	115	63	112	114	26	46	39	26	46
4	75	91	94	86	60	36	29	59	52	38
5	108	61	92	66	102	47	50	47	29	50
6	72	71	81	97	101	25	50	41	46	43
7	78	92	65	90	115	56	57	38	58	44
8	104	76	61	110	80	38	45	40	39	35
9	79	72	101	78	102	25	48	36	46	58
10	**74**	**98**	**94**	**73**	**119**	**34**	**37**	**32**	**40**	**26**

Table 3: Purchasing prices according to product value range (r_l) and the amount of product purchased related to periods (R_{lt})

	Product value level (l)			
	Period (t)	**1**	**2**	**3**
	1	13	42	1
	2	12	54	3
R_{lt}	**3**	5	37	4
	4	13	51	1
	5	6	35	1
	r_l	**0**	**20**	**50**

Table 4: The final product demands and number of returned product values

Period (t)	1	2	3	4	5	Total
Number of returned product	56	69	46	65	42	**278**
Final product demands(dm_t)	**71**	**70**	**60**	**69**	**49**	319

Here, value range limits of product and repair threshold value of component was adopted $n_1 = 4$, $n_2 = 7$ and $n = 4$ respectively.

Solution

Mixed integer linear programming model developed in accordance with these data was solved in GAMS/CPLEX 23.3 software package, the following results were obtained.

Table 6: The optimal objective function value

Objective Function	Value
TR	400005
TC	209253.29
TPC	153246
TMC	36642
TMC1	30900
TMC2	310

Table 7: The process detail of returned products

	Time period					
Process	**1**	**2**	**3**	**4**	**5**	Total
Repair	1	3	4	1	1	10
Disassembly	42	54	37	51	35	219
Disposal	**13**	**12**	**5**	**13**	**6**	**49**

Table 8: The flow detail of products

Time period	Z_t	V_t	Q_t
1	70	71	1
2	67	70	3
3	56	60	4
4	68	69	1

TMC3	5432
TTC	18505.20
TDC	860.09
Z	190751.71

According to the solution results; the total revenue is 400005 $, the total cost is 209253.29$ and the optimal objective function value maximized profit is 190751.71$. Table 7 gives process details applied to purchased product. Accordingly first period, one product has been repaired and 42 products have been disassembled. As for 13 products, they have been discarded because of can not reused.

Table 9: The process detail of components

Period	Variables	Component									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	$\mathbf{X_{it}}$	70	140	210	210	140	69	280	210	280	138
	$\mathbf{Y_{it}}$	90	121	92	81	128	72	112	111	81	74
	$\mathbf{W_{it}}$	90	121	92	81	128	72	112	111	81	74
1	$\mathbf{S_{it}}$	25	31	26	30	27	25	22	31	23	34
	$\mathbf{N_{it}}$	0	0	0	0	0	1	0	0	0	2
	$\mathbf{M_{it}}$	17	11	16	12	15	16	20	12	20	6
	K_{jt}	0	0	0	0	0	0	0	1	1	0
	$\mathbf{X_{it}}$	67	128	201	199	134	67	268	201	268	134
	$\mathbf{Y_{it}}$	126	120	129	91	75	84	108	82	87	101
	$\mathbf{W_{it}}$	126	120	129	91	75	84	108	82	87	101
2	$\mathbf{S_{it}}$	36	29	32	29	36	37	41	39	33	34
	$\mathbf{N_{it}}$	0	6	0	2	0	0	0	0	0	0
	$\mathbf{M_{it}}$	19	19	23	24	18	17	13	16	22	20
	K_{jt}	1	0	1	1	0	0	0	1	1	0
	$\mathbf{X_{it}}$	56	112	168	168	112	56	224	168	224	112
	$\mathbf{Y_{it}}$	123	104	74	126	113	98	82	77	117	105
	$\mathbf{W_{it}}$	123	104	74	126	113	98	82	77	117	105
3	$\mathbf{S_{it}}$	21	28	28	27	26	24	21	24	20	21
	$\mathbf{N_{it}}$	0	0	0	0	0	0	0	0	0	0
	$\mathbf{M_{it}}$	16	10	10	11	11	13	17	14	17	16
	K_{jt}	0	1	1	1	0	0	1	1	0	0
	$\mathbf{X_{it}}$	68	136	198	204	130	68	272	204	272	136
	$\mathbf{Y_{it}}$	132	82	112	111	66	104	110	117	92	76
	$\mathbf{W_{it}}$	132	82	112	111	66	104	110	117	92	76
4	$\mathbf{S_{it}}$	34	37	26	27	29	39	38	32	32	37
	$\mathbf{N_{it}}$	0	0	6	0	6	0	0	0	0	0
	$\mathbf{M_{it}}$	18	14	20	24	16	12	13	19	19	14
	K_{jt}	1	0	1	0	0	0	0	0	0	0
	$\mathbf{X_{it}}$	48	96	144	144	96	48	192	144	192	96
	$\mathbf{Y_{it}}$	86	106	137	78	129	120	130	90	136	121
	$\mathbf{W_{it}}$	86	106	137	78	129	120	130	90	136	121
5	$\mathbf{S_{it}}$	21	24	23	20	23	24	29	25	24	24
	$\mathbf{N_{it}}$	0	0	0	0	0	0	0	0	0	0
	$\mathbf{M_{it}}$	15	11	12	16	12	12	6	10	11	11
	K_{jt}	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**

Product demand which is 71 in first period is met with 1 repaired and 70 zero product (table 8). According to table 9, total of 160 components 1 are procured in first period (70 components 1 are procured to factory from supplier and 90 components 1 are procured to distribution center from supplier). 90 components 1 are sent to distribution center from supplier; 72 of them met zero part demand and 18 of them met remaining used part demand due to there aren’t adequate amount of used part.

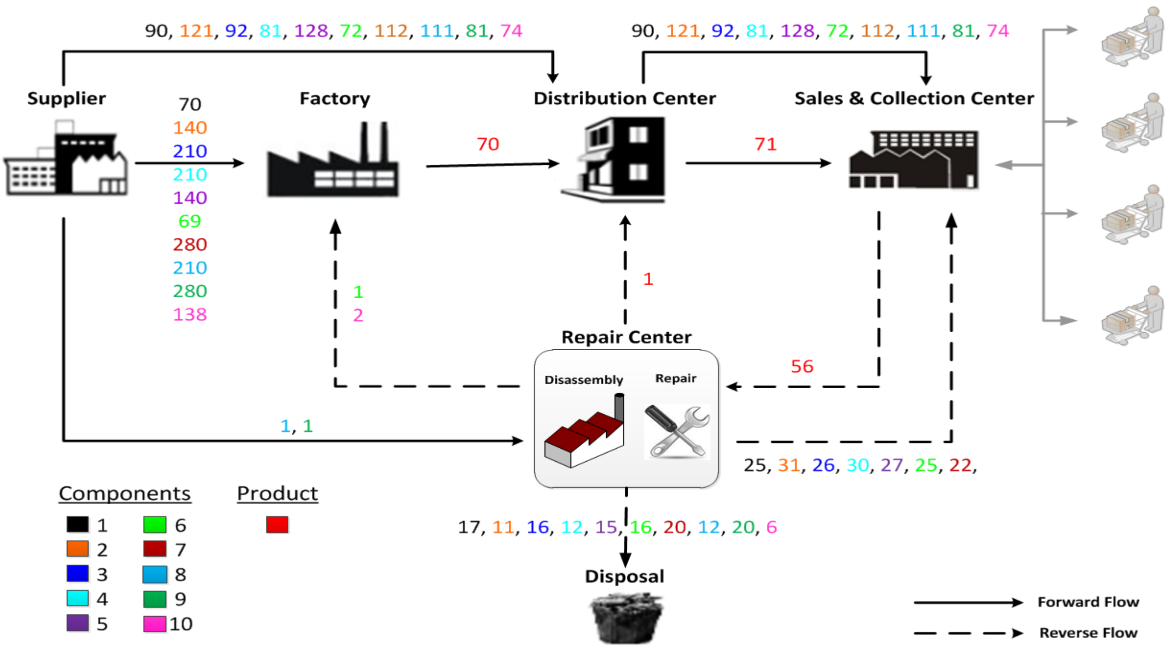

Figure 2: Optimal flow at first period

CONCLUSION

The businesses working to adapt changing life conditions resort to improvement its supply chain to provide the most effective service to its customers by taking into consideration polluted environment, decreasing natural resources day by day and state regulations. At the same time, social and economic level of achievements in this context to get the business, the necessity of CLSC design is increasing. But the design of CLSC network is more complex than traditional supply chain network. It quite complicates the design stage to be connected to uncertainties of decisions such as determining to what amount products will be collected from customers, will be classified according to what of deformation range in the product, determining to optimal improvement process to recovered product, in addition to delivering products to customer. At this stage, IoT system reduces related uncertainty by providing all life information of returned product and substantially mitigates planning of reverse flow activities. So that increase of things produced their data on their own will bring a more reliable knowledge accumulation, reduce losses, avoid waste and also reduce costs pursue it.

In this study, a closed-loop supply chain network met the S&C center demands with new, repaired and remanufactured products was considered. Manufacturer on the network is manufacture an intelligent product placed diot and thereby can follow to product during its all life cycle. System is arranged to be applied of three different recovery options including repair, complete disassembly and disposal to evaluate returned. A mixed integer linear programming model is proposed for a single type of product is completely modular (automobile, computer, telephone, etc.). The model meets products and components demands of customer based period, maximizes profit consist of different sales revenues and total cost (total production, purchase, transportation and disposal costs) and determines how to evaluate all returned products. The proposed model has been verified with the aid of a numerical example by solving in GAMS software.

For future research, the proposed model could be applied in business performed CLSC activities and developed on networks with multi-product, more product recovery options and fixed costs to be more realistic. Also uncertainties in product returns could be added as fuzzy to network structure.

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AN INTEGRATED MODEL FOR DECENTRALIZED CLOSED-LOOP SUPPLY CHAINS WITH COMMON SOURCES: COMPARATIVE ANALYSIS OF INTERACTIVE FUZZY PROGRAMMING APPROACHES

Ahmet Çalık[19], Nimet Yapıcı Pehlivan[20], Turan Paksoy[21]

Abstract − Reverse Logistics and Closed-Loop Supply Chain (CLSC) management has attracted more attention because of environmental regulations or consumer pressures in recent years. In the 21st century, companies are forced to share their resources for being the best company in the market. Companies having common activities for supply chains have started to corporate each other in order to achieve higher service levels. In this study, firstly a multi-level mixed-integer linear programming model is examined that includes common sources four different decision makers at two different decision levels. Secondly, for deriving a satisfactory solution we used different fuzzy interactive programming approaches to solve this CLSC model. Finally, a numerical example is solved and conclusions are discussed.

Keywords − Common Sources, Decentralized Closed-Loop Supply Chain, Interactive Fuzzy Programming, Multi-Level Programming.

INTRODUCTION

Supply chain management (SCM) has received lots of attentions with the increasing globalization, economic competitiveness, time and quality of service [1]. In recent decades, Supply Chain (SC) models dealt with two different concepts. One of them is forward SC which includes material suppliers, production facilities, distribution facilities and customers. The other one is called Reverse SC that includes the collection centers, disassembly and refurbishing centers and disposal. The integration of forward and reverse logistic as called CLSC and include both forward and reverse facilities.

There has been growing attention in CLSC network design with different solution approaches. Sabri and Beamon [2] developed a multi-objective SC model including production, delivery, and demand uncertainty. In this model, facilitates simultaneous strategic and operational planning are handled using an iterative method. A multi-objective model which consists of minimizing total cost and environmental influence is developed by Wang et al. [3]. Efficiency of the model is tested by a sixnode example and a case study. Krikke et al. [4] developed a mixed-integer linear programming with multiple product design options and multiple product recovery options. The model is applied Japanese consumer electronics Company for different scenarios. Hasani et al. [5] (2012) developed a CLSC model with multiple periods, multiple products, and multiple under uncertain demand and purchasing cost. An interval robust optimization technique is used to handle uncertainty of parameters. Olugu and Wong [6] developed a fuzzy rule-based evaluation for performance evaluation of a CLSC performance assessment. The applicability of the performance measurement system was used an automobile manufacturing company in Malaysia. Zhou et al. [7], focus on managing internal manufacturing–remanufacturing conflict from the perspective of the OEM in a decentralized closed-loop supply chain. The differences of their model is that the original equipment manufacturers can select a centralized or decentralized control mode to manage its manufacturing and remanufacturing activities before the supplier prices the new component. Tseng et al. [8] compared the close-loop and open hierarchical structures with the real status of green supply chain management under uncertainty. In order to assess qualitative preferences in green supply chain management under evaluation they used ANP method. Fallah-Tafti et al. [9], has presented an interactive multi-objective possibilistic mixed-integer model with multi-period under uncertainty. In order to solve model, a novel interactive fuzzy solution approach, namely possibilistic-STEM, is proposed. A multi-

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product, multi-facility capacitated closed-loop supply chain framework was proposed by Jindal and Sangwan [10]. The uncertainties of related parameters are represented by triangular fuzzy numbers. The effectiveness of the proposed approach is investigated by solving an illustrative example. Özceylan and Paksoy [11] a mixed integer programming model is proposed to optimize transportation, purchasing, refurbishing costs, and the fixed costs of potential plants and retailers. In order to analyze performance measures of various parameters a number of scenarios were performed. Özceylan and Paksoy [12] are developed a fuzzy multi-objective model that capacity, demand and reverse rate uncertainties are incorporated into the model through a fuzzy modelling approach. Özceylan and Paksoy [13] developed a CLSC network model consisting of various conflicting decisions of forward and reverse facilities. The solution of the model is obtained using three different interactive fuzzy programming methods. The study is the first study using IFP approaches in the context of the integration of CLSC network and disassembly line balancing problems. Demirel et. al. [14] used genetic algorithm to solve crisp and fuzzy CLSC models. A number of scenarios are generated for obtaining validity of mixed integer CLSC model. Liang [15] develops an interactive fuzzy multi-objective linear programming (i-FMOLP) method for solving the fuzzy multi objective transportation problems with piecewise linear membership function. The total distribution costs and the total delivery time are optimized simultaneously using the proposed i-FMOLP method. Selim and Özkarahan [16] developed a multi-objective linear programming model to address the Supply Chain networks distribution problem in their study. The model has two conflict objective functions and the goal of the model is to optimize these objective functions in the same time like as when select the optimum numbers, locations and capacity levels of plants and warehouses to deliver products to retailers at the least cost while satisfying desired service level to retailers. They used fuzzy modelling approach in their solution methodology and proposed a new and generic interactive fuzzy goal programming (IFGP)-based solution approach to determine the preferred compromise solution. Torabi and Hassini [17] presented supply chain master planning model consisting of multiple suppliers, one manufacturer and multiple distribution centers. First, they developed an optimization model for a supply chain master planning. Second, a fuzzy multi-objective mixed-integer program is used to handle uncertainty. As an alternative, fuzzy set theory provides a framework to handle different kind of uncertainty, including fuzzy coefficients for lack of knowledge or epistemic uncertainty as well as flexibility in constraints and goals at the same time [18, 13].

In this study a CLSC network is considered which consists of two allied SCs that include a set of suppliers, plants, customers, and collection centers. The suppliers are divided two categories: Common suppliers or own suppliers in each SC. Plants choose purchasing the parts from common suppliers or own suppliers but they send the used products only common collection centers. In the developed model, four DMs are handled in two levels. At the first decision level, the plants of common SCs are considered as the upper level DMs of the Stackelberg Game. At the second level, common suppliers and common collection centers are considered as the lower level DMs. The objective functions of the first level DMs consist of four different components transportation cost, purchasing cost, fixed operating costs and inventory costs. The objective functions of the lower level DMs are to maximize the total their profits. We have considered the DMs have cooperate mutually and share their sources with each other. Assuming that the DMs essentially cooperate with each other, we used three IFP approaches: Zimmermann [19] approach (hereafter the ZIM approach), Selim and Özkarahan [16] approach (hereafter the SO approach) and Torabi and Hassini [17] approach (hereafter the TH approach).

The remaining part of the paper is organized as follows: Section 3 describes the problem, introduces the proposed multi-level model for the CLSC and mathematical formulations. Computational results are presented for a hypothetical data to show and validate the applicability of the model in Section 4. Finally, some concluding remarks and future studies are given in Section 5.

PROBLEM DEFINITION

The integrated CLSC network discussed in this paper is a multi-period, multi-product, multi-stage logistics network including suppliers, plants, customers and collection centers. The CLSC network consists of two allied SCs. The first SC referred to as SC1 and the allied SC referred to as SC2. Integrated CLSC network, offer more advantages compared to single CLSC network. The companies use their networks more effectively with the usage of common sources. They can handle necessary materials/parts/products more lower prices if they share their resources. Using the common units such as suppliers, plants, collection centers, etc. companies can decrease overall costs, lead time and inventory levels. Here, in CLSC, an integrated CLSC network is considered to achieve more saving costs.

As illustrated in Figure 1, in the forward flow, a certain utilization number of different parts/components shipped from common suppliers or own suppliers in the SCs to plants. Purchased parts/components are assembled in plants, and products are transported to customers from there as a forward flow. New products are manufactured in the plants that each plants can purchase necessary parts from own suppliers or common suppliers. Because of the distances between common-own suppliers are different the purchasing prices of suppliers are different. Customer demands are assumed to be predetermined and fixed for each period. The reverse flow starts with the collection of the used products from customers. It is assumed that a certain amount of used products, defined as a percentage (η_1) for *SC1* and (η_2) for *SC2*, of demand must be collected in customer zones. The used products are shipped to common collection centers through a push system. After the disassembly process, the remaining of parts/components are sent to the plants as a second hand part/component and entered to forward flow as new parts. The common collection can be identical for both SCs. There are four ways for SCs to supply parts. Purchasing the required parts from own suppliers, common suppliers, parts inventory and the other is acquiring them by disassembling and refurbishing the used products.

Further assumptions about the problem are as follows:

- All demands of customers' for each product is for multi-periods, is deterministic, and must be fully satisfied. (I.e. no shortages are allowed).
- The cost of transportation, purchasing, inventory and opening facilities, are fixed and deterministic.
- The capacities of all facilities both forward and reverse are limited and fixed.
- There is no waste during the part production from parts and after disassembly process.
- All price parameters and facility opening costs are deterministic and known a priori.
- There is no difference between the original parts sent from suppliers to plants and used parts renewed by collection centers.

MODEL FORMULATION

The mixed integer mathematical model, which provides all of the above-mentioned decisions and assumptions, and its formulation are presented below:

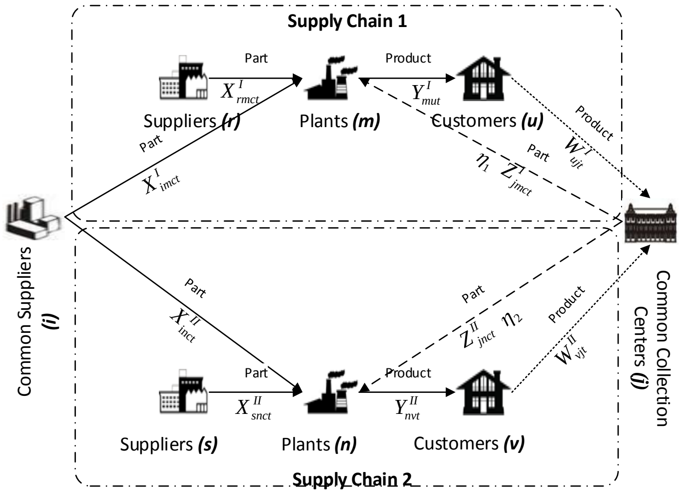

Figure 1. Structure of integrated CLSC network

Indices

i	set of common suppliers	*i= {1, 2...I};*
r	set of suppliers for *SC1*	*r= {1, 2…R};*
s	set of suppliers for *SC2*	*s= {1, 2…S};*
m	set of plants for *SC1*	*m= {1, 2…M};*
n	set of plants for *SC2*	*n= {1, 2…N};*
u	set of customers for *SC1*	*u= {1, 2…U};*
v	set of customers for *SC2*	*v= {1, 2…V};*
j	set of common collection centers	*j= {1, 2…J};*
c	set of parts	*c= {1, 2…C};*
t	set of periods	*t= {1, 2…T}.*

Parameters

d_{rm} distance between supplier *r* and plant *m* for SC1 (km),
d_{sn} distance between supplier *s* and plant *n* for SC2 (km),
d_{im} distance between supplier *i* and plant *m* for SC1 (km),
d_{in} distance between supplier *i* and plant *n* for SC2 (km),
d_{mu} distance between plant *m* and customer *u* for SC1 (km),
d_{nv} distance between plant *n* and customer *v* for SC2 (km),
d_{uj} distance between customer *u* and common collection center *j* for SC1 (km),
d_{vj} distance between customer *v* and common collection center *j* for SC2 (km),
d_{jm} distance between collection center *j* and plant *m* for SC1 (km),
d_{jn} distance between collection center *j* and plant *n* for SC2 (km),
a^{I}_{rct} capacity of supplier *r* for part *c* in period *t* for SC1 (ton),
a^{II}_{sct} capacity of supplier *s* for part *c* in period *t* for SC2 (ton),
a_{ict} capacity of common supplier *i* for part *c* in period *t* (ton),
b^{I}_{mct} capacity of plant *m* for part *c* in period *t* for SC1 (ton),
b^{II}_{nct} capacity of plant *n* for part *c* in period *t* for SC2 (ton),
ca_{jt} capacity of common collection center *j* in period *t* (ton),
de^{I}_{ut} demand of customer *u* in period *t* for SC1 (ton),
de^{II}_{vt} demand of customer *v* in period *t* for SC2 (ton),

α_{mt}^{I} the fixed opening cost for plant *m* in period *t* for SC1 ($),
α_{nt}^{II} the fixed opening cost for plant *n* in period *t* for SC2 ($),
α_{jt} the fixed opening cost for common collection center *j* in period *t* ($),
p_{rc} unit cost of purchasing of supplier *r* for part *c* for SC1 ($/ton),
p_{sc} unit cost of purchasing of supplier *s* for part *c* for SC2 ($/ton),
p_{ic} unit cost of purchasing cost/sale price of common supplier *i* for part *c* ($/ton),
e_{jc} unit cost of purchasing cost/sale price of common collection center *j* for part *c* ($/ton),
hcp_{mct}^{I} unit holding cost of part *c* at plant m in period *t* for SC1($/ton),
hcp_{nct}^{II} unit holding cost of part *c* at plant n in period *t* for SC2($/ton),
r_c the weight ratio of one part *c* in end product,
η_1 percentage of collected amount which is re-sent to plants for SC1 (%),
η_2 percentage of collected amount which is re-sent to plants for SC2 (%),
λ_1 percentage of kept amount in inventory for SC1 (%),
λ_2 percentage of kept amount in inventory for SC2 (%),
utc unit cost of shipping (($/ton).km);

Variables

X_{rmct}^{I} amount of part *c* shipped from supplier *r* to plant *m* in period *t* for SC1 (ton),
X_{snct}^{II} amount of part *c* shipped from supplier *s* to plant *n* in period t with vehicle *p* for SC2 (ton),
X_{imct}^{I} amount of part *c* shipped from common supplier *i* to plant *m* in period *t* for SC1 (ton),
X_{inct}^{II} amount of part *c* shipped from common supplier *i* to plant *n* in period *t* for SC2 (ton),
Y_{mut}^{I} amount of product shipped from plant *m* to customer *u* in period t for SC1 (ton),
Y_{nvt}^{II} amount of product shipped from plant *n* to customer *v* in period t for SC2 (ton),
W_{ujt}^{I} amount of product shipped from customer *u* to common collection center *j* in period *t* for SC1 (ton),
W_{vjt}^{II} amount of product shipped from customer *v* to common collection center *j* in period *t* for SC2 (ton),
Z_{jmct}^{I} amount of part *c* shipped from common collection center *j* to plant *m* in period *t* for SC1(ton),
Z_{jnct}^{II} amount of part *c* shipped from common collection center *j* to plant *n* in period *t* for SC2 (ton),
Q_{mt}^{I} If plant *m* is open in period t, 1; otherwise, 0 for SC1,
Q_{nt}^{II} If plant *n* is open in period t, 1; otherwise, 0 for SC2,
QC_{jt} If common collection center *j* is open in period *t*, 1; otherwise, 0,
$Cinv_{mct}^{I}$inventory amount of part *c* at plant *m* in period *t* for SC1 (ton),
$Cinv_{nct}^{II}$inventory amount of part *c* at plant *n* in period *t* for SC2 (ton).

Supply Chain 1 (Plant 1) → Decision Maker 1 (DM_1)

$Min\ Z_1 =$
$utc.\left(\sum_{r\in R}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T} X_{rmct}^{I}.d_{rm} + \sum_{m\in M}\sum_{u\in U}\sum_{t\in T} Y_{mut}^{I}.d_{mu} + \sum_{j\in J}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T} Z_{jmct}^{I} d_{jm} +\right.$
$\left.\sum_{i\in I}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T} X_{imct}^{I}.d_{im}\right) +$ (1)
$\left[\left(\sum_{r\in R}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T} X_{rmct}^{I}.p_{rc} + \sum_{i\in I}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T} X_{imct}^{I}.p_{ic}\right) + \sum_{j\in J}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T} Z_{jmct}^{I}.e_{jc}\right] +$
(2)
$\sum_{m\in M}\sum_{t\in T} Q_{mt}^{I}\,\alpha_{mt}^{I} +$ (3)
$\sum_{m\in M}\sum_{c\in C}\sum_{t\in T} Cinv_{mct}^{I}\, hcp_{mct}^{I}$ (4)

Supply Chain 2 (Plant 2) → Decision Maker 2 (DM_2)

$$Min\ Z_2 =$$
$$utc.\left(\sum_{s\in S}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}X^{II}_{snct}.d_{sn}+\sum_{n\in N}\sum_{v\in V}\sum_{t\in T}Y^{II}_{nvt}.d_{nv}+\sum_{j\in J}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}Z^{II}_{jnct}.d_{jn}+\right.$$
$$\left.\sum_{i\in I}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}X^{II}_{inct}.d_{in}\right) \tag{5}$$
$$[(\sum_{s\in S}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}X^{II}_{snct}.p_{sc}+\sum_{i\in I}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}X^{II}_{inct}.p_{ic})+$$
$$\sum_{j\in J}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}Z^{II}_{jnct}.e_{jc}]+ \tag{6}$$
$$\sum_{n\in N}\sum_{t\in T}Q^{II}_{nt}\ \alpha^{II}_{nt}+ \tag{7}$$
$$\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}Cinv^{II}_{nct}\ hcp^{II}_{nct} \tag{8}$$

Common Supplier → Decision Maker 3 (DM_3)

$$Maks\ Z_3 = (\sum_{i\in I}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T}X^{I}_{imct}.p_{ic}+\sum_{i\in I}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}X^{II}_{inct}.p_{ic}) \tag{9}$$

Common Collection Center → Decision Maker 4 (DM_4)

$$Max\ Z_4 =$$
$$(\sum_{j\in J}\sum_{m\in M}\sum_{c\in C}\sum_{t\in T}Z^{I}_{jmct}.e_{jc}+\sum_{j\in J}\sum_{n\in N}\sum_{c\in C}\sum_{t\in T}Z^{II}_{jnct}.e_{jc}-utc(\sum_{u\in U}\sum_{j\in J}\sum_{t\in T}W^{I}_{ujt}.d_{uj}+$$
$$\sum_{v\in V}\sum_{j\in J}\sum_{t\in T}W^{II}_{vjt}.d_{vj})-\sum_{j\in J}\sum_{t\in T}QC_{jt}\ \alpha_{jt} \tag{10}$$

Constraints

$$\sum_{m\in M}X^{I}_{rmct}\le a^{I}_{rct} \qquad \forall\, r\in R, c\in C, t\in T \tag{11}$$
$$\sum_{n\in N}X^{II}_{snct}\le a^{II}_{sct} \qquad \forall\, s\in S, c\in C, t\in T \tag{12}$$
$$\sum_{m\in M}X^{I}_{imct}+\sum_{n\in N}X^{II}_{inct}\le a_{ict} \qquad \forall\, i\in I, c\in C, t\in T \tag{13}$$
$$r_c\sum_{u\in U}Y^{I}_{mut}\le b^{I}_{mct}\ Q^{I}_{mt} \qquad \forall\, m\in M, c\in C, t\in T \tag{14}$$
$$r_c\sum_{v\in V}Y^{II}_{nvt}\le b^{II}_{nct}\ Q^{II}_{nt} \qquad \forall\, n\in N, c\in C, t\in T \tag{15}$$
$$\sum_{m\in M}Y^{I}_{mut}\ge de^{I}_{ut} \qquad \forall\, u\in U, t\in T \tag{16}$$
$$\sum_{n\in N}Y^{II}_{nvt}\ge de^{II}_{vt} \qquad \forall\, v\in V, t\in T \tag{17}$$
$$\sum_{u\in U}W^{I}_{ujt}+\sum_{v\in V}W^{II}_{vjt}\le ca_{jt}QC_{jt} \qquad \forall\, j\in J, t\in T \tag{18}$$
$$\sum_{m\in M}Y^{I}_{mut}-\sum_{j\in J}W^{I}_{uj(t+1)}=0 \qquad \forall\, u\in U, t\in T \tag{19}$$
$$\sum_{n\in N}Y^{II}_{nvt}-\sum_{j\in J}W^{II}_{vj(t+1)}=0 \qquad \forall\, v\in V, t\in T \tag{20}$$
$$r_c(\eta_1\sum_{u\in U}W^{I}_{ujt})-\sum_{m\in M}Z^{I}_{jmct}=0 \qquad \forall\, j\in J, c\in C, t\in T \tag{21}$$
$$r_c(\eta_2\sum_{v\in V}W^{II}_{vjt})-\sum_{n\in N}Z^{II}_{jnct}=0 \qquad \forall\, j\in J, c\in C, t\in T \tag{22}$$
$$Cinv^{I}_{mc(t-1)}+\sum_{i\in I}X^{I}_{imct}+\sum_{r\in R}X^{I}_{rmct}+\sum_{j\in J}Z^{I}_{jmct}-r_c(\sum_{u\in U}Y^{I}_{mut})=Cinv^{I}_{mct}$$
$$\forall\, m\in M, c\in C, t\in T \tag{23}$$
$$Cinv^{II}_{nc(t-1)}+\sum_{i\in I}X^{II}_{inct}+\sum_{s\in S}X^{II}_{snct}+\sum_{j\in J}Z^{II}_{jnct}-r_c(\sum_{v\in V}Y^{II}_{nvt})=Cinv^{II}_{nct}$$
$$\forall\, n\in N, c\in C, t\in T \tag{24}$$
$$Cinv^{I}_{mct}\ge\sum_{u\in U}de^{I}_{ut}.\lambda_1 \qquad \forall\, m\in M, c\in C, t\in T \tag{25}$$
$$Cinv^{II}_{nct}\ge\sum_{v\in V}de^{II}_{vt}.\lambda_2 \qquad \forall\, n\in N, c\in C, t\in T \tag{26}$$
$$Cinv^{I}_{mct}\le b^{I}_{mct} \qquad \forall\, m\in M, c\in C, t\in T \tag{27}$$
$$Cinv^{II}_{nct}\le b^{II}_{nct} \qquad \forall\, n\in N, c\in C, t\in T \tag{28}$$
$$X^{I}_{rmct}\ge 0 \qquad \forall\, r\in R, m\in M, c\in C, t\in T \tag{29}$$
$$X^{II}_{snct}\ge 0 \qquad \forall\, s\in S, n\in N, c\in C, t\in T \tag{30}$$
$$X^{I}_{imct}\ge 0 \qquad \forall\, i\in I, m\in M, c\in C, t\in T \tag{31}$$
$$X^{II}_{inct}\ge 0 \qquad \forall\, i\in I, n\in N, c\in C, t\in T \tag{32}$$
$$Y^{I}_{mut}\ge 0 \qquad \forall\, m\in M, u\in U, t\in T \tag{33}$$
$$Y^{II}_{nvt}\ge 0 \qquad \forall\, n\in N, v\in V, t\in T \tag{34}$$

$W^{I}_{ujt} \geq 0$	$\forall\, u \in U, j \in J, t \in T$	(35)
$W^{II}_{vjt} \geq 0$	$\forall\, v \in V, j \in J, t \in T$	(36)
$Z^{I}_{jmct} \geq 0$	$\forall\, j \in J, m \in M,\ c \in C, t \in T$	(37)
$Z^{II}_{jnct} \geq 0$	$\forall\, j \in J, n \in N,\ c \in C, t \in T$	(38)
$Cinv^{I}_{mct} \geq 0$	$\forall\, m \in M, c \in C, t \in T$	(39)
$Cinv^{II}_{nct} \geq 0$	$\forall\, n \in N, c \in C, t \in T$	(40)
$Q^{1}_{mt} = \{0,1\}$	$\forall\, m \in, t \in T$	(41)
$\mathrm{Q}^{2}_{\mathrm{nt}} = \{0,1\}$	$\forall\, n \in N, t \in T$	(42)
$\mathrm{QC}_{\mathrm{jt}} = \{0,1\}$	$\forall\, j \in J, t \in T$	(43)

Numerous objective functions can be taken with respect to DMs. Thus, the objective functions are changed according to the DMs. Here, we considered four different DMs as stated in the following: The DM_1 who is the Plant 1 in SC1; the objective function has six components. The first component represents the cost of transportation of the network in the forward and reverse chains (1). The second component represents the cost of purchasing over all product parts (2). The third component represents the fixed opening costs associated with locating the plants in SC1 (3). The last component represents the cost of part inventory of plants (4).

The similar objective function is valid for DM_2 who is the Plant 2 in SC2. Common supplier which is called DM_3 wants to maximize ıts profit with the sale of the parts. For the common collection center as referred DM_4 the objective function has three components. The first component represents the cost of sale price over all product parts. The second component represents the cost of transportation. The last component represents the fixed opening costs of common collection centers.

Constraint (11) and (12) indicates that the total quantity of purchased parts from suppliers cannot exceed the assembly capacity of those suppliers during any period for *SC1* and *SC2*, respectively; Constraint (13) indicates that the total quantity of purchased parts from common suppliers cannot exceed the assembly capacity of those suppliers during any period. Constraint (14) and (15) stipulates that the production quantities for the end product must not exceed the production capacity of that assembler during any period for *SC1* and *SC2*, respectively. Constraint (16) and (17) ensures that the demands of all customers are fully met for *SC1* and *SC2*. Constraint (18) indicates that the total quantity of transportation products from customers to common collection centers cannot exceed the capacity of those common collection centers during any period. Constraints (19)–(22) are the balance equations for customers for *SC1* and *SC2*: the quantities that enter to these facilities must be equal to the amount of products/parts that leave the facilities. Constraints (23)–(24) evaluates the amount of parts held in inventory for *SC1* and *SC2*. Constraints (25)–(26) are the safety stock constraints. Constraints (27)–(28) ensures that the total quantity of held parts at plants cannot exceed the capacity of those plants during any period for *SC1* and *SC2.* Constraints (29)–(40) enforce the non-negativity restriction on the decision variables. Lastly, Constraints (41)-(43) represent the binary variables.

COMPUTATIONAL EXPERIMENTS

In this section, a numerical example is presented to illustrate how the developed CLSC model works in a multi-product, multi-period and multi-stage. Instances are produced, based on randomly generated parameters, to illustrate the properties of the problem.

Description of data

To assess the performance of the integrated CLSC model, at first we solved all objective functions individually. The results of the individual objectives can be seen in this section. Then, several IFP approaches are implemented and the related results are reported following sections. The parameters of our data are generated randomly by using the uniform distribution and Table 1 presents the information about the parameters.

Table 1. The sources of random generation of data

Parameters	Corresponding random distribution
d_{rm}, d_{sn}	~ Uniform (100, 300)
d_{im}, d_{in}	~ Uniform (100, 400)
d_{mu}, d_{nv}	~ Uniform (50, 150)
d_{uj}, d_{vj}	~ Uniform (25, 200)
d_{jm}, d_{jn}	~ Uniform (50, 450)
$a^{I}_{rct}, a^{II}_{sct}$	~ Uniform (500, 1000)
a_{ict}	~ Uniform (500,2000)
$b^{I}_{mct}, b^{II}_{nct}$	~ Uniform (250,750)
ca_{jt}	~ Uniform (100,1000)
$de^{I}_{ut}, de^{II}_{vt}$	~ Uniform (50,250)
$\alpha^{I}_{mt}, \alpha^{II}_{nt}, \alpha_{jt}$	~ Uniform (10000, 100000)
p_{rc}, p_{sc}	~ Uniform (100, 10000)
p_{ic}, e_{jc}	~ Uniform (100, 7500)
$hcp^{I}_{mct}, hcp^{II}_{nct}$	~ Uniform (100, 1000)

The network that occurs the basis of the sample problem consists of six common suppliers, six suppliers in SC1 and four suppliers in SC2, four plants in SC1 and SC2, three customers in SC1 and SC2 in the forward logistics network and three common collection centers in the reverse logistic network (Figure 2). Suppliers provide four kinds of components that have different utilization rates of 0.20, 0.25, 0.32 and 0.23 respectively, which, in turn, are converted into end products (Figure 2).

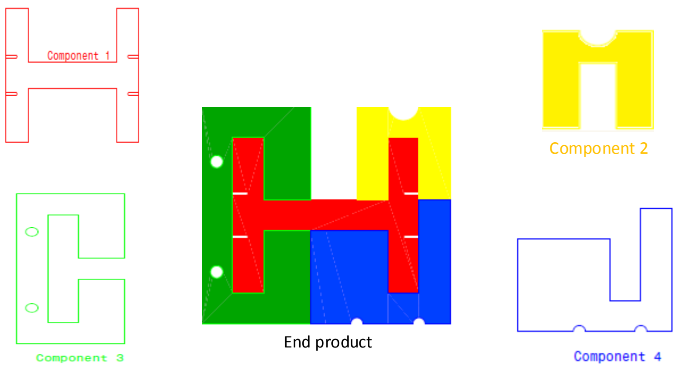

Figure 2. Bill of material of the end-product

The unit transportation cost (utc) was accepted as 1.25 cents per ton-km that is calculated based on operating costs and contains salaries, wages, insurance, cost of fuel and operating supplies and depreciation[36]. It is assumed that amount of used products, defined as a percentage $\eta_1 = 0.15$ for *SC1* and $\eta_2 = 0.15$ for *SC2*, of demand must be collected in customer zones. The percentage of parts kept in inventory is accepted $\lambda_1 = 0.20$ for *SC1* and $\lambda_2 = 0.18$ for *SC2*. The mixed integer linear programming formulation (1)–(43) of the sample network contains 881 variables and 511 constraints for DM_1. The mathematical model was solved with GAMS-CPLEX 24.0.1, on a laptop with Intel Core i5 M480 2.67 GHz and 3 GB RAM memory and the computation time required to solve the model to optimality using the GAMS-CPLEX 24.0.1 is 0.22 CPU seconds

The solution of the CLSC model with different IFP approaches

The developed CLSC model has the character of multi-level programming and in order to solve the multi-level problem, three approaches are utilized including Zimmermann [19], Selim and Özkarahan [16] and Torabi and Hassini [17] approach. The solutions of the problem are presented below:

The solution of the problem with Zimmermann (1978) approach

In this approach, the multi-level optimization problem is transformed to a single-objective optimization problem with additional constraints. At first, we obtained the pay-off table. The pay-off table in which Z_g^L ve Z_g^U values indicate the lower and upper bounds of the related objective function values of each individual problem can be observed is given in Table 2.

Table 2. Pay-off table of each problem

	Z₁	***Z₂***	***Z₃***	***Z₄***
min Z_1	**6043221.70** (Z_1^1)	12425179.50	1579852.46	474300.07
min Z_2	19040732.61	**5388166.23** (Z_2^1)	6246762.63	351875.50
maks Z_3	107882387.83	108213826.34	**181186145.34** (Z_3^1)	1350160.34
maks Z_4	30091470.46	11523320.06	8995806.32	**1815077.84** (Z_4^1)
The worst values	*107882387.83* (Z_1^0)	*108213826.34* (Z_2^0)	*1579852.46* (Z_3^0)	*351875.50* (Z_4^0)

In the Table 2 the bold values (Z_G^1) indicates as the best/optimal value of the corresponding individual programming problem and the italic values (Z_G^0) represents the worst objective function value among the optimal solutions to the other individual programming problems. So that, Z_1, Z_2, Z_3 and Z_4 values always included between these values. After determining the pay-off table, the membership functions are obtained as following:

$$\mu_1(Z_1(x)) = \begin{cases} 1, & Z_1(x) \leq 6043221.70 \\ \frac{107882387.83 - Z_1(x)}{107882387.83 - 6043221.70}, & 6043221.70 \leq Z_1(x) \leq 107882387.83 \\ 0, & Z_1(x) \geq 107882387.83 \end{cases} \tag{44}$$

$$\mu_2(Z_2(x)) = \begin{cases} 1, & Z_2(x) \leq 5388166.23 \\ \frac{108213826.34 - Z_2(x)}{108213826.34 - 5388166.23}, & 5388166.23 \leq Z_2(x) \leq 108213826.34 \\ 0, & Z_2(x) \geq 108213826.34 \end{cases} \tag{45}$$

$$\mu_3(Z_3(x)) = \begin{cases} 1, & Z_3(x) \geq 181186145.34 \\ \frac{Z_3(x) - 1579852.46}{181186145.34 - 1579852.46}, & 1579852.46 \leq Z_3(x) \leq 181186145.34 \\ 0, & Z_3(x) \leq 1579852.46 \end{cases} \tag{46}$$

$$\mu_4(Z_4(x)) = \begin{cases} 1, & Z_4(x) \geq 1815077.84 \\ \frac{Z_4(x) - 351875.50}{1815077.84 - 351875.50}, & 351875.50 \leq Z_4(x) \leq 1815077.84 \\ 0, & Z_4(x) \leq 351875.50 \end{cases} \tag{47}$$

The formulation of the ZIM max-min approach can be written as follows:

$Maks\ \alpha$
Subject to

$$\alpha \leq \mu_1(Z_1(x)) = \frac{107882387.83 - Z_1(x)}{107882387.83 - 6043221.70}$$

$$\alpha \le \mu_2(Z_2(x)) = \frac{108213826.34 \ - \mathrm{Z}_2(\mathrm{x})}{108213826.34 \ - 5388166.23}$$
$$\alpha \le \mu_3(Z_3(x)) = \frac{\mathrm{Z}_3(\mathrm{x}) - 1579852.46}{181186145.34 - 1579852.46}$$
$$\alpha \le \mu_4(Z_4(x)) = \frac{\mathrm{Z}_4(\mathrm{x}) - 351875.50}{1815077.84 - 351875.50}$$
Constraints (1)-(43)
$$0 \le \alpha \le 1 \tag{48}$$

The optimal solution of the main problem is obtained using the GAMS-CPLEX 24.0.1 and the minimal satisfactory level is calculated as ***0.53***. The satisfaction levels of the other *DMs* are obtained $\boldsymbol{\mu_1 = \mu_2 = \mu_3 = \mu_4 = \alpha}$ respectively.

The solution of the problem with Selim and Özkarahan (2008) approach

After determining the pay-off table and the membership functions the following linear programming model is solved. Up to this point all steps are same as the Zimmermann's approach. Considering the membership functions in previous section, and using $w_1 = 0.25, w_2 = 0.25, w_3 = 0.2$ and $w_4 = 0.25$, mathematical formulation of the problem can be developed as follows:

$$Maks \quad \gamma\lambda + (1-\gamma)[0.25\lambda_1 + 0.25\lambda_2 + 0.25\lambda_3 + 0.25\lambda_4]$$
Subject to
$$\lambda + \lambda_1 \le \mu_1(Z_1(x)) = \frac{107882387.83 - \mathrm{Z}_1(\mathrm{x})}{107882387.83 - 6043221.70}$$
$$\lambda + \lambda_2 \le \mu_2(Z_2(x)) = \frac{108213826.34 \ - \mathrm{Z}_2(\mathrm{x})}{108213826.34 \ - 5388166.23}$$
$$\lambda + \lambda_3 \le \mu_3(Z_3(x)) = \frac{\mathrm{Z}_3(\mathrm{x}) - 1579852.46}{181186145.34 - 1579852.46}$$
$$\lambda + \lambda_4 \le \mu_4(Z_4(x)) = \frac{\mathrm{Z}_4(\mathrm{x}) - 351875.50}{1815077.84 - 351875.50}$$

Constraints (1)-(43)
$$\gamma, \lambda, \lambda_1, \lambda_2, \lambda_3, \lambda_4 \epsilon [0,1] \tag{49}$$

The results related to the different γ values are given in Table 3.

Table 3. The optimum results related to the different γ values

γ-value	Z1	Z2	Z3	Z4	λ	μ1	μ2	μ3	μ4	CPU (S)
0	9768324.04	6404808.11	5303941.41	1814727.84	0	0.963	0.990	0.021	1	0.16
0,2	9601980.90	7073482.27	6194772.40	1814727.84	0	0.965	0.984	0.026	1	0.17
0,4	10305691.09	7472514.93	6642643.01	1813127.84	0	0.958	0.980	0.028	0.999	0.42
0,6	55707831.43	55533866.29	93596303.64	1810659.09	0.512	0.512	0.512	0.512	0.997	0.53
0,8	55030847.40	54850324.47	94790250.88	1798864.93	0.519	0.519	0.519	0.519	0.989	0.57
1	54348145.21	54161009.09	95994282.82	1121043.51	0.526	0.526	0.526	0.526	0.526	0.59

The solution of the problem with Torabi and Hassini (2008) approach

The integrated CLSC model can be formulated as the following equation according to the TH approach:

$$Maks \quad \gamma\lambda + (1-\gamma)[0.25.\mu_1(Z_1(x)) + 0.25.\mu_2(Z_2(x)) + 0.25.\mu_3(Z_3(x)) + 0.25.\mu_4(Z_4(x))]$$

Subject to

$$\lambda \le \mu_1(Z_1(x)) = \frac{107882387.83 - \mathrm{Z}_1(\mathrm{x})}{107882387.83 - 6043221.70}$$

$$\lambda \le \mu_2(Z_2(x)) = \frac{108213826.34 - \mathrm{Z}_2(\mathrm{x})}{108213826.34 - 5388166.23}$$

$$\lambda \le \mu_3(Z_3(x)) = \frac{\mathrm{Z}_3(\mathrm{x}) - 1579852.46}{181186145.34 - 1579852.46}$$

$$\lambda \le \mu_4(Z_4(x)) = \frac{\mathrm{Z}_4(\mathrm{x}) - 351875.50}{1815077.84 - 351875.50}$$

Constraints (1)-(43)

$$\gamma, \lambda \epsilon [0,1] \qquad (50)$$

The solution of the Equation (50) is obtained by fixing $\gamma = 1$ and minimal satisfactory level, DMs' satisfactory levels are obtained 0.526. Objective function values, CPU times and satisfaction degrees of DMs are presented related to the different γ values in Table 4.

Table 4. The optimum results related to the different γ values

γ-value	Z1	Z2	Z3	Z4	λ	μ1	μ2	μ3	μ4	CPU (S)
0	9768324.04	6404808.11	5303941.41	1814727.84	0	0.963	0.990	0.021	1	0.15
0,2	56940130.83	49414577.37	91422987.26	1814925.34	0.500	0.500	0.572	0.500	1	0.25
0,4	54766808.17	54583727.55	95255917.56	1807996.12	0.522	0.522	0.522	0.522	1	0.31
0,6	54875987.57	54693964.54	95063365.84	1810586.59	0.520	0.520	0.520	0.520	0.997	0.33
0,8	54713959.31	54530366.75	95349123.24	1806670.34	0.522	0.522	0.522	0.522	0.994	0.37
1	54348145.21	54161009.09	95994282.82	1121043.51	0.526	0.526	0.526	0.526	0.526	0.40

Comparison of IFP approaches

According to the obtained results the following implications can be shown:

- In terms of the objective function values, SO and TH approaches showed similar results when increased the γ value between 0.6 to 1. When we compared the γ value between 0 to 0.6, SO and TH approaches showed different results. If the γ value increase 0 to 1, the CPU time also increased both approaches.
- In terms of the CPU times TH approach gives the shorter times than SO approaches.
- While increasing the γ value, the satisfaction levels of DM_1, DM_2 and DM_4 decrease but satisfaction level of DM_3 was increase for SO approach. Meanwhile, the same change occurs in the TH approach.
- According to the IFP approach SO approach is more sensitive to γ value than TH approach.

CONCLUSION

This paper is an attempt to how we integrate the SCs when we have different SC networks. This paper presents a decentralized multi-level mixed integer linear programming model for integrated CLSC network design through allied SCs. The developed CLSC network consists of two allied SCs with different four DMs.

The DMs at the upper level are the plants in two SCs, common suppliers and common collection centers are the lower level DMs. To solve the developed model, three IFP approaches are implemented. Results of the computational experiments indicate that decentralized CLSC models can be handled with IFP approaches. The comparasion of IFP approaches show that SO approach is more sensitive to γ value than TH approach while we obtain the results more rapid with TH approach.

There are some possible extensions of our study in the future. For the large size problems, heuristics algorithms such as Genetic Algorithm, Simulated Annealing and Particle Swam Optimization can be used. On the other hand, some factors such as demand and returns are uncertain in real world cases. Thus, the parameters can be handled under fuzzy environment or other uncertainty techniques like stochastic approach and grey theory can be considered to handle the problem.

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A MULTI-OBJECTIVE OPTIMIZATION MODEL FOR CLOSED-LOOP SUPPLY CHAIN

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Abstract -In most of the past researches, the design of Forward Supply Chain and Reverse Supply Chain Networks is considered separately, but the configuration of the Reverse Supply Chain Network has a strong influence on the Forward Supply Chain network and vice versa. Separating the design may result in sub optimality; therefore the design of the forward supply chain and reverse supply chain network should be integrated. According to the most of the literature, closed-loop supply chain networks are designed as a single – purpose and minimize the total cost. But generally real-life problem is based on the multi-objective models. In this study, we propose a new model to evaluate the systematic supply chain configuration minimizing the total cost and maximizing customer service level as objectives of the logistic network. The network takes into account the hybrid processing facilities whereby both distribution and collection are processed at the same location. In the forward direction include plants, distribution /collection centres and customers while, the reverse flow, returned product collection centre and disposal. The proposed model aims to minimize the total costs and maximize the customer service level that can be delivered to customer in terms of delivery time. Multi- objective model is solved in order to show the trade-off between objectives. The result indicates important insight for decision making process.

Keywords_*Closed- loop supply chain, Multi-objective programming, optimal solutions*[26]

INTRODUCTION

Closed loop supply chain (CLSC) comprises two parts: forward and reverse logistics. For the forward logistic, after suppliers and plants, the distributors will deliver the final products to the customers to satisfy their demands, and the position of the customers is typically the end of the process. For the reverse logistic, the flow of used products is processed from the customers back to the dismantlers to carry out the sorting or disassembling for recovery, reuse, or disposal [1]. In models proposed for closed loop supply chain design, minimization of total cost is considered as main objective function. However, successful supply chain management requires considering the various performance measures. While profitability tries to reduce the costs and the number of facilities, responsiveness causes a contrary effect. For this reason, authors not only should consider the total cost, but also they should take into account other factors by multi-objective models [2] - [3].

In this paper, a general closed loop supply chain network is configured. In forward flow, the raw materials are shipped from suppliers to plants for production. The new products are conveyed from plants to customers via distribution centres to meet customer demands. In backward flow, the returned product collected from customers are transferred to collection centres for testing and inspecting, then the recoverable products are send to plant to remanufacture a reusable product and the non- utilizable products are carried to disposal centres , respectively. In addition, the network deals with hybrid processing facilities whereby both distribution and collection are processed at the same location. We propose an integrated model as a multi-objective model which minimize the total costs and maximize the customer service. Then, the model is solved by ε-*constraints* method.

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The paper is organized as follows. The literature review is presented in Section 2. Section 3 introduces model formulation. In Section 4, related model is tested with a numerical example in GAMS package program. Finally, in Section 5 conclusion is presented. The supply chain network design problems are usually modelled as a single objective problem. But any "design" in practice is usually involving trade-offs among different conflicting objectives. Therefore, considering supply network design with multi-objective optimization is another influential trend worthy of study [4]. CLSC network design problems have often incompatible objectives and high complexity. Therefore, these problems require multi-objective approaches rather than a single objective approach and it is necessary for researchers to pay more attention to multi objective functions instead of single objective ones. Recently, multi objective optimization of supply chain network design has been considered by different researchers in literature.

Sheu et al. [5] presented a multi-objective linear programming model for optimizing the operations of a green supply chain, composed of forward and reverse flows, including decisions pertaining to shipment and inventory. The model is based on a typical five-layer chain and considers a single product only, although it is applicable to any industry. The authors present computational results of the model based on the data set of a notebook computer manufacturing chain [6]. Gupta and Evans [7] proposed a non-pre-emptive goal programming approach to model a closed-loop supply chain network. Pishvaee and Torabi [8] proposed a multi-objective possibility mixed integer programming model to cope with the issue of uncertainty in closed-loop supply chain network design. Wang et al. [4] studied a supply chain network design problem with environmental concerns and proposed a multi-objective optimization model that captures the trade-off between the total cost and the environment influence. Vahdani et al. [9] applied fuzzy multi-objective robust optimization to configure a CLSC network.

Amin and Zang [2] investigated a CLSC network which includes multiple plants, collection centres, demand markets, products and proposed a mixed-integer linear programming model to minimize the total cost. The model is extended to consider environmental factors by weighed sums and e-constraint methods. They utilized two methods to solve the multi-objective programming model including weighted sums and e-constraint methods. In addition, they investigate the impact of demand and return uncertainties on the network configuration by stochastic programming (scenario-based). Amin and Zang [10] configured a general closed-loop supply chain network and proposed a three-stage model including evaluation, network configuration, and selection and order allocation to evaluate and choose the best suppliers, remanufacturing subcontractors, and refurbishing sites based on qualitative and quantitative criteria. To this end, they presented a multi-objective mixed-integer linear programming model. Özkır and Başlıgil [11] proposed a fuzzy multiple objective optimization model for formulating CLSC design problem and various recovery processes. Proposed model defines essential objectives in a supply chain related to profit maximization and customer satisfaction related to price adjustment and demand fulfilment. Özceylan and Paksoy [12] proposed a mixed integer fuzzy mathematical model for a CLSC network with multiple periods and multiple parts and applied a fuzzy multi-objective model (FMOM) approach to take into account the fuzziness in the capacity, objectives, and demand constraints and also in the reverse rates. Ramezani et al. [13] presented a stochastic multi-objective model for forward/reverse logistic network design under a uncertain environment. They demonstrate a method to evaluate the systematic supply chain configuration maximizing the profit, customer responsiveness, and quality as objectives of the logistic network. The set of Pareto optimal solutions is obtained and also financial risk relevant to them is computed in order to show the trade-off between objectives.

Fallah-Tafti et al. [14] presented an interactive multi-objective possibility mixed-integer programming model to formulate a closed-loop supply chain network problem in a multi-echelon, multi-period under uncertainty. Proposed closed-loop supply chain network design integrates network design decisions in both forward and reverse supply chain networks into a unified structure as well as incorporates the tactical decisions with strategic ones (e.g., facility location and supplier selection) at each period. To do so, various conflicting objectives and constraints are simultaneously taken into account in the presence of some uncertain parameters, such as cost coefficients and customer demands. Subulan et al. [15] developed a new multi-objective, multi-echelon, multi-product CLSC network design model for a lead/acid battery industry considering both financial and collection risks using several risk measures under different uncertainty types. Ramezani et al. [3] addressed the application of fuzzy sets to design a multi-product, multi-period, closed-loop supply chain network which includes three objective functions: maximization of profit, minimization of delivery time, and maximization of quality. According to fuzzy components considered, they adopted a fuzzy optimization approach to convert the proposed fuzzy multi-objective mixed-integer linear program into an equivalent auxiliary crisp model to obtain the relevant solutions.

Model Formulation

Proposed model for closed loop logistic network is shown in Fig. 1. In forward flow, the raw materials are shipped from suppliers to plants for production. The new products are conveyed from plants to customers via distribution centres to meet customer demands. In backward flow, the returned product collected from customers are transferred to collection centres for testing and inspecting, then the recoverable products are send to plant to remanufacture a reusable product and the non- utilizable products are carried to disposal centres, respectively. This network structure considers the hybrid processing facilities which in both distribution and collection are established at the same location in order to reduce cost and pollution.

This integrated logistics network may involve a trade-off between the total costs and the network's responsiveness. In some cases, companies would like to decide to open more facilities in order to increase customer's responsiveness, which may cause to a greater investment cost. Thereby, this integrated logistics network take into account network cost and network responsiveness.

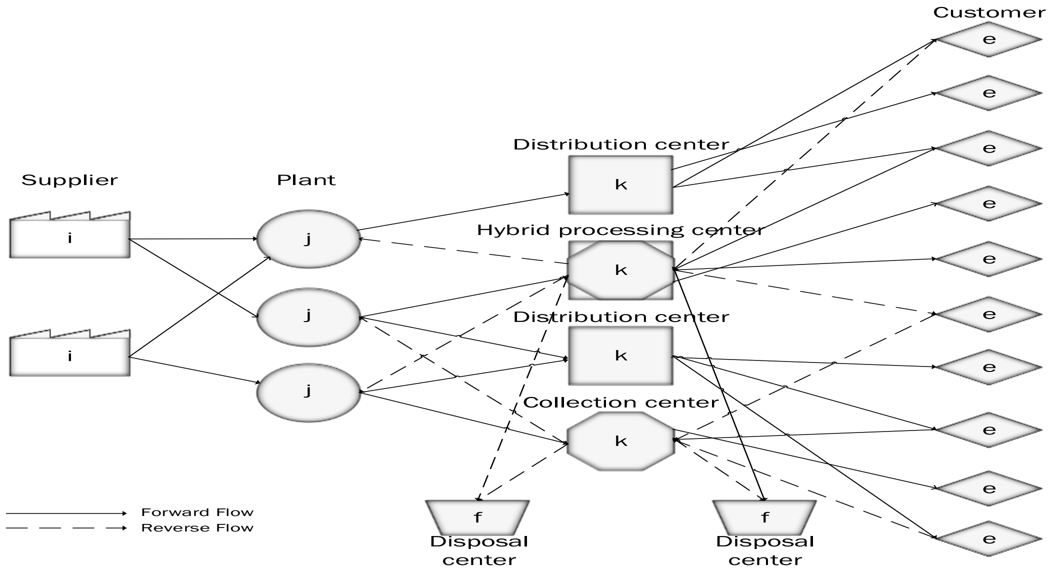

Figure 1. General Structure of Network

We use this following notation in this model formulation:

Sets

I = Sets of fixed locations of suppliers, i = {1, 2, 3……., I}
J = Set of plants, j= {1, 2… J}
K= Set of forward distribution, collection and hybrid processing facilities, k= {1, 2…K}
E= Set of customer, e = {1, 2… E}
P= Set of product, p= {1, 2 …P}
F= Set of disposal center, f= {1, 2 ….F}

Parameters

Variables Costs

$S_i =$ Unit purchasing material cost from supplier i.
$P1_{jp} =$ Unit production cost of product p at plant j.
$O_k =$ Unit operation cost at forward distribution centre k.
$I_k =$ Unit inspection and testing cost at hybrid / collection processing centre k.
$R_{pj} =$ Unit recovery cost of returned product p at plant j.
$DC_{pf} =$ Unit disposal cost pf product p at disposal centre f.

Transportation Costs

$t1_{ij} =$ Unit transportation cost for raw materials shipped from supplier i to plant j .
$t2_{jkp} =$ Unit transportation cost for product p transferred from plant j to forward processing facility k.
$t3_{kep} =$ Unit transportation cost for product p transferred from forward processing facility k to customer e.
$t4_{ekp} =$ Unit transportation cost for returned product p transferred from customer e to collection centre k.
$t5_{kjp} =$ Unit transportation cost for recoverable product p transferred from hybrid processing facility k to plant j.
$t6_{kfp} =$ Unit transportation cost for scrapped product p transferred from collection centre k to disposal centre f.

Fixed Costs

$F1_j =$ Fixed cost for opening plant j.
$F2_k =$ Fixed cost for opening distribution centre k.

Demand of customer

$D_{ep} =$ Demand of customer e for product p.

Capacity of Facilities

$Cap_j =$ Capacity of plant j
$Cap_k =$ Capacity of collection/ hybrid processing centre
$CapM_k = Capacity\ of\ \ hybrid\ \ proces$ sing facility k

Ratio

$RR_p =$ Return ratio of used product at customer e.
$RX =$ Recovery ratio.
$RD =$ Disposal ratio.
$v_p =$ Utilization ratio of raw material per unit of finished product p.
$\alpha =$ Weighting factor for forward responsiveness (or importance); $1-\alpha$ shows that the weighting factors the reverse responsiveness.
$tf_{ke} =$ Delivery time from distribution centre k to customer e.
$tr_{ek} =$ Collection time from customer e to collection / inspection centre k.

exdtf = Expected delivery time in forward network.
exdtr = Expected delivery time in reverse network.
$T(f)$ = Set of customers can be answered from distributor k in time rspf.
$T(\mathrm{r})$ = Set of customers can be answered from collector k in time rspr.

Decision Variables

$Q1_{ij}$ = Amount of raw material shipped from supplier to plant j.
$Q2_{jkp}$ = Amount of product p shipped from plant j to distribution centre k.
$Q3_{kep}$ = Amount of product p shipped from processing facility k to customer e.
$Q4_{ekp}$ = Amount of product p shipped from customer e to collection / hybrid processing facility k.
$Q5_{kjp}$ = Amount of returned product p shipped from collection/hybrid processing facility k to plant j.
$Q6_{kfp}$ = Amount of disposed product p shipped from collection centre k to disposal centre f.

Binary Variables

$$X_j = \begin{cases} 1, \text{ If plant j is opened} \\ 0, \text{otherwise} \end{cases}$$

$$Y_k = \begin{cases} 1, \text{If collection center k is opened} \\ 0, \text{ otherwise} \end{cases}$$

$$L_{ke} = \begin{cases} 1, \text{If shipment link is allocated to distribution } center\ k\ and\ customer\ e \\ 0, \text{ otherwise} \end{cases}$$

$$B_{ek} = \begin{cases} 1, \text{ If shipment link is allocated to customer e and hybrid center k} \\ 0, \text{ otherwise} \end{cases}$$

$$H_k = \begin{cases} 1, & If\ hybrid\ proces\text{sing facility } k \text{ is opened} \\ 0, & otherwise \end{cases}$$

Multi - objective, multi-echelon, and multi products integrated logistic network design are formulated as follows;

Objective Functions

The first objective is to minimize the total cost of supply chain network including purchasing cost of raw materials from supplier, producing cost in plant, operating cost in distribution centres, inspecting and testing cost of returned products, remanufacturing cost of recoverable product, disposal cost of scrapped product, transportation cost between facilities and fixed opening cost of facilities.

$$Min\ f_1 = \sum_i \sum_j Q1_{ij} S_i + \sum_j \sum_k \sum_p Q2_{jkp} P1_{jp} + \sum_k \sum_e \sum_p Q3_{kep} O_k + \sum_e \sum_k \sum_p Q4_{ekp} I1_k + \sum_k \sum_j \sum_p Q5_{kjp} R_{pj} + \sum_k \sum_f \sum_p Q6_{kfp} DC_{pf} + \sum_i \sum_j Q1_{ij} t1_{ij} + \sum_j \sum_k \sum_p Q2_{jkp} t2_{jkp} + \sum_k \sum_e \sum_p Q3_{kep} t3_{kep} + \sum_e \sum_k \sum_p Q4_{ekp} t4_{ekp} + \sum_k \sum_j \sum_p Q5_{kjp} t5_{kjp} + \sum_k \sum_f \sum_p Q6_{kfp} t6_{kfp} + \sum_j F1_j X_j + \sum_k F2_k Y_k \tag{1}$$

The second objective aims to minimize the total customer service level in both forward and reverse direction.

$$Max\ f_2 = \alpha . \left(\sum_k \sum_{T(f)} \sum_p Q3_{kep} \right) + (1-\alpha) . \left(\sum_{T(r)} \sum_k \sum_p Q4_{ekp} \right) \tag{2}$$

Constraints

Balance Constraints

$$\sum_j Q1_{ij} \le Cap_i, \qquad \forall i \tag{3}$$

$$\sum_k \sum_p Q2_{jkp}(v_p) \le \sum_i Q1_{ij} + \sum_k \sum_p Q5_{kjp}(v_p), \qquad \forall j \tag{4}$$

$$\sum_j Q2_{jkp} = \sum_e Q3_{kep,} \qquad \forall k, p \tag{5}$$

$$Q3_{kep} = D_{ep} L_{ke,} \qquad \forall k, e, p \tag{6}$$

$$\sum_k L_{ke} = 1, \qquad \forall e \tag{7}$$

$$Q4_{ekp} = D_{ep} B_{ek} . RR_p, \qquad \forall e, k, p \tag{8}$$

$$\sum_k B_{ek} = 1, \qquad \forall e \tag{9}$$

$$\sum_e Q4_{ekp} RX = \sum_j Q5_{kjp,} \qquad \forall k, p \tag{10}$$

$$\sum_{e} Q4_{ekp}\ RD = \sum_{f} Q6_{kfp}, \quad \forall k, p \tag{11}$$

$$\sum_{k}\sum_{p} Q2_{jkp} \leq Cap_j X_{j,} \quad \forall j \tag{12}$$

$$\sum_{e}\sum_{p} Q3_{kep} + \sum_{j}\sum_{p} Q5_{kjp} + \sum_{f}\sum_{p} Q6_{kfp} \leq Cap_k Y_k + CapM_k H_k, \quad \forall k \tag{13}$$

$$X_j, Y_k, L_{ke}, B_{ek}, H_k \in \{0,1\},$$

$$Q1_{ij}, Q2_{jkp}, Q3_{kep}, Q4_{ekp}, Q5_{kjp}, Q6_{kfp} \geq 0, \quad \forall i, j, k, e, p$$

Constraint (3) shows that, for each product, the flow exiting from each plant is less than the sum of the flow entering to the plant from all suppliers and collection centres. Constraint (4) indicates that, the flow entering to each distribution center must be equal to the flow exiting from this distribution centre for each product. Constraint (5) imposes that, for each product, the flow exiting distribution centres must be satisfied the demand of all customers. Constraint (6) states that, distribution center k is linked to single customer in forward direction. Constraint (7) shows that, the returned product collected from customers transferred to collection center for each product. Constraint (8) describes the single sourcing of customers in backward flow. Constraint (9) shows, for each product, the flow exiting each collection center to all reproduction centres must be equal to the flow entering to each collection venter from all customers multiplied by the recovery ratio. Constraint (10) explains for each product, the flow exiting each collection center to disposal centres must be equal to the flow entering to each collection center from all customers multiplied by the disposal ratio. Constraint (11) shows the sum of the flow exiting from each plant to all distribution centres must not exceed the capacity of this plant. Constraint (12) indicates that, the sum of the flow exiting each distribution center to all customers, each collection center or hybrid processing facility to all plants and disposal centres must not exceed the capacity of relevant facility.

Numerical Examples

In this section, we presented a numerical example to indicate the proposed model. There is a set of 2 suppliers and 2 types of products are produced in 3 candidates' plant. These products are shipped to 4 distribution center or hybrid processing facilities candidates in order to meet the demand of 10 customers. In backward flow, the returned products are shipped the collection center or hybrid processing facilities to testing and inspecting and then, are transferred recovery and disposal facilities. The network composed of two objective functions, the first one is to minimize the total cost between all echelons (suppliers, manufacturing, distribution centres and customers) while the other is to maximize the customer service level in both forward and reverse networks. The priority of objectives obtained to find of purposes according to AHP methodology. According to Table 2, weight of each objective is 0.8, 0.2 respectively.

Table 1. Relatives of Objective Functions (AHP)

	F1	F2
F1	1	4
F2	1/4	1

Table 2 Normalized AHP Matrix

	F1	F2
F1	0.80	0,80

Table 3. Opening cost of facilities

Number	Opening cost of f factory	Opening Cost of k facilities
1	10200	26100
2	12050	20200
3	1000	28350
4		30000

Table 4. Capacity of facilities

Number	Capacity of f	Capacity of k
1	35000	37000
2	40000	44000
3	50000	32000
4		25000

Returned ratios of used products are 0.7 and 0.6 respectively. For returned product, the recovery ratio is %85, while disposal ratio is %15. The weighting factor for forward and reverse responsiveness are the same (α = 0.5). The numerical example has been formulated by using the proposed MILP model.

Table 5. The result obtained by Gams package

Decision	Value	Decision	Value
$Q1_{12}$	11252	$Q4_{111}$	3500
$Q1_{22}$	18000	$Q4_{212}$	1080
$Q2_{321}$	18560	$Q4_{421}$	1155
$Q2_{341}$	17250	$Q5_{242}$	20325
$Q2_{222}$	9902	$Q5_{231}$	981
$Q3_{221}$	4000	$Q5_{132}$	22465
$Q3_{251}$	2500	$Q6_{121}$	3586
$Q3_{271}$	2560	$Q6_{122}$	173

According to data obtained Gams package program, result are given Table 5. Decision maker purchased raw materials from all suppliers, 11252 units from first suppliers, 18000 units from second suppliers, are transported to manufacturers.18560 units and 17250 units which come from third manufacturer are shipped to second and fourth distribution centre. Second distribution centre is distributed the first products to customers' demand 4000, 2500, 2560 units respectively. Returned product from first, second and fourth customers are shipped 3500 and 1080 units to the first hybrid centre, 1155 units to second hybrid centre. Objective value (first and second objective functions) calculated about 4840200 Tl.

Conclusions

This paper focused the design of a bi- objective reverse logistics network. A bi- objective MIP optimization model for integrated logistic network was developed, the first objective is to minimize of total cost of networks, while second objective maximizes the customer service both forward and reverse directions. We developed model to determine from which suppliers, plants, distribution /collection /hybrid centre, how much amounts will be transported to meet customers demand. This model included binary variables decided which plant and distribution /hybrid centre are opened and shipment link is allocated between distribution centre and customers.

Further work will be addressed to improve the mathematical model by modifying the model scenario and utilization of other solving methods for multi – objective optimization.

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BIOMASS SUPPLY CHAIN: A LITERATURE SURVEY

Melda Bölek, Murat Baskak

Abstract − *The need of energy consumption in developed countries increases every day and will continue to increase in the future as well. As a result of this industrial development, the usage of natural resources is gaining more importance compared to fossil resources which harm the nature in order to provide energy. The regulation of 'Usage of Renewable Energy Resources in Energy Production', dated as 10th of May, 2005, defines renewable resources as hydraulic, wind, solar, geothermal, biomass, biogas (including sewage gas), wave, stream and tide. Our study will focus on the literature search of biomass supply chain functions, systems and network design.*

Keywords **–** *Biomass, renewable energy, supply chain.*

INTRODUCTION

Most of the energy consumed is retained from fossil sources, whereas the rest comes from nuclear and renewable energy sources. The harm that fossil fuels give to environment and the price that human beings will pay for this will reach to an extreme level. The need of energy consumption in developed countries increases every day and will increase in the future as well. The environmental problems such as air, water and soil pollution result in increased concerns regarding environment protection.

The regulation of 'Usage of Renewable Energy Resources in Energy Production', dated as 10th of May, 2005, defines renewable resources as hydraulic, wind, solar, geothermal, biomass, biogas(including sewage gas), wave, stream and tide [43].

According to the Renewable Energy Directive 2009/28/EC in European Union, until 2020 the member countries have to;

- Decrease the level of greenhouse gas emissions less than 20%,
- Gain at least 20% of energy consumption from renewable energy sources,
- Gain 10% of the transportation energy from renewable energy sources,
- Decrease 20% of energy consumption(without stopping industrial development),

Figure 1 shows the previous and current renewable energy consumption of European Union countries.

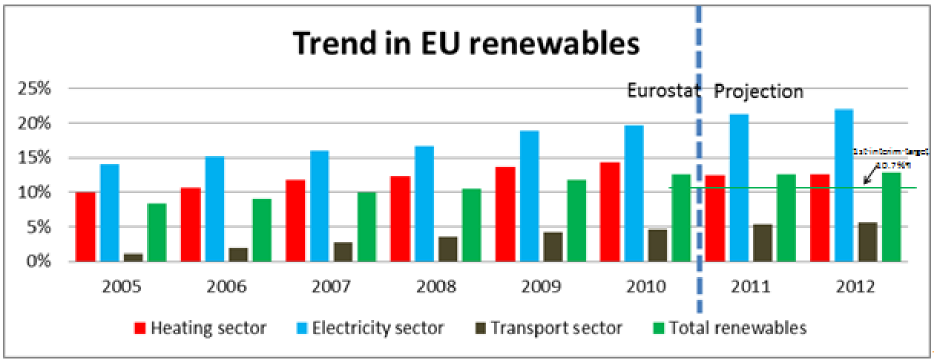

Figure 1. Renewable Energy Trend in European Union.

As seen in Figure 2, in year 2010's report all member countries have exceeded their country targets.

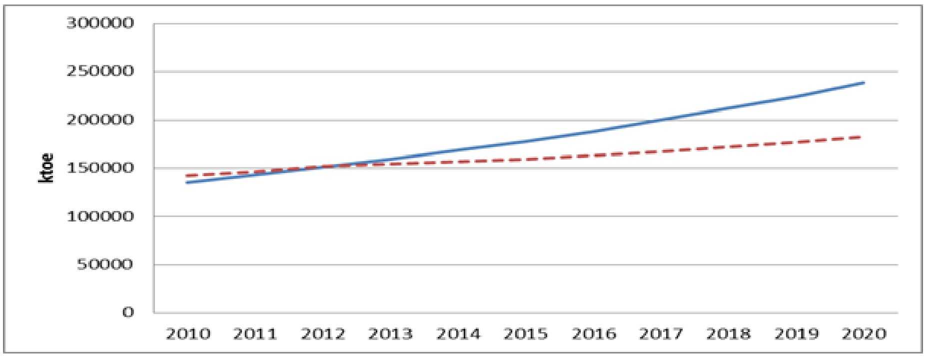

Figure 2. 2010-2020 Targeted and forecasted actual renewable energy production
(Blue: targeted, red: forecasted actual).

As of 2010, in Euro Zone the percent of renewable energy production was 8, 7% of whole energy production. According to the commission's study, in 2020, due to the local politics, economic crisis, managerial barriers and long investment durations, the renewable energy production will be below the planned value. The targeted versus forecasted actual biomass sourced renewable energy is shown in Figure 3.

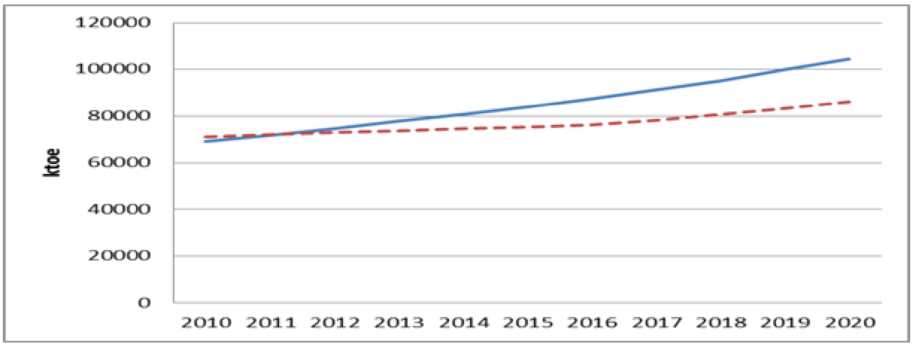

Figure 3. Targeted vs forecasted actual biomass energy production in the EU
(Blue: targeted, red: forecasted actual).

According to the Act 5346, biomass incudes not only organic waste but also vegetable oil waste, agricultural waste and all solid, liquid and gas fuels that are gained from agricultural and forest products.

Biomass energy sources include some features different from fossil energy sources such as coal, petrol and natural gas. Biomass sources are generally non homogeneous, with high water and oxygen content, low density, low heat content which result in bad quality of fuels.

These negative features can be eliminated by physical and transformation processes. Advantages of biomass energy can be stated as below:

- It can be grown everywhere
- There is knowledge in production technologies
- Energy can be produced in every scale
- Adequate in low light
- Can be stored
- 5-35˚C is enough for performance
- Important in socio-economic situations
- Creates no pollution (low NOx and SO2)
- Creates less greenhouse effect compared to other energy sources
- Balances CO2 in atmosphere
- Creates no acid rain

LITERATURE REVIEW

Agricultural Biomass

Supporting the renewable energy sources decreases environmental problems such as dependency on fossil sources, air pollution and greenhouse emission gases [13, 33]. Usage of biomass creates a vital energy source [40]. Various researches focused on biomass usage in energy production were carried out [3, 28, 42].

A general approach for biomass supply chain is shown in Figure 4.

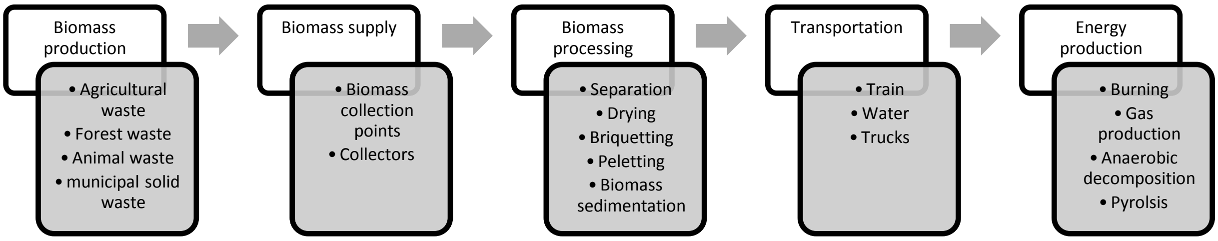

Figure 4. Biomass supply chain.

The main bottleneck for biomass usage in energy production is the logistics cost. There is a need for a more detailed approach in order to manage the increasing biomass demand and multi-step supply chain network. The quality and quantity of biomass needed according to energy demand structure, energy production technology and the final usage of energy depends on cost effectiveness and efficiency of logistics operations. Regional capacities and seasonality also limit the biomass production systems.

Figure 5 indicates the five elements of biomass supply chain in summary.

Figure 5. Biomass supply chain.

Biomass supply chain differs from other supply chains from a number of points. Due to the seasonality of agricultural biomass, biomass has to be stored throughout the year [36]. In order to decrease the seasonality problems, similar multi biomass can be used [32]. Since biomass density is low, transportation and warehousing needs are increasing and specialised collection and handling must be arranged. Limited shelf life, demand and price elasticity, weather fluctuations result in complexity in biomass supply chain. This issue is very critical in creating buffer in demand and transportation difference for high perishable biomass.

The relationships between variables in a biomass logistics system and reflections of these in supply chain effectiveness and costs have been discussed in various studies [1, 4, 15, 21, 24].

Usually, the energy conversion points are located near the biomass sources. However recently, biomass is collected from different suppliers even imported from other countries. Harvest policies, marketing channels, logistics activities, vertical coordination and risk management have to be investigated in detail [9]. In this sense, the decision process has to be evaluated as strategic, tactical and operational [5, 35].

In the strategic level, biomass supply management, selection of collection and conversion points, selection of suitable energy conversion system, supply chain network design, selection of collection-pre-processing-warehousing machinery, information technology system design are topics to be discussed. The decisions taken at this level affect the operations and provide limitations to sublevel decisions.

The tactical level includes aggregate production planning, supply chain coordination, inventory management and vehicle routing. In operational level daily issues such as stock control is managed [16]. A short summary of biomass decisions can be seen in Figure 6.

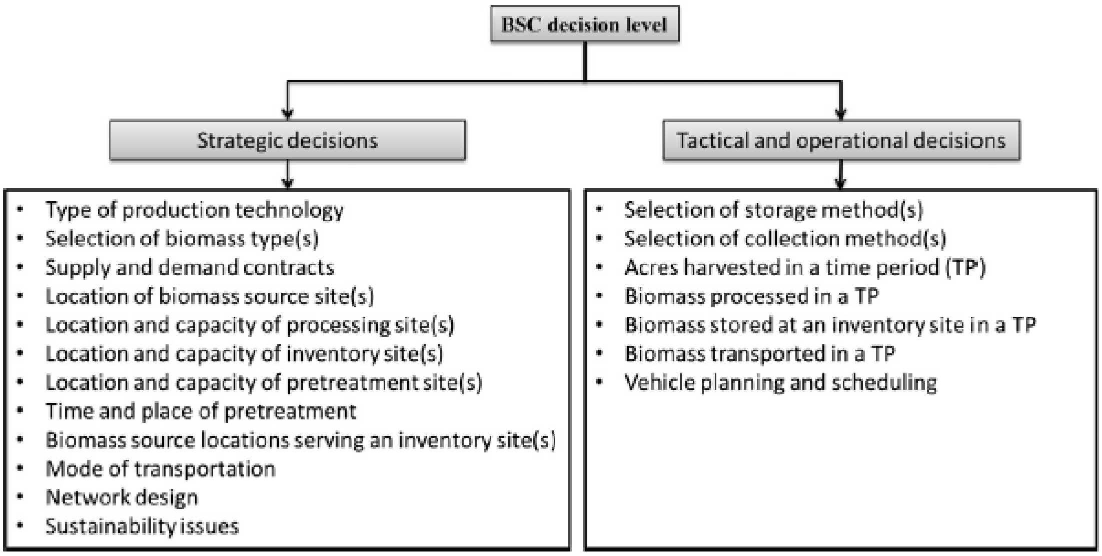

Figure 6. Decision levels in biomass supply chain [34].

Fuels can be extracted from biomass through physical (downsizing, breaking, grinding, drying, filtration, extraction and briquetting) and transformation (biochemical and thermochemical) processes. Transformation processes are illustrated in Figure 7.

Conversion processes	Technological solutions	Final products
Thermochemical processes	Combustion	● Steam ● Process heat ● Electric energy
	Gasification	● Steam ● Process heat ● Electric energy ● Fuel gas methane
	Pyrolysis	● Charcoal ● Bio-coal ● Fuel gas
Biochemical processes	Fermentation Anaerobic digestion	● Ethanol ● Water for irrigation ● Compost ● Biogas

Figure 7. Transformation processes and final products in biomass supply chain [19].

Animal Biomass

Animal waste's features depends on various criteria such as animal type, nutrition habits and season. One of the important factor that specifies suitability to biological processes is the waste's solubility. Since lignin resists against the microbiological attacks in cow's waste the biological solubility is low. Therefore in anaerobic decomposition mixing animal waste with other industrial organic wastes under suitable conditions and ratios performs more effective results [41]. Some features of animal waste can be seen in Table 1.

Table 1. Features of some animal waste [2].

Parameter	Cow-ox (milk production)	Cow-ox (meat production)	chicken (meat and egg)	lamb
Animal weight, kg	636	431	2.0-2.3	45
waste, lt/day	36.8	28.3	0.095-0.160	3.1
waste density, t/m^3	0.99	0.96	0.96	1.04
waste mass, %	15	15	15-85	23

The main problem faced in animal waste is the transportation of the waste to central units. Therefore Source Maps have to be drawn. Source maps define the capacity and the quantity of the waste sources. It has been studied that if the dry mass of the farm animal waste is around 70%, it can be transported until 40km distance whereas 10% dry mass can be transported to 10km distance economically [2]. The maximum proven distances proven to be economically transportable are shown in Table 2.

Table 2. Dry mass ratios and suggested transportation distances [2].

Group	dry mass (%)	distance (km)
Cow and lamb	8-15	10
Egg production and poultry(only waste)	30	40
Poultry for meat (sewage + waste)	70	40

In 2001, TUBITAK carried out a feasibility research in three areas for gaining energy from animal waste, manure production and removing waste according to environmental guidelines. For Kayseri anaerobic decomposition, for Çorum composting and for Manyas gasification is selected. The founding of the study was;

a. In composting and anaerobic decomposition, the payback period is 5-6 years. After this, the plants will be profitable by selling electricity and manure.
b. In gasification, depending on the sales price of the energy, the payback period is 3, 5-5 years.

Forest Biomass

The different biomass types are characterized by a set of physical/chemical parameters that influence the efficiency of the various processes [19]. An important parameter is the volumetric mass, VM [kg/m^3], i.e. the ratio between the dry mass [kg] and the volume [m^3]. The biomass moisture content, MC [%], represents the water amount present in the biomass and it can be expressed as a percentage of the dry weight. The moisture content MC of the biomass is extremely variable, as it depends on the species, on the biomass age at collection, and on the time that elapses between collection and use in the conversion plant. Heating value is one of the most important parameters of biomass fuels because it indicates the energy content of a material and is usually measured as the energy content per unit mass [11].

The woody biomass resources can be considered in two groups: forest and non-forest. The first group includes the biomass directly collected in the forest parcels, while the second group includes the biomass coming from agricultural or industrial sectors. The forest operations are represented by the felling, processing and primary transportation phases. In the present work, the felling and processing phases, are relevant to the operations executed by chainsaw [11]. The productivity depends on the execution time of debarking, delimbing, and cross cutting operations.

The forest primary transportation is the transport from the felling areas to the landing points near the first available road. The landing points are collection areas where the forest biomass is temporarily collected before being transported to a warehouse or to the plant. The transportation technique depends on the slope class of the sub parcel. The productivity decreases with the increase of the distance from the felling areas to the landing points [11]. The forest biomass supply chain is seen in Figure 8.

A forest supply chain network, in which forest wood residues from final cuttings that are used to produce torrefied wood in two torrefaction plants which supply to one gasification unit was designed [27]. In the study a location-allocation model based on least delivery cost was used.

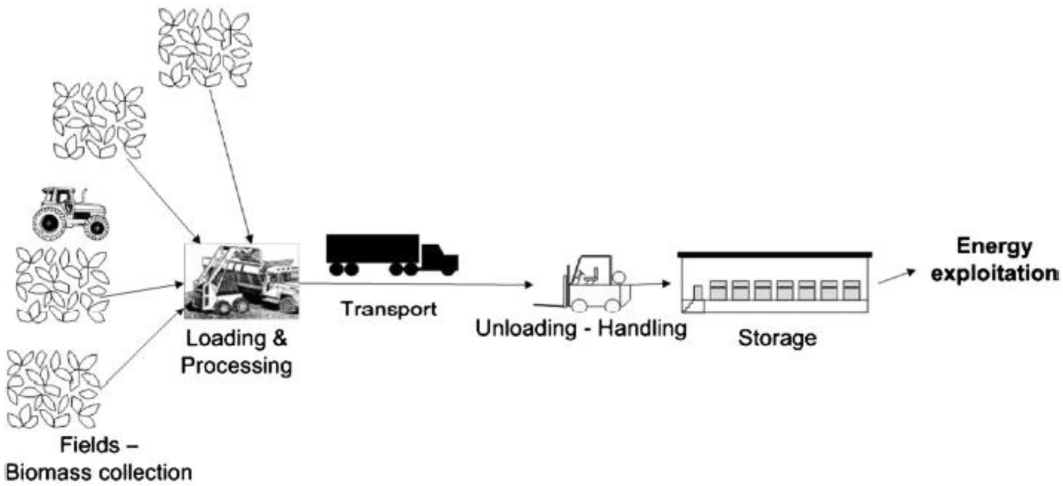

Figure 8. Forest biomass supply chain [29].

Taken several aspects (economic, technical, regulatory, and social), decision support systems for the locating energy plants and computing their optimal sizing (defining which kind of energy is convenient to produce for the specific area) are studied [10]. Biomass collection and harvesting are also planned in these studies.

Municipal and Industrial Solid Waste

Waste materials are generated from manufacturing processes, industries and municipal solid wastes (MSW) [17]. In literature, MSW is defined as waste durable goods, nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, and industrial sources. In waste management, at first, waste minimization is aimed. Secondly, recycling is studied and promoted through trainings given by authorities to locals. Thirdly, energy conversion methods are applied. As the fourth option, waste is safely removed. MSW is collected by local authorities and gathered at collection points and then transferred to either energy plants or storage areas.

In Turkey, depending on life quality, 60-65% of the MSW is organic whereas the rest is paper, textile, plastic, leather, metal, wood, glass and ash.

MODELLING

When modelling the variables in supply chain is concerned, supply chains can be classified in two, namely deterministic and stochastic [20]. Deterministic models include linear programming and mixed integer programming. Stochastic models include simulation, sequenced quadratic programming, genetic algorithm and heuristic approaches. A more detailed diagram of supply chain decision models is as illustrated in Figure 9.

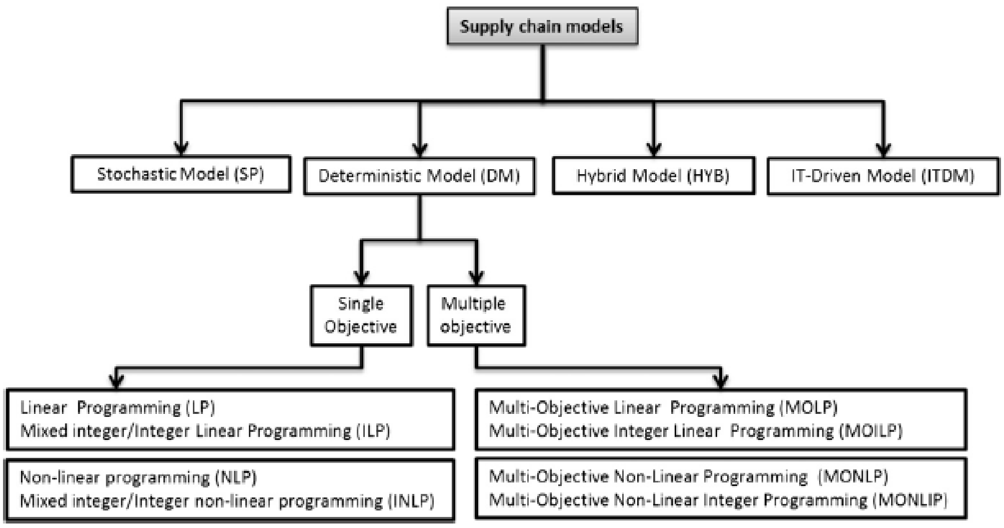

Figure 9. Supply chain decision models [32].

In analysis of biomass supply chain costs, table analysis is used. These are useful for decision support systems, scenario modelling and sensitivity analysis [6]. It is found out that 20-50% of the cost comes from transportation and handling [1]. Various bioenergy conversion technologies with a Bioenergy Evaluation Model were evaluated [21] and was used in another study which focused biomass production, collection and warehousing in short rotation forestry [22].

An international logistics scenario which includes a production point, a central collection point, export and import terminals and an energy plant was studied [15]. This study also determined the possible effects of various parameters on supply chain performance. 56-76% of the operational costs come from logistics [4].

The linear model that optimised the distances of biomass sources to a central production plant was developed [7]. Specifically monthly production, delivery and capacity programs depending on weather changes were studied. The cotton straw supply chain was optimised by a linear programming model [36] whereas geographic information system based decision support systems were analysed in energy production with forestry waste [10, 11].

Mixed integer linear programming was used by in investment decisions [23], in forecasting annual flow under different scenarios in biomass supply chains [8] and for alternative supply, transportation and processing [39]. However all of these models focused on a part of the supply chain deterministically but not as a whole.

While investigating the bioenergy systems authors faced with different dimensions other than linearity. Most of the nonlinear methods do not provide the best solution. Computer simulation models have been widely used in biomass supply chains [12]. A cost based simulation model named Biologics (BIOmass LOGIstics Computer Simulation) and its application with PROSIM simulation package was carried out [8]. Several studies were carried out in wheat straw handling simulation [24, 25, 26]. The Integrated Biomass Supply, Analysis and Logistics (IBSAL) model which included seasonal and operational limits, supply and transportation operations and biomass logistics cost from the field to the bio refinery was developed and also applied with three biomass types [18, 37]. Heuristic approaches are also used in forest supply chain [14]. Various management parameters whilst comparing two policies in biomass logistics system with separate simulation models was analysed [29].

Considering multi biomass energy conversion applications, a decision support system can be developed [29]. In another approach, a good solution from the optimisation is selected by genetic algorithm and a further improvement with sequenced quadratic programming is applied. Warehousing three types of biomass together was another issue in warehouse criteria [31, 32].

CONCLUSION

Biomass supply chains differ from other supply chains since it requires knowledge in many disciplines such as agriculture, forestry, animal breeding, warehousing, logistics and energy production. One of the main flaws in Turkey is that there is no stable biomass supply market where the biomass can be traded. Therefore the supply analysis and its pricing strategy is of high importance and should be worked on. The coordination among collection points and the logistics network design will affect the logistics costs which is the highest cost element in the biomass supply chain. Various mathematical models can be improved in order to design the network efficiently.

In further analysis of biomass supply chain, geographic information systems (GIS) for quantity analysis and selection of collection points and energy conversion plant can be used. Recently there has been an increasing interest in biomass supply chain with GIS applications. In the literature, it has been concluded that most of the studies were focused on only economic variables of the biomass supply chain. However with the growing importance of environmental issues, environmental and social factors have to be included in the biomass supply chain model as well as the economic factors.

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LEAN AND GREEN @ INTRALOGISTICS CASE STUDY: SBS/RS VERSUS AS/RS

Tone Lerher[27], Iztok Potrč[28], Tomaž Kramberger[29], Bojan Rosi[30], Goran Dukic [31]

Abstract – Attention in lean and green intralogistics has been increasing recently. Automated storage and retrieval systems that are used to buffer materials and products for a specific time period to be used later play significant role in intralogistics activities. In this study, we analyze an autonomous vehicle system known as shuttle-based storage and retrieval system (SBS/RS) in comparison with traditional crane-based system known as mini load automated storage and retrieval system (CBAS/RS). Models for throughput and energy consumption calculations have been proposed for both systems. We also present performance comparison of SBS/RS and mini-load CBAS/RS for the selected storage rack configurations and velocity profile of the selected material handling equipment. The results may serve as guidelines to warehouse designers and managers for designing new or improving existing automated warehouses.

Keywords – Lean and green, intralogistics, automated warehouses, efficiency analysis

INTRODUCTION

Lean philosophy is one of the most important trends. In general, the lean concept is about the elimination of waste, decrease of inventory and manufacturing lead times, which ultimately increases supply chain efficiency. Other significant global trends are environmental protection and energy efficiency initiatives, known as Lean&Green. According to the literature review, the most significant wastes (inventory, transportation, space and time, packaging, etc.) are deeply engaged with the intralogistics. If the intralogistics is about managing inventory and operating the internal transport, warehousing and packaging, the Lean&Green concept is about speed, flow and energy efficiency of the material handling equipment. It is generally known that the cost of intralogistics could range up to 20 % of the total cost, based on the type of industry. In order to restrict the cost of intralogistics to a reasonable level, new concepts for designing intralogistics processes and systems are required. In this study we present a case study where performance of an SBS/RS is compared with a traditional crane-based system autonomous storage and retrieval system (CBAS/RS).

Autonomous Vehicle Storage and Retrieval Systems (AVS/RS), a relatively new technology for automated unit-load systems, has been implemented at many facilities, primarily in Europe [19]. Due to the ability of accessing any storage positions in the storage racks and flexibility in changing the number of autonomous vehicles, this system has advantages compared to traditional crane-based system and has been successfully researched by the following authors [2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 19, 20, 23, 25].

Shuttle-Based Storage and Retrieval Systems (SBS/RS) are widely used in many fields of industry, where the basic transport unit load is presented by a tote and has been successfully researched by the following authors [1, 16, 17, 18, 21, 22, 24]. The SBS/RS is composed of multiple parallel aisles of Storage Racks (SR), elevator (lift) intended for each aisle of the SR, tier-captive shuttle carriers, Input and Output (I/O) location, buffer position in each tier and roller conveyors. Advantages of SBS/RS are: efficient utilization of the warehouse space, reduction of damage and loss of goods, increased control upon storage and retrieval of goods and decrease in the number of warehouse workers. However, due to having an autonomous vehicle in each tier,

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SBS/RS requires a high initial investment cost compared to other types of automated warehouses [17]. A mini load CBAS/RS is in generally composed of a picking aisle with single deep SR on both sides of the aisle, Storage and Retrieval (S/R) machine, Input and Output (I/O) location and accumulating conveyors. Advantages of the application of mini load CBAS/RS are: efficient utilization of warehouse space, reduction of damage and loss of goods, increased control upon storage and retrieval of goods and decrease in the number of warehouse workers. On the other hand mini load CBAS/RS also requires a high initial investment and they are rather inflexible to meet future demands. Therefore, a careful design of mini load CBAS/RS is crucial for an AS/RS to be successful [15].

The performance of SBS/RS and mini load CBAS/RS is often evaluated in terms of throughput rate (number of totes processing per hour). Since the objective of this paper is to analyze Lean&Green concept, energy consumption and CO_2 emissions are as much important as the throughput capacity of the system. For this reason the comparison of both systems has been done according to the throughput performance, energy consumption and CO_2 emissions.

SHUTTLE-BASED STORAGE AND RETRIEVAL SYSTEMS

Shuttle-Based Storage and Retrieval Systems (SBS/RS) are composed of elevator with lifting tables that are attached on the mast, shuttle carriers, buffer positions and the storage racks (Figure 1).

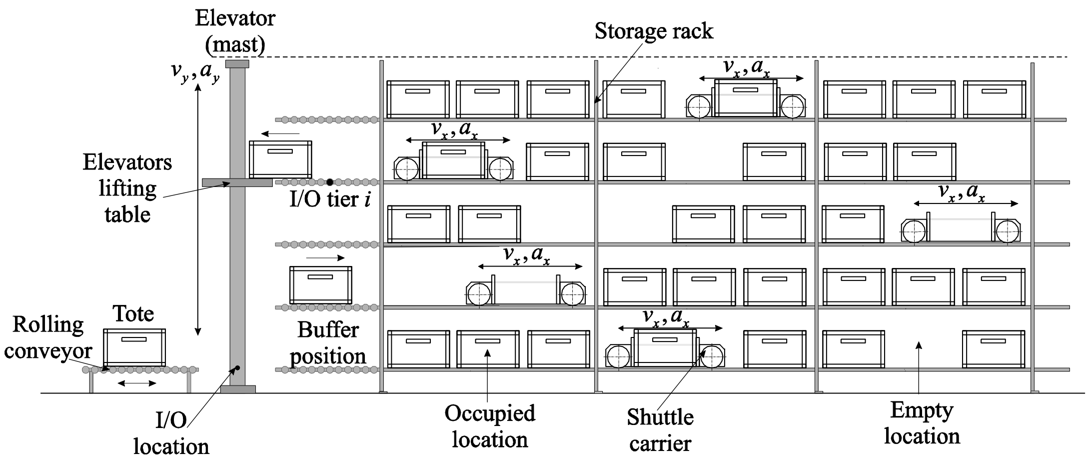

Figure 1. Shuttle-based storage and retrieval systems [15]

The elevator through the lifting table moves totes up and down to the prescribed level in the storage rack. In the studied system, an elevator can carry two loads placed on its right and left sides simultaneously. An elevator can move lifting tables up to v_y = 3.0 m/s. Elevators are often bottlenecks in the system so they usually determine the performance of the system [16, 17, 18].

A shuttle carrier is a small autonomous vehicle that transports totes from the buffer position to the storage locations in the storage racks. It is equipped with telescopic attachment for manipulating totes. The maximal weight of a tote should not exceed 50 kg/shuttle carrier. A shuttle carrier can travel up to v_x = 4 m/s. There are two buffer positions placed either side of the storage rack and is used for buffering the totes from the elevator and shuttle carriers. The storage rack is composed of storage compartments that can receive n totes. By multiplying storage compartments in the horizontal and in the vertical direction, the length L and the height H of the storage rack is achieved. The storage rack can be implemented as a single or a double deep [16, 17, 18].

CRANE-BASED MINI LOAD AUTOMATED STORAGE AND RETRIEVAL SYSTEMS

An important part of warehouses are CBAS/RS, which are widely used in automotive, chemical, pharmaceutics industry, where the Transport Unit Load (TUL) is presented by a container. This system is generally composed of a picking aisle with single-deep Storage Rack (SR) on both sides of the aisle, anS/R machine, I/O location and accumulating conveyors (Figure 2).

Due to increasing requests for higher throughput capacities and shorter response times in handling orders, special design of S/R machines with extremely high velocities for travelling in the horizontal and hoisting in the vertical direction, have been introduced to the market. Other way to increase the throughput capacity is the application of the multi-shuttle S/R machines that can receive up to three containers simultaneously [15].

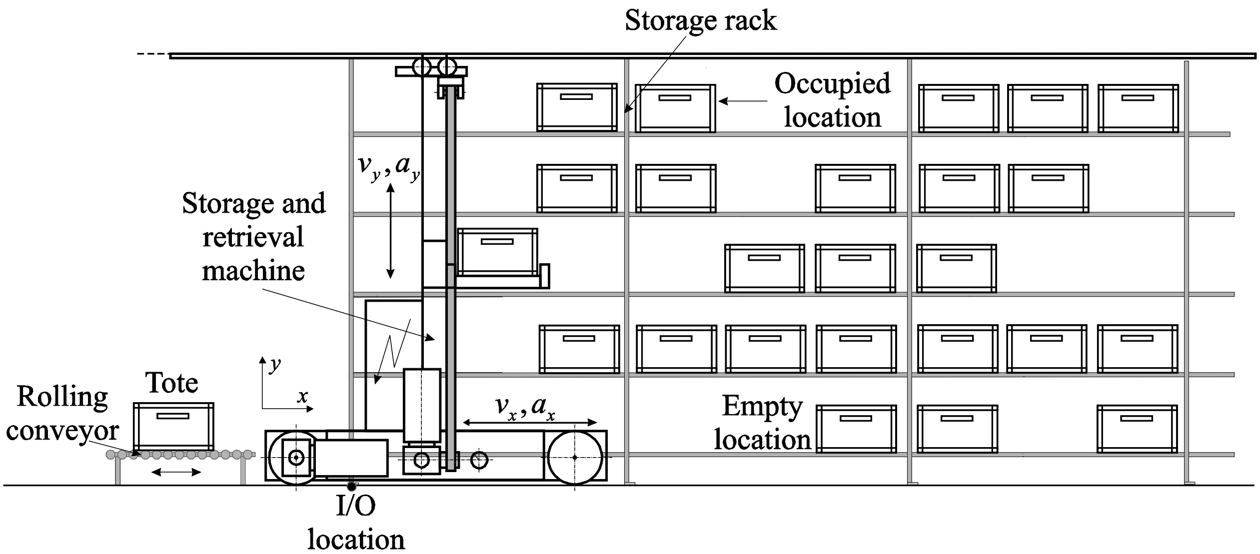

Figure 2. Crane-based mini-load automated storage and retrieval systems

MODEL FOR THROUGHPUT AND ENERGY CONSUMPTION CALCULATIONS

In continuation model for throughput and energy consumption calculation is presented. Since the throughput performance is inversely dependent on the travel (cycle) time, the foundation of travel time is presented. Expressions for travel (cycle) times and energy consumptions are based on analytical expressions that have been previously published in international journals. Because of double command cycles dominate over single command cycles, double command cycles have been used in our research.

Foundation of travel time

Two types of velocity profiles can be distinguished depending on whether the obtained peak velocity $v(t_p)$ is less than $v_{\max}$ (type I) or equal to $v_{\max}$ (type II) (see Figure 3). It can be verified that time $T < 2v_{\max} / a$ for type I and $T > 2v_{\max} / a$ for type II [14].

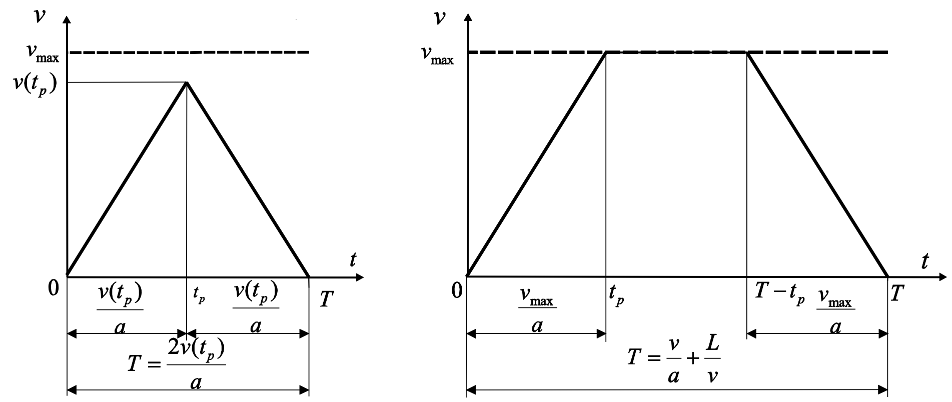

Figure 3. Velocity time dependence of travel time for type I and II [14]

- Travelling for type I

The velocity in dependence of time $v(t)$ equals the following expression:

$$v(t) = \begin{cases} at, & t \in (0, t_p) \\ -a(t - T), & t \in (t_p, T) \end{cases} \tag{1}$$

The distance in dependence of time $d(T)$ equals the following expression:

$$d(T) = \int_0^T v(t)dt = \frac{a \cdot T^2}{4} \tag{2}$$

Because of the acceleration and deceleration are equal in magnitude, the time necessary to reach the peak velocity equals $t_p = T / 2$. For the verification of (2) see [14].

- Travelling for type II

The velocity in dependence of time $v(t)$ equals the following expression

$$v(t) = \begin{cases} at, & t \in (0, t_p) \\ v_{\max}, & t \in (t_p, T - t_p) \\ -a(t - T), & t \in (T - t_p, T) \end{cases} \tag{3}$$

The distance in dependence of time $d(T)$ equals the following expression

$$d(T) = \int_0^T v(t)dt = v_{\max} \cdot T - \frac{{v_{\max}}^2}{a} \tag{4}$$

For the verification of (4) see [14].

Shuttle-based storage and retrieval systems

- **Travel time, throughput performance and energy consumption of the elevator**

Travel times of the elevator, which is feeding the storage rack are variable times. They depend on the kinematics properties of the elevators lifting table, the height H of the SR and the storage policy.

Expected dual command cycle time of the elevator $E(\mathrm{DC})_{\mathrm{LIFT}}$ equals the following expression:

$$E(\mathrm{DC})_{\mathrm{LIFT}} = 4 \cdot t_{\mathrm{P/S\ LIFT}} + E(\mathrm{SC})_{\mathrm{LIFT}} + E(\mathrm{TB})_{\mathrm{LIFT}} \tag{5}$$

where $t_{\mathrm{P/S\ LIFT}}$ stands for the pickup and set down times for the elevator, $E(\mathrm{ES})_{\mathrm{LIFT}}$ stands for the expected one way travel time for travelling from the I/O location to any randomly selected buffer position in the i^{th} tier of the SR and $E(\mathrm{TB})_{\mathrm{LIFT}}$ stands for the expected one way travel time for travelling from the buffer position in the i^{th} tier of the SR to any randomly selected buffer position in the j^{th} tier of the SR.

For a more detailed insight into the statistical analysis of travel time considering the real operating characteristics of the elevator, see paper Lerher et al. [17].

Throughput capacity in case of double command cycle of the elevator $\lambda(\mathrm{DC})_{\mathrm{LIFT}}$ equals the following expression:

$$\lambda(\mathrm{DC})_{\mathrm{LIFT}} = \frac{3600}{E(\mathrm{DC})_{\mathrm{LIFT}}} \cdot k \qquad (k = 2) \tag{6}$$

Energy consumption of elevator EC_{LIFT} counted on a yearly basis depends on the engine power of the elevator P_{LIFT}, efficiency of the elevator η_{LIFT}, number of working hours in a shift T_{shift}, number of working days in a week n_{wd}, number of weeks n_{weeks}, number of elevators lifting tables n and is calculated by (7):

$$EC_{\mathrm{LIFT}} = P_{\mathrm{LIFT}} \cdot \eta_{\mathrm{LIFT}} \cdot T_{shift} \cdot n_{wd} \cdot n_{weeks} \cdot n \tag{7}$$

NOTE: In practice the energy consumption of the elevator is not completely equal to the expression (7), but is equal to the integral of the power consumption over time. It is assumed that the simplified expression is good enough for the study, which is to analyze the throughput and energy consumption of the SBS/RS.

- **Travel time, throughput performance and energy consumption of the shuttle carrier**

Travel times of the shuttle carrier in the i^{th} tier of the SR are variable times. They depend on the kinematic properties of the shuttle carrier, the length L of the SR and the storage policy.

Expected dual command cycle time of the shuttle carrier $E(\mathrm{DC})_{\mathrm{SCAR}}$ equals the following expression:

$$E(\mathrm{DC})_{\mathrm{SCAR}} = 4 \cdot t_{\mathrm{P/S\ SCAR}} + E(\mathrm{SC})_{\mathrm{SCAR}} + E(\mathrm{TB})_{\mathrm{SCAR}} \tag{8}$$

where $t_{\mathrm{P/S\ SCAR}}$ stands for the pickup and set down times for the shuttle carrier, $E(\mathrm{ES})_{\mathrm{SCAR}}$ stands for the expected one way travel time for travelling from the I/O location to any randomly selected storage location in the i^{th} tier of the SR and $E(\mathrm{TB})_{\mathrm{SCAR}}$ stands for the expected one way travel time for travelling from the i^{th} storage location in the SR to randomly selected j^{th} storage location of the SR.

For a more detailed insight into the statistical analysis of travel time considering the real operating characteristics of the shuttle carrier, see paper Lerher et al. [17].

Throughput capacity in case of double command cycles of the shuttle carrier $\lambda(\mathrm{DC})_{\mathrm{SCAR}}$ equals the following expression:

$$\lambda(\mathrm{DC})_{\mathrm{SCAR}} = \frac{3600}{E(\mathrm{DC})_{\mathrm{SCAR}}} \cdot k \quad (k=2) \tag{9}$$

Energy consumption of shuttle carriers EC_{SCAR} counted on a yearly basis depends on the engine power of the shuttle carrier P_{SCAR}, efficiency of the shuttle carrier η_{SCAR}, number of working hours in a shift T_{shift}, number of working days in a week n_{wd}, number of weeks n_{weeks}, number of shuttle carriers n and is calculated by (10):

$$EC_{\mathrm{SCAR}} = P_{\mathrm{SCAR}} \cdot \eta_{\mathrm{SCAR}} \cdot T_{shift} \cdot n_{wd} \cdot n_{weeks} \cdot n \tag{10}$$

NOTE: In practice the energy consumption of the shuttle carrier is not completely equal to the expression (10), but is equal to the integral of the power consumption over time. It is assumed that the simplified expression is good enough for the study, which is to analyze the throughput and energy consumption of the SBS/RS.

Crane-based automated storage and retrieval systems

Travel times of the S/R machine to any randomly selected location in the SR are variable times. They depend on the kinematics properties of the S/R machine and the hoisted carriage, the length L and the height H of the SR and the storage policy. For a more detailed insight into the statistical analysis of travel time considering the real operating characteristics of the S/R machine, see paper Hwang and Lee [11].

Expected dual command cycle time $E(\mathrm{DC})_{\mathrm{AS/RS}}$ equals the following expression:

$$E(\mathrm{DC})_{\mathrm{AS/RS}} = 4 \cdot t_{\mathrm{P/S}} + E(\mathrm{SC})_{\mathrm{AS/RS}} + E(\mathrm{TB})_{\mathrm{AS/RS}} \tag{11}$$

where $t_{\mathrm{P/S}}$ stands for the pick up and set down times of the S/R machine, $E(\mathrm{ES})_{\mathrm{AS/RS}}$ stands for the expected one way travel time for travelling of the S/R machine from the I/O location to any randomly selected storage location in the storage rack and $E(\mathrm{TB})_{\mathrm{AS/RS}}$ stands for the expected one way travel time for travelling of the S/R machine from the i^{th} to the j^{th} randomly selected storage location in the SR.

Throughput capacity in case of dual command cycles $\lambda(\mathrm{DC})_{\mathrm{AS/RS}}$ equals the following expression:

$$\lambda(\mathrm{DC})_{\mathrm{AS/RS}} = \frac{3600}{E(\mathrm{DC})_{\mathrm{AS/RS}}} \cdot k \quad (k=2) \tag{12}$$

Energy consumption of the storage and retrieval machine EC_{CRANE} counted on a yearly basis depends on the engine power of the storage and retrieval machine P_{CRANE}, efficiency of the storage and retrieval machine η_{CRANE}, number of working hours in a shift T_{shift}, number of working days in a week n_{wd}, number of weeks n_{weeks}, and is calculated by (13):

$$EC_{\mathrm{AS/RS}} = P_{\mathrm{AS/RS}} \cdot \eta_{\mathrm{AS/RS}} \cdot T_{shift} \cdot n_{wd} \cdot n_{weeks} \tag{13}$$

Energy consumption of the hoisted carriage EC_{HOIST} counted on a yearly basis depends on the engine power of the hoisted carriage P_{HOIST}, efficiency of the hoisted carriage η_{HOIST}, number of working hours in a shift T_{shift}, number of working days in a week n_{wd}, number of weeks n_{weeks}, and is calculated by (14):

$$EC_{\mathrm{AS/RS}} = P_{\mathrm{AS/RS}} \cdot \eta_{\mathrm{AS/RS}} \cdot T_{shift} \cdot n_{wd} \cdot n_{weeks} \tag{14}$$

NOTE: In practice the energy consumption of the storage and retrieval machine and the hoisted carriage is not completely equal to expressions (13 and 14), but is equal to the integral of the power consumption over time. It is assumed that the simplified expressions are good enough for the study, which is to analyze the throughput and energy consumption of the AS/RS.

PERFORMANCE ANALYSIS AND RESULTS

In this section, main input data for the analysis are provided and discussed. Stock keeping unit represents a tote filled with items with the following dimensions: length l_{tote} = 0.6 m, width w_{tote} = 0.4 m and height h_{tote} = 0.24 m. With regard to the tote, the storage location has the following dimensions: length (depth) of the storage rack l_{COM} = 0.6 m, width of the column w_{COM} = 0.5 m and height of the tier h_{COM} = 0.50 m. Dimensions of the storage rack (*L* and *H*) depends on the number of columns *C* in the horizontal direction and number of tiers *M* in the vertical direction, respectively [17].

In continuation the geometrical properties of the SR (Table 1), velocity profiles (Table 2 and 3) and other relevant input data for the analysis (Table 4) will be provided.

Table 4. Storage rack

Storage rack configuration (RC*i*)	Number of tiers (*M*)	Number of aisles (*A*)	Number of columns (*C*)	Length of the SR (*L*)	Height of the SR (*H*)	Warehouse volume (*Q*)
1	12	1	60	30	6	1440

Table 2. Velocity profile of the storage and retrieval machine and the hoisted carriage

Velocity profile (vp$_i$)	Storage and retrieval machine			Hoisted carriage		
	v_x (m/s)	a_x^+ (m/s^2)	a_x^- (m/s^2)	v_y (m/s)	a_y^+ (m/s^2)	a_y^- (m/s^2)
1	6	3	3	3	3	3

Table 3. Velocity profile of the shuttle carrier and the elevator

Velocity profile (vp$_i$)	Shuttle carrier			Elevator		
	v_x (m/s)	a_x^+ (m/s^2)	a_x^- (m/s^2)	v_y (m/s)	a_y^+ (m/s^2)	a_y^- (m/s^2)
1	2	2.5	2.5	2.5	1.5	1.5

Table 4. Other input data

Variable	Units of measure	Data
$t_{\text{P/S AS/RS}}$	s	2.65
$t_{\text{P/S SCAR}}$	s	3.00
$t_{\text{P/S LIFT}}$	s	2.00
$P_{\text{S/R MAS.}}$	kW	15.00
$P_{\text{S/R HC}}$	kW	10.00
P_{LIFT}	kW	2.50
P_{SCAR}	kW	0.36
T_{shift}	hours	16
n_{wd}	days	5
n_{weeks}	weeks	50

Throughput performance calculations for CBAS/RS and SBS/RS

Table 5 summarizes expected dual command cycle time $E(\mathrm{DC})_{\mathrm{AS/RS}}$ of the S/R machine along with the throughput performance $\lambda(\mathrm{DC})_{\mathrm{AS/RS}}$ of the mini-load AS/RS. Tables 6 summarizes expected dual command cycle time of the shuttle carrier $E(\mathrm{DC})_{\mathrm{SCAR}}$ and the elevators lifting table $E(\mathrm{DC})_{\mathrm{LIFT}}$ along with the throughput performance of the shuttle carrier $\lambda(\mathrm{DC})_{\mathrm{SCAR}}$ and the elevators lifting table $\lambda(\mathrm{DC})_{\mathrm{LIFT}}$.

Table 5. Travel time and throughput performance of the mini-load AS/RS

RC*i*	S/R machine $T(\mathrm{DC})_{\mathrm{AS/RS}}$ (sec.)	S/R machine $\lambda(\mathrm{DC})_{\mathrm{AS/RS}}$ (totes/hour)	$\eta_{\mathrm{AS/RS}}$ (/)	$\lambda(\mathrm{DC})_{\mathrm{AS/RS}}$ (totes/hour)
1	23.02	297	0.95	297

Table 6. Travel time and throughput performance of the SBS/RS

RC*i*	Shuttle carrier $T(\mathrm{DC})_{\mathrm{SCAR}}$ (sec.)	Shuttle carrier $\lambda(\mathrm{DC})_{\mathrm{SCAR}}$ (totes/hour)	Elevator $T(\mathrm{DC})_{\mathrm{LIFT}}$ (sec.)	Elevator $\lambda(\mathrm{DC})_{\mathrm{LIFT}}$ (totes/hour)	η_{SCAR} (/)	η_{LIFT} (/)	$\lambda(\mathrm{DC})_{\mathrm{SBS/RS}}$ (totes/hour)
1	28.84	3000	15.48	465	0.16	1.00	465

Throughput performance of both systems (AS/RS and SBS/RS) depends on the geometric properties (*L* and *H*) of the SR, the velocity profile of material handling devices and the storage policy. Compared to mini-load AS/RS, the throughput performance of the SBS/RS is larger for 168 totes/hours, which proves to be better for the selected installation. Throughput performance of SBS/RS is calculated according to the expected bottleneck of the elevator. Usually the bottleneck of the SBS/RS is the elevator, except for some special cases, where we have the installation configuration with small number of tiers *M* (small SR) and large number of columns *C* (long SR). Since both systems should be carefully designed, that is not to spend too much energy and to release too much CO_2, energy consumption and CO_2 emissions will be evaluated and discussed in the next subchapter.

Energy consumption and CO_2 emissions of the CBAS/RS and SBS/RS

In this section, energy consumption and CO_2 emissions of CB AS/RS and SBS/RS are presented. Analysis is performed by considering the proposed storage rack configuration and velocity profiles for the mini-load AS/RS and SBS/RS. Table 7 summarizes expected energy consumption EC_{CRANE} of the S/R machine along with CO_2 emissions $E(CO_2)_{\mathrm{CRANE}}$. Table 8 summarizes expected energy consumption EC_{HOIST} of the hoisted carriage along with CO_2 emissions $E(CO_2)_{\mathrm{HOIST}}$.

Table 7. Energy consumption and CO_2 emissions of the S/R machine

RC*i*	η_{CRANE} (/)	P_{CRANE} (kWh)	$T_{\mathrm{shift}} \cdot n_{\mathrm{wd}} \cdot n_{\mathrm{weeks}}$ (hours)	n_{CRANE}	EC_{CRANE} (kWh/ year)	$E(CO_2)_{\mathrm{CRANE}}$ (kg CO_2/ year)	S_{Forest} (m^2 forest/ 10 year)
1	0.95	15	4000	1	57.000	33.630	3363

Table 8. Energy consumption and CO_2 emissions of the hoisted carriage

RC*i*	η_{HOIST} (/)	P_{HOIST} (kWh)	$T_{shift} \cdot n_{wd} \cdot n_{weeks}$ (hours)	n_{HOIST}	EC_{HOIST} (kWh/ year)	$E(CO_2)_{HOIST}$ (kg CO_2/ year)	S_{Forest} (m^2 forest/ 10 year)
1	0.95	10	4000	1	38.000	22.420	2242

Table 9 summarizes expected energy consumption EC_{SCAR} of shuttle carriers along with CO_2 emissions $E(CO_2)_{SCAR}$. Table 10 summarizes expected energy consumption EC_{LIFT} of the lift along with CO_2 emissions $E(CO_2)_{LIFT}$.

Table 9. Energy consumption and CO_2 emissions of shuttle carriers

RC*i*	η_{SCAR} (/)	P_{SCAR} (kWh)	$T_{shift} \cdot n_{wd} \cdot n_{weeks}$ (hours)	n_{SCAR}	EC_{SCAR} (kWh/ year)	$E(CO_2)_{SCAR}$ (kg CO_2/ year)	S_{Forest} (m^2 forest/ 10 year)
	0.16	0.36	4000	12	2765	1631	163

Table 10. Energy consumption and CO_2 emissions of the elevator

RC*i*	η_{LIFT} (/)	P_{LIFT} (kWh)	$T_{shift} \cdot n_{wd} \cdot n_{weeks}$ (hours)	n_{LIFT}	EC_{LIFT} (kWh/ year)	$E(CO_2)_{LIFT}$ (kg CO_2/ year)	S_{Forest} (m^2 forest/ 10 year)
	1.00	2.50	4000	1	10.000	5900	590

According to the energy consumption of both systems (mini-load CBAS/RS and SBS/RS), one can notice that the energy consumption and consequently the CO_2 emissions dominates by the mini-load AS/RS, compared to the SBS/RS. This observation can be argued with the fact that because of the high weight of the S/R machine along with the hoisted carriage, powerful engines are needed ($P_{S/R\ MAS.}$ = 15 kW and $P_{S/R\ HC}$ = 10 kW) compared to relatively light shuttle carrier (P_{SCAR} = 0.36 kW) and elevators lifting table (P_{LIFT} = 2.5 kW) in case of SBS/RS.

This founding is with the accordance with the Lean&Green methodology, since we have proved that in the case of SBS/RS higher throughput performance is achieved (Lean concept) along with the lower energy consumption and CO_2 emissions (Green concept).

CONCLUSIONS

In this paper, a case study of SBS/RS versus mini-load AS/RS is presented. The model for the throughput and energy consumption calculations is proposed, which takes into account three different objectives like throughput performance, energy consumption and CO_2 emissions.

Paper presents performance analysis of the selected case study, limited to the proposed geometry of the storage rack and velocity profile of the selected material handling equipment. Results indicate that there is a good potential for reducing energy consumption and consequently CO_2 emissions by implementing SBS/RS instead of mini-load CBAS/RS. More, in the case of SBS/RS the throughput performance is even higher compared to mini-load CBAS/RS, which proves that SBS/RS corresponds with the Lean&Green methodology.

The results may serve as guidelines to warehouse designers and managers for designing new or improving existing automated warehouse. In the further research, analytical models and heuristics for non-tier captive shuttle carriers should be analyzed.

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A SUPPLY CHAIN DESIGN PROBLEM INTEGRATED FACILITY UNAVAILABILITIES MANAGEMENT

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Abstract − *A supply chain is a set of facilities connected together in order to provide products to customers. The supply chain is subject to random failures caused by different factors which cause the unavailability of some sites. Given the current economic context, the management of these unavailabilities is becoming a strategic choice to ensure the desired reliability and availability levels of the different supply chain facilities. In this work, we treat two problems related to the field of supply chain, namely the design and unavailabilities management of logistics facilities. Specifically, we consider a stochastic distribution network with consideration of suppliers' selection and distribution centres location (DCs) decisions and DCs' unavailabilities management. Two resolution approaches are proposed. The first consists on define the optimal supply chain structure using an optimization approach based on genetic algorithms (GA), then to simulate the supply chain performance with the presence of DCs failures. The second approach consists on define the optimal supply chain structure and simulate its performance with the presence of DCs failures in the same time. Note that, we replace each unavailable DC by the closest DC in the two strategies. The obtained results of the two strategies are detailed and compared showing their effectiveness.*

Keywords − *Supply chain management, location-allocation, suppliers selection, genetic algorithms.*

INTRODUCTION

A supply chain is a network of facilities and distribution options that performs the functions of materials procurement, these materials transformation into intermediate and finished products, and finished products distribution to customers. As technological complexity has increased, logistics and supply chains have become more complex and dynamic. Increase flexibility is needed to remain competitive and respond to rapidly changing markets [1]. Today's customers demand cheaper and high quality products, on-time delivery and excellent after-sale services. From companies' point of view, customers prove to be increasingly influential in terms of purchasing and negotiating power. Hence, companies have to co-operate or coordinate with suppliers to maximize the productivity at the smallest cost while satisfying customer requirements. The supply chain design requires the consideration of different decisions divided according to their temporal influences to three decision levels: strategic, tactical and operational.

The location and the choice of different entities (suppliers, factories, inventory and distribution facilities) and the different used transportation modes is one of the strategic decisions that companies look to optimize first. This optimization traditionally focused on costs has become difficult due to the introduction of new decision criteria such as customer satisfaction (delivery time, product and / or service quality, ...), and the explicit consideration of different risks (social, environmental and economic). These decisions can become increasingly complex and difficult to manage due to uncertain events. The uncertainty affecting the system can significantly impact the supply chain performances.

Various risks and uncertainties that could affect the network are usually neglected in many distribution networks design problems. These risks can cause the unavailability of a site (distribution center (DC), suppliers, etc..) and can be an external event result such as a natural disaster (tsunami), epidemic, war (military invasion) or an internal problem such as a conflagration. The unavailability of one or more logistics

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sites have disastrous effects on the system and leads to losses related to customer demands and other losses such as the raw materials and transportation modes lack. For this, it is necessary to take these risks and uncertainties into account in modeling and solving supply chain design problems in order to approach reality as possible [2].

In this work, we treat two problems related to the field of supply chain, namely the design and unavailabilities management of logistics facilities. Our approach is based on two steps. The first step consists to define the optimal supply chain structure through the consideration of three types of decisions that are: location of DCs, DCs to retailers allocation and selection of suppliers. Once the network structure defined, we consider in the second step that some DCs may become unavailable. The purpose of this step is to optimize the management of these unavailabilities.

The rest of the paper is organised as follows: section 2 presents some research works dedicated to location-allocation, suppliers selection and facility reliability problems. Section 3 describes the problem under consideration. Section 4 illustrates the proposed optimization and simulation approach. Section 5 shows the obtained results and their analysis. Section 6 concludes the paper with some directions for future research works.

LITERATURE REVIEW

The problem addressed in this paper originates mainly from three research areas: suppliers selection, facility location problems and facility reliability problems that have been widely addressed. However, few of the existing works consider these three decisions simultaneously. The interactions of suppliers selection, facility location, and reliability have not been considered previously. This section summarizes briefly the proposed approaches and the obtained results in the literature for the three problems mentioned above.

Meixell and Gargeya [3] reviewed the model-based literature for the global supply chain design problem by using dimensions related to ongoing and emerging issues in supply chain globalization. Overall, they realized that although the research community has tackled some of the most difficult global supply chain issues, few models comprehensively address outsourcing, integration, and strategic alignments in global supply chain design. They concluded that ‘global supply chain models need to address the composite supply chain design problem by extending models to include both internal manufacturing and external supplier locations’, ‘global supply chain models need broader emphasis on multiple production and distribution tiers in the supply chain’, ‘the performance measures used in global supply chain models need to be broadened in definition to address alternative objectives’, and ‘more industry settings need to be investigated in the context of global supply design’.

In [4], the authors consider a general class of location-allocation problems with n candidate sites. A mixed integer multidimensional optimization problem is presented; the authors compare several methods for solving this problem such as neighborhood search, tabu search and evolutionary algorithms.

Stochastic versions of the joint inventory-location model are firstly presented in [5] and [6]. Tanonkou et al. treat a stochastic distribution network design problem where decisions of suppliers’ selection, DCs location and the assignment of customers to DCs are integrated into a single optimization model [7]. The studied network is composed of multiple suppliers supplying in random delays, a set of DCs to locate which meet demands (in one product type) from different demand areas/customers. By hypothesis, each supplier is connected to each potential DC by a single transport connection. The objective is to choose the best suppliers, best locations for DCs, and the best assignments of customers to DCs in order to minimize a nonlinear cost function. The authors propose a lagrangian relaxation based method to solve the problem. This problem is addressed by Maliki and Sari [8] which propose a multicriteria genetic algorithm for its resolution in order to optimize the transport time and an oriented cost function. The same authors studied this problem by using different inventory management policies at the DCs to see the considered policies impact on the supply chain structure [9].

Maliki et al. [10] consider the problem treated in [8] and present a sensitivity analysis of some parameters on the obtained supply chain structure. More specifically, the authors studied the impact of transportation costs, inventory management costs and customer demand and supply lead time variances on the supply chain structure. The authors concluded that the opened DCs increase when transportation and inventory management costs increase and decreases when customer demand and supply lead time variances increases.

Motivated by uncertainty reduction and customer service improvement, many companies are interested to multiple sourcing, i.e. to engage with more than one supplier at the same time. In the design of any supply chain, finding a method/approach for suppliers selection problem is crucial. According to De Boer et al. [11] the suppliers selection goes through four steps: problem definition, selection criteria for evaluating suppliers, suppliers pre-qualification and final suppliers' selection. In this work the authors present some methods solving the suppliers selection problem, discuss different works related to this problem and classify the works based on the four presented steps.

The suppliers selection decision is complicated because several qualitative and quantitative criteria should be considered. For more details on the existing research for this subject the reader may consult the reference [12] wherein the authors present a complete state of the art about suppliers selection problem, and describe the various steps taken into consideration in the suppliers selection cycle and the different criteria used for evaluating suppliers performances. In addition, the authors present the characteristics of this problem and the available methods in the literature to solve it.

Our objective is to integrate location-allocation and suppliers selection decisions in the same model taking into account facilities unavailabilities. Note that few works integrate these decisions in the same model and address reliability problem in the supply chains design.

In [13], the authors present convincing arguments that supply chains are particularly vulnerable to intentional or accidental disruptions and propose possible approaches to reduce these disruptions. However, the authors don't present quantitative models to solve these problems.

Snyder [14] presents a detailed state of the art on robust and stochastic facility location problems; the author illustrates the optimization approaches variety under uncertainty existing in the literature and their application to facility location problems.

Snyder and Daskin [15] present location-allocation models based on the P-median and uncapacitated facility location problem (UFLP) problems. The objective is to minimize transportation costs, taking into account transportation costs generated in case of facilities unavailability. The authors present a Lagrangian relaxation for solving these problems.

Maliki et al. [16] consider the same distribution network studied in the reference [8] with DCs maintenance inclusion. The authors propose a simple genetic algorithm in order to obtain the optimal supply chain structure. Then a simulation of the supply chain performance at the presence of possible DCs failures is performed. Two simulation strategies are developed, one incorporating a maintenance policy and the other without maintenance policy. The authors present and compare the two strategies obtained results demonstrating the benefits and performance of the incorporating maintenance policy.

Tanonkou et al. address the unreliable facilities distribution network design problem [2]. The author proposes two different design models with Monte Carlo optimization combined Lagrangian relaxation resolution method. The first model concerns a single supplier / single product distribution network with unreliable DCs [17] and the second model is a multi-supplier / single product distribution network with unreliable suppliers [18]. In their works, the author considers that unavailable facilities are lost permanently; this is not the case of our problem in which we suppose that DCs are unavailable for a specified period and become operational after.

In [19], Maliki et al. consider a stochastic distribution network with suppliers selection and distribution centres location (DCs) decisions and DCs' unavailabilities management. The proposed resolution approach consists firstly on define the optimal supply chain structure using an optimization approach based on genetic algorithms (GA), then to simulate the supply chain performance with the presence of DCs failures. Two simulation strategies are performed, one by replace each unavailable DC by the closest DC and the other consist on performing a reallocation using genetic algorithm.

CONSIDERED PROBLEM

The studied problem in this work is based on a supply chain that consists on a set of potential suppliers connected to a set of retailers, every retailer is identified by his/her location zone (town or region) and every zone represents a potential zone of location DC. Located DCs satisfy the random single commodity demands generated by retailers. To manage inventory in DCs, the economic order quantity (EOQ) policy is used by each DC, and a safety stock level is kept to ensure a given retailer service level to protect against the possibility of stockouts during the supply lead-time. The supply lead-time for deliveries from the suppliers to the DCs is random. Figure 1 illustrates the considered supply chain structure.

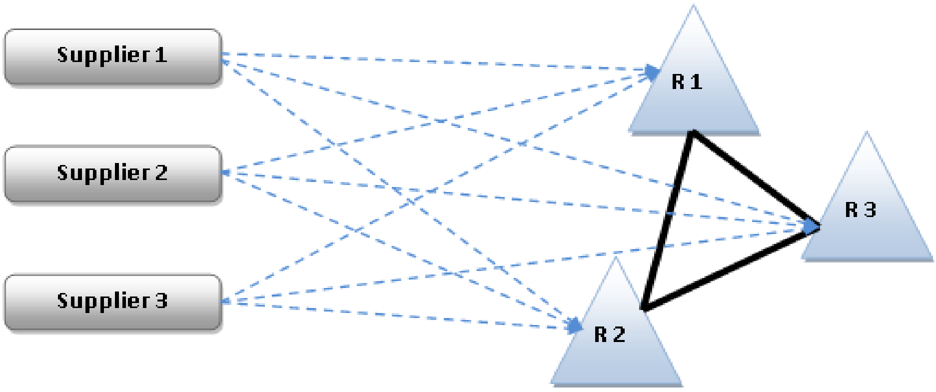

Figure 2. The studied supply chain structure

We assume that the considered supply chain copes to DCs failures that make them unavailable. These failures nature is of various origins: natural disasters, availability of transport road, workers strike and terrorism acts etc. However, the supply chain should be robust and in correct running every time a DC failure occurs.

Two resolution approaches are proposed, the first one is divided into two distinct steps E1 and E2. The first step consists on find the optimal structure of the supply chain by assuming that all DCs are operational. Contrariwise, in the second step one or more DCs may become unavailable; the objective of this step is to optimize the management of these unavailibilities. So, the resolution of this problem consists on solve the problem during the step E1 by taking three types of decisions that are: location of DCs, DCs to retailers allocation and selection of suppliers. This problem is solved by using a genetic algorithm [8] and [16]. This algorithm provides the optimal structure of our distribution network.

Based on the supply chain structure obtained in the first step, the second step consists to simulate the supply chain performance taking into account possible failures of one or more DCs. We assume that the DCs cannot be simultaneously unavailable. The objective of this step is to optimize the unavailabilities management of DCs in order to minimize the total generated cost.

The second approach consists on define the optimal supply chain structure and simulate its performance with the presence of DCs failures in the same time in order to minimize the total generated cost. Note that each unavailable DC will be replaced by the nearest DC during his unavailability in the two approaches. The nearest DC is the DC that has the minimum delivery cost.

A comparative study between the two strategies is performed will enable us to highlight the earnings generated by the second strategy versus the first.

USED VARIABLES AND NOTATIONS

We use the following variables and notations for the mathematical formulation of the considered problem:

The used notations are:
$\boldsymbol{I}$: Set of retailers indexed by i;
$\boldsymbol{K}$: Set of suppliers indexed by k;
$\boldsymbol{DC_j}$: DC located at retailer j;
$\boldsymbol{\mu_i}$: Global demand of retailer i;
$\boldsymbol{D_j}$: Daily demand of $\boldsymbol{DC_j}$;
$\boldsymbol{\sigma_i^2}$: Global demand variance of retailer i;
$\boldsymbol{f_j}$: Fixed annual cost of locating $\boldsymbol{DC_j}$;
$\boldsymbol{d_{ij}}$: Per-unit shipement cost from $\boldsymbol{DC_j}$ to retailer i;
$\boldsymbol{h_j}$: Inventory holding cost per unit per year in $\boldsymbol{DC_j}$;
$\boldsymbol{F_{jk}}$: Fixed order cost (include transport fixed cost) placed by $\boldsymbol{DC_j}$ at the supplier k;
$\boldsymbol{a_{jk}}$: Per-unit shipment cost (purchase and transport costs) from supplier k to $\boldsymbol{DC_j}$;
$\boldsymbol{L_{jk}}$: Mean lead-time in days from supplier k to $\boldsymbol{DC_j}$;
$\boldsymbol{\lambda_{jk}^2}$: Variance of lead-time from supplier k to $\boldsymbol{DC_j}$;
$\boldsymbol{\alpha}$: Desired service level at DCs;
$\boldsymbol{Z_\alpha}$: Standard normal variate such that $P(Z \leq z_\alpha)$;
$\boldsymbol{C_{unav\,j}}$: Total cost of $\boldsymbol{DC_j}$ unavailability;
$\boldsymbol{\Phi_j(E_2)}$: Number of $\boldsymbol{DC_j}$ unavailabilities during step $\mathbf{E_2}$;
$\boldsymbol{M_{unav\,j}}$: Mean cost of $\mathbf{DC_j}$ unavailability;
$\boldsymbol{C(E_1)}$: Global generated cost in the step $\mathbf{E_1}$;
$\boldsymbol{C(E_2)}$: Global generated cost in the step $\mathbf{E_2}$;
$\boldsymbol{CGI(E_2)}$: Unavailabilities management cost during step $\mathbf{E_2}$.

The decision variables are:
$\boldsymbol{X_j}$= {1 if $\boldsymbol{DC_j}$ is located; 0 otherwise};
$\boldsymbol{Y_{ij}}$ = {1 if retailer i is served by $\boldsymbol{DC_j}$; 0 otherwise};
$\boldsymbol{Z_{jk}}$ = {1 if supplier k is selected to supply $\boldsymbol{DC_j}$; 0 otherwise};

MATHEMATICAL FORMULATION

Based on the reference [7], we present in this section our problem mathematical formulation. During the first step, the resolution of the problem allows us to determine the decision variables $\boldsymbol{X_j}$, $\boldsymbol{Y_{ij}}$ and $\boldsymbol{Z_{jk}}$ and therefore our supply chain structure [9]. Thus, the mathematical formulation of the problem in the first step is as follows:

$$(MF)\ J^* = \min_{X,Y,Z} \boldsymbol{J(X,Y,Z)}$$

With $\boldsymbol{J(X,Y,Z)}$ defined by

$$J(X,Y,Z) = \sum_{j\in I} f_j X_j + \sum_{j\in I}\sum_{i\in I} \mu_i d_{ij} Y_{ij} + \sum_{j\in I}\sum_{i\in I}\sum_{k\in K} \mu_i a_{jk} Y_{ij} Z_{jk}$$
$$+ \sum_{j\in I}\sum_{k\in K} \sqrt{2h_j F_{jk} \sum_{i\in I} \mu_i Y_{ij}}\, Z_{jk} + \sum_{j\in I}\sum_{k\in K} Z_{\alpha} h_j \sqrt{L_{jk} \sum_{i\in I} \sigma_i^2 Y_{ij} + \lambda_{jk}^2 D_j^2}\, Z_{jk} \quad (1)$$

Subject to

$$\sum_{j\in I} Y_{ij} = 1 \qquad \forall i \in I \qquad (2)$$
$$\sum_{k\in K} Z_{jk} = X_j \qquad \forall j \in I \qquad (3)$$
$$Y_{ij} \le X_j \qquad \forall i, j \in I \qquad (4)$$
$$X_j, Y_{ij}, Z_{jk} \in \{0,1\} \qquad \forall i, j \in I, \forall k \in K \qquad (5)$$

The objective function (1) to minimize is the sum of the following costs: fixed cost to locating facilities, shipment plus transportation costs from DCs to retailers and from suppliers to DCs, the third term represents the total inventory costs at the DCs (assuming that each DC uses an EOQ policy) and the last term represent the costs of holding safety stock at the DCs to maintain a service level $\boldsymbol{\alpha}$. Constraint (2) ensures that each retailer is assigned to one located DC. Constraint (3) assumes that each open DC is supplied by a single supplier. Constraint (4) states that retailers can be only assigned ($\mathbf{Y_{ij} = 1}$) to opened DCs($\mathbf{X_j = 1}$). Constraints (5) are standard integrity constraints.

NON-INTEGRATED APPROACH

In this approach, we divide our study in two stages. To solve the problem (MF) during the first stage E1, a genetic algorithm is used to determine the optimal supply chain structure. In our case, a candidate solution is composed of binary values 0 or 1, where each chromosome is composed of three parts. The first part represents the DCs location, the second part shows the allocation of retailers to DCs and the third part represents the assignment of DCs to suppliers. We calculate the fitness of each candidate solution using equation (1) to obtain the total generated cost (see section 3.3).

Therefore, a chromosome represents a supply chain structure; it is composed of three parts corresponding to the three decision variables X_j, Y_{ij} and Z^{jk} (see section 3.3). Thus, a representation in integers is used where each gene can have the value 0 or 1. An example of chromosome corresponds to a problem with 4 retailers (we have 4 candidates DCs since DCs are located in the same regions as retailers) and 3 potential suppliers is shown in Figure 2.

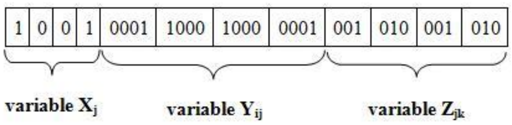

Figure 2. A chromosome example

The GA used steps are as follows:

- **Step 1.** Generate the initial population P of size N randomly.
- **Step 2.** Evaluate all solutions of P by calculate their fitness.
- **Step 3.** Select two parents using the « binary tournament selection ». It consists on select two solutions of the population P randomly and chooses the lowest fitness solution.
- **Step 4.** Generate two children solutions by crossing the two parents using single point crossover with probability $0.25 \le Pc \le 0.95$.
- **Step 5.** Execute the mutation operator using deterministic mutation with probability $0.05 \le Pm \le 0.1$ for the two generated children.

- **Step 6.** A correction procedure is executed if the obtained solution is infeasible*.
- **Step 7.** Add both children in the next population G.
- **Step 8.** Repeat steps 3 to 7 until having N solutions in G.
- **Step 9.** Repeat steps 2 to 8 until the stopping conditions satisfaction (The number of iterations NI_{max}=20).

*A solution is called infeasible if it does not respond to problem constraints. Thus, a chromosome modification procedure is executed after mutation to verify the following constraints:

- A candidate solution is correct if at least one DC is located;
- Each retailer is served by one DC;
- Each open DC is supplied by one supplier;
- If a DC serves a retailer, it must be located.

For the step E2, one or more DCs may become unavailable. Each unavailable DC will be replaced by the closest DC. The retailers demands assigned to replaced DC during his unavailability are satisfied by replacing DC. During this step, the global generated cost $\boldsymbol{C(E_2)}$ is equal the sum of delivery costs, shipment costs, inventory and maintain safety stock costs and DCs unavailabilities costs. None location cost (investment cost) will be generated during the second step, since there will not new DCs locations [19].

For each DC the unavailability cost is calculated as follows:

$$C_{unav\ j} = \Phi_j(E_2) M_{unav\ j} \qquad (6)$$

Where,

$\boldsymbol{C_{unav\ j}}$: DC_j unavailability total cost;

$\boldsymbol{\Phi_j(E_2)}$: DC_j unavailabilties number during step $\mathbf{E_2}$;

$\boldsymbol{M_{unav\ j}}$: Per DC_j unavailability mean cost.

INTEGRATED APPROACH

In this approach, we use the the above genetic algorithm with the same chromosome representation, except that one or more DCs may become unavailable during the determination of the supply chain structure. In this case, each unavailable DC will be replaced by the closest DC and the total generated cost is calculated using equations (1) and (6).

Order to compare the effectiveness of the two approaches, we calculate the unavailabilities management cost after obtaining the supply chain structure using the same scenarios like the non-integrated approach in the step E2. This cost $\boldsymbol{C(E_2)}$ is equal the sum of delivery costs, shipment costs, inventory and maintain safety stock costs and DCs unavailabilities costs.

OBTAINESD RESULTS AND ANALYSIS

This section evaluate the performance of our proposed approaches, we studied different supply chains instances of different sizes. The instances are obtained by varying the number of retailers who represents the candidates DCs number and the number of suppliers. During the second step, we consider five different scenarios for each instance depending on DCs unavailabilities (numbers, times and duration of unavailabilities). The numerical experiments are performed using a Pentium core 2 Duo 2.20 GHZ and 2 GB of RAM. Note that the simulation programs of the two steps are implemented in "VBA" language. The used parameters are presented as follows:

- **The number of retailers location (#RL):** we have considered problems with 10, 15, 20, 30, 40 and 60 retailers (each retailer location can be selected to host a DC).
- **The number of suppliers (#F):** we have considered problems with 4, 6, 8, 12, 15 et 18 suppliers.
- **Retailer demands:** for each retailer, the mean demand $\boldsymbol{\mu_i}$ is discretized through time t, it is randomly generated with $\boldsymbol{\mu_i(t) \sim U\ [100,\ 1600]}$.
- **Supply lead times:** for each potential location, the average supply lead time is randomly generated with $\boldsymbol{L_{jk} \sim U\ [10,\ 30]}$.

- **The standard deviations of demand and supply lead time:** are randomly generated with $\boldsymbol{\sigma_i} \sim \mathbf{U}\ [\mathbf{50}, \mathbf{100}]$ and $\boldsymbol{\lambda_j} \sim \mathbf{U}\ [\mathbf{5},\ \mathbf{10}]$.
- **Fixed facility location cost $(\boldsymbol{f_j})$, transportation cost $(\boldsymbol{a_{jk}})$ and shipment cost $(\boldsymbol{d_{ij}})$:** are randomly generated with respect to $\boldsymbol{f_j} \sim \mathbf{U}\ [\mathbf{4500},\ \mathbf{10000}]$, $\boldsymbol{a_{jk}} \sim \mathbf{U}\ [\mathbf{2},\ \mathbf{10}]$ and $\boldsymbol{d_{ij}} \sim \mathbf{U}\ [\mathbf{1}, \mathbf{5}]$.
- **Desired service level:** $\boldsymbol{\alpha} = \mathbf{97.5}\%$ for $\mathbf{Z}\boldsymbol{\alpha} = \mathbf{1.96}$ for all studied problems.
- **Inventory holding costs $(\boldsymbol{h_j})$:** constant value for all DCs equal to 25.
- **Fixed ordering costs $(\boldsymbol{F_j})$:** constant value for all DCs equal to 50.
- **Per unavailability mean cost $(\boldsymbol{M_{unav\,j}})$:** this cost is generated randomly for each DC with $\boldsymbol{M_{unav\,j}} \sim \mathbf{U}\ [\mathbf{1000},\ \mathbf{5000}]$.
- **Mean time between unavailabilities (MTBU) and unavailability mean time (UMT):** are randomly generated for each DC with $\boldsymbol{MTBU} \sim \mathbf{U}\ [\mathbf{100},\ \mathbf{250}]$ **and** $\boldsymbol{UMT} \sim \mathbf{U}\ [\mathbf{15},\ \mathbf{30}]$.
- **Simulation time $(\mathbf{E_1}, \mathbf{E_2})$:** For each step, we have considered 1250 working days (5 years) for each step.

The Table 1 show the obtained results for each instance of our problem. These results represent the supply chain structure (located DCs and selected suppliers) and the global generated cost $\boldsymbol{C(E_2)}$ for the two proposed approaches obtained for five different scenarios simulation.

Table 5. The obtained results

		Non-integrated approach			Integrated approach			Earnings
#RL	*#F*	*#DC*	*#S*	*C(E2)*	*#DC*	*#S*	*C(E2)*	
10	4	***6***	***3***	***664.502***	***3***	***2***	***214.695***	**67.69 %**
15	6	***6***	***3***	***441.115***	***5***	***4***	***258.839***	**41.32 %**
20	8	***10***	***5***	***828.525***	***7***	***5***	***304.989***	**63.18 %**
30	12	***17***	***9***	***842.781***	***11***	***6***	***618.232***	**26.64 %**
40	15	***15***	***11***	***1195.127***	***15***	***10***	***666.352***	**44.24 %**
60	18	***26***	***13***	***1455.509***	***19***	***11***	***1200.487***	**17.52 %**

- ***#DC***: Number of located DCs;
- ***#S***: Number of selected suppliers;
- $\boldsymbol{C(E_2)}$: Global generated cost during step $\mathbf{E_2}$;
- ***Earnings***: Earnings in unavailabilities management cost between both strategies;
- The costs are in millions money unit.

From Table 1, we see that that the global generated cost increase compared to the number of located DCs and selected suppliers. It is also clear that the global generated cost obtained by the integrated approach are lower than those obtained by the non-integrated approach during the second step, with winnings percentages between 17% and 67%. The obtained results show clearly that unavailabilities management optimization using an integrated approach gave better results.

CONCLUSIONS AND PERSPECTIVES

In this article, we studied location -allocation integrated suppliers selection problem with DCs unavailabilies. Firstly, we use a non-integrated approach consisting on using a genetic algorithms based optimization approach to solve a stochastic distribution network problem design where the strategic decisions of suppliers selection, DCs location and retailers allocation are integrated in the same model . Then, a simulation of the considered supply chain was performed with the presence of possible DCs unavailabilities wherein we replace each unavailable DC by the closest DC. The second approach consists on using an integrated approach wherein we consider the same stochastic distribution network problem with unvailabilities management i.e. one or more DCs may become unavailable during the determination of the supply chain structure. We use the same genetic algorithm to solve this problem. After obtaining the supply chain structure for both approaches, we calculate the unavailabilities management cost for the same scenarios. The comparison between the two strategies through generated earnings has shown that the integrated approach strategy provides better performances in the DCs unavailabiliies management.

This work has identified several future directions research. The most immediate is to consider other meta-heuristics for structure supply chain optimization; it is also possible to extend the problem to a maintenance integrated approach. In this direction a DCs maintenance policy can be considered to reduce failures number and improve the DCs unavailabiliies management.

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A DESIGN OF EXPERIMENT FOR PERFORMANCE ANALYSIS OF SBS/RS

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Abstract – In this study, we conduct an experimental design for a shuttle-based storage and retrieval system (SBS/RS) to identify statistically significant factors affecting its performance. SBS/RS is a new technology for automated storage and retrieval system developed for high transaction rate for small sized unit-load storage system. This new technology comprises multiple tiers of storage with dedicated shuttles for each level. Hence, loads are stored and removed from the shelves by at high speed, and the average throughput rate of SBS/RS is very high. There are several design concepts that could affect the performance of an SBS/RS. In this study, we consider four factors that could affect the studied SBS/RS and, a single performance measure: average cycle time of storage transactions (S_CT) to measure the interaction effects of these factors on this performance measure. We utilize simulation for the modeling purpose. The results indicate that the four factors have four-way interaction effect on the response.

Keywords – SBS/RS, DOE, simulation, automated storage, warehousing.

INTRODUCTION

Increasing trends towards greater product variety and shorter response times has led to the development of a new automated storage and retrieval system (AS/RS), called shuttle-based storage and retrieval system (SBS/RS) [1-5]. This technological design has been developed for high transaction environments where a more "traditional" mini-load AS/RS crane may be inadequate for the transaction rate needed over a given number of storage locations. Typically, an SBS/RS comprises multiple tiers of storage with dedicated shuttles for each level (see Figure 1). Hence, loads are stored and removed from the shelves by SBS/RS at high speed, and the load handling equipment of the shuttle is designed for short handover times (see for example, http://www.dematic.com/multishuttle, accesed on 28/08/2015).

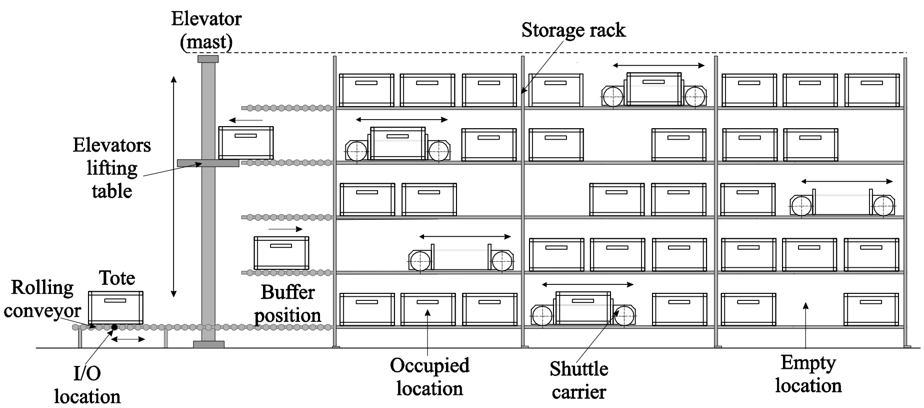

Figure 3. Side view of the SBS/RS

Lifting devices (such as vertical conveyors or elevators) installed at the end of the aisles enable the transfer of shuttles between tiers. A typical design of an SBS/RS is shown in Figure 1. In this design,there is a shuttle for each tier, and a lift mechanism for each aisle. Each lift serves every tier in a specific aisle, and therefore often

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becomes a cause of delay in the system. Hence, an alternative SBS/RS design incorporating a mechanism with dual lifting tables has been developed. In this design, the capacity of the lifts is doubled by attaching tables to either side of the lifting system . In this study, we consider the system with lifting tables attached to either side of the lifting mechanism.

LITERATURE REVIEW

There are very few studies on SBS/RS. Marchet, Melacini, Perotti, and Tappia [2] presented an analytical model to estimate SBS/RS performance measures (the transaction cycle time and waiting times). The model is based on an open queuing network approach. The model effectiveness in performance estimation is validated through simulation.

Marchet, Melacini, Perotti, and Tappia [3] use simulation to highlight main design trade-offs for SBS/RS for several warehouse design scenarios involving tier-captive shuttle carriers. Their four performance measures from the system were as follows: utilizations of lifts and shuttles, average flow time, waiting times and cost of limited number of pre-defined rack designs were considered.

Recent studies on SBS/RS by Lerher [4] and Lerher, Sraml, Borovinsek, and Potrc [5] consider the concept of energy efficiency in the system design. The proposed models present several designs, the performances of which are assessed in terms of the velocity profiles of lifts and shuttles, performances in terms of energy (electricity) consumption, amount of CO_2 oscillation, and throughput capacity. These studies provide a significant contribution to promoting environmentally-friendly automated warehouse planning by emphasising the importance of enegy efficiency.

Another related study by Carlo and Vis [1] introduced a type of SBS/RS developed by Vanderlande Industries "B.V.", in which two non-passing lifting systems were mounted along the rack. Focusing on the scheduling problem of lifts, two innovative (piece-wise linear) functions were used to evaluate candidate solutions, and an integrated look-ahead heuristic was proposed for the solution procedure.

Most of the existing SBS/RS design studies consider a limited number of factors, which usually include rack configuration, scheduling rule and speed profiles of devices. Alos, no study provides statistical analyses to identify statistical significance of these design factors on the performance of this system, or the existense of an interaction effect between these factors. This study, to the best of our knowledge, is the first to simultaneously consider multiple factors that could affect the performance of these systems. Here, our aim is to identify the statistically significant design factors from those pre-defined factors, i.e. storage policy, rack design, arrival rate and scheduling rule, and any influence that their interaction has on the performance of SBS/RS. Thus, the system designer will benefit from a significantly improved understanding of ways to improve the performance efficiency of these systems. For this purpose, an appropriate design of experiment (DOE) is used as a tool [6].

SIMULATION MODELING OF THE SYSTEM

The SBS/RS warehouse considered in the simulation model consists of racks, lifts, and shuttles. Shuttles are tier-captive and their main purpose is to store totes and retrieve them from their storage locations. Racks (on either side of an aisle) consist of bays, each of which can hold one tote. Because each aisle of the studied SBS/RS is identical in terms of number of tiers and bays, we simulate a single aisle. The lifts, located at the end of the aisle, can carry two totes independently. A transaction arriving at an aisle occupies the available lifting table, according to the scheduling rule defined in the DOE. Each aisle has an I/O point. The other assumptions used in the simulation model are as follows:

- Arrivals follow a Poisson process, and the mean arrival rates for S/R are equal ($\lambda_S = \lambda_R$). We also vary the arrival rates in the DOE as $\lambda_S = \lambda_R = 300$ and 330 totes per hour for an aisle.
- The time taken to load the totes onto the shuttle, and unload them from it is assumed to be three seconds.
- Vehicle and lift acceleration and deceleration delays are also considered in the model.
- If the S/R transaction is located at the first tier, then the lift is not used.
- The I/O point is located at the first tier of each aisle.
- There are two buffer positions at each tier, from which the lifting tables discharge and charge the loads.

The speed profiles of lifts and shuttles, as well as the distance metrics of the warehouse are based on those of Lerher, Edl, and Rosi [5]. The simulation model was completed using ARENA 14.0 commercial simulation software, and was assumed to be a non-terminating system, allowing us to conduct a steady state analysis. The warm-up period is defined as three months by the eye-ball technique. Each simulation run was for one year, and model was run for 10 independent replications.

The verification of the simulation model was completed by debugging the model via the trace module in the simulation software. The validation of the model was completed by comparing the average travel time of lifts with the analytical model results given in Lerher, Edl, and Rosi (2013).

DESIGN OF EXPERIMENT

DOE is a design tool analyzing the relation between independent (input) and dependent (input) variables. This tool is used to identify the significant factors (independent variables) that affect the output (dependent variable) as well as to indicate how these factors affect the response. The performance measure is considered to be average cycle time of storage transactions (*S_CT*). Here, cycle time is defined as time between the origin and fulfillment of a request. Cycles are measured in minutes from the simulation runs. We consider four factors in the DOE that are likely to have an effect on these performance measures: the storage policy (SR), rack design (RD) in terms of the number of tiers and bays, arrival rate (AR), and scheduling rule (SR). Details of these design factors and their levels are explained in the following paragraphes.

Four independent factors used in simulation experiments are shown in Table 1. Each factor has two levels with the exception of the second factor, RD, which has three. Hence, for each performance measure totally 240 (24×10 replications) values were analyzed by ANOVA using MINITAB. In the simulation model, a recognised and valid variance reduction technique for comparing two or more alternative configurations: common random numbers (CRN) variance reduction technique was used. To ensure variance reduction in CRN, a stream used for creating a random number purpose in one experiment, is similarly used for the same purpose in other experiments.

Table 6. Factor Levels

	Factors	*Level Codes*	*Levels*
1	Storage policy	1	Class-based
		2	Random
2	Rack design	1	13-29 (Tier-Bay)
		2	15-25 (Tier-Bay)
		3	17-22 (Tier-Bay)
3	Arrival rate	1	300 totes/hour
		2	330 totes/hour
4	Scheduling rule	1	DC
		2	SPT

In the ***storage policy*** (SP) factor, two levels are considered as class-based storage policy (CSP) and random storage policy (RSP). In RSP, every incoming load is assigned to a location in the warehouse selected randomly from all eligible empty locations with equal probability. As an alternative to the RSP, we consider a class-based storage policy – CSP, which works on the principle of dividing items into classes. Based on the Pareto's method, the idea is to group products to ensure that the fastest moving class contains only about 20% of the products stored, but contributes about 80% of the turnover. Each class is then assigned to a dedicated area of the warehouse. Storage within each area is random. Classes are determined by demand frequency of the products. We considered three item classes – *A*, *B*, *C* –; i.e., we assume that 80% of the arrivals occupy 20% of the warehouse storage locations. In such a system, class *A* items are stored in the first 20% of tiers, *B* class of items are stored at the following 30% and *C* class of items are stored at the following 50%. Specifically, if there are 15 tiers in the warehouse, with 80% (*A*-class), 15% (*B*-class) and 5% (*C*-class) probabilities, the incoming load is assigned to the first three tiers (20% × 15 tiers = 3 tiers), the following five tiers (30% × 15 tiers = 5 tiers) and the following seven tiers (15 tiers – (3 + 5) tiers = 7 tiers), respectively. Through this policy of assigning the most frequently ordered items to the lower levels of the warehouse, it is expected that the average travel time, and hence utilization of the lifts will be decreased. By decreasing lift average travel time, we also expect to decrease *S_CT*.

For the ***rack design*** (RD) factor, three different rack configurations are considered in terms of the number of tiers and the number of bays. Clearly, rack configuration affects the average travel time of the lifts and shuttles. However, rather than focus on this point in isolation, it would be more valuable to identify any interaction effect between RD and the other factors.

The intial simulation model is developed for the 19^{th} experiment, in which the number of possible combinations of tiers and number of bays was 15-25 (see Table 2). In this design, each aisle has 750 storage locations (15 tiers × 25 bays× 2 sides). Assuming that the number of storage locations is fixed at 750 for each aisle, alternative rack designs can be achieved by varying the number of tiers, as follows: 13-29 (13 tiers × 29 bays× 2 sides = 754 locations), and 17-22 (17 tiers × 22 bays× 2 sides = 748 locations).

The ***arrival rate*** (AR) refers to the number of incoming storage and retrieval transactions in the warehouse per unit-time. For ARs for storage and retrieval transactions, two levels are considered: low and high, 300 and 330 totes per hour, respectively. The figures represent the number of incidences of storage and retrievals, separately. As mentioned in the assumptions of the simulation modeling section, we consider mean storage and retrieval arrival rates to be equal, and follow a Poisson process. The aim of this approach is to determine whether this factor interacts with other factors, and if so, how it affects the system performance.

In the ***scheduling rule*** factor, we consider two levels: dual command (DC) and shortest process time (SPT). Since lifts cause delays in the system, SR is applied to the scheduling process of lifts. The shuttles process is based on the first-in-first-out rule. An SBS/RS can operate either in a single command (SC) or a DC cycle. In an SC cycle, the lift performs a single storage or retrieval transaction. The storage cycle time is then equal to the sum of the time taken for the load to be picked up at the input station (i.e, first tier), to be taken to the storage location by shuttle, and to be discharged by shuttle onto the rack. The retrieval cycle time can be defined as the sum of time taken toward to the storage location, time taken for the load to be picked up from this location and return to the buffer position, and the time taken for the lift to travel to the output location. A storage and a retrieval transaction in a single cycle is called a DC cycle. In this case, the cycle time is defined as the sum of the times taken for a load to be picked-up, to be moved to the storage location and to be stored; the travel time to the retrieval location, and the time taken to pick up and transport the load to the output station. Clearly, compared to first-come first-serve systems, the total time for all S/R transactions is reduced for DCs. Under the shortest process time (SPT) rule, the pending transaction closest to the current location of the lift is selected.

RESULTS

Table 2 presents details of the DOE. The final column shows the averages of 10 simulation replication result of the *S_CT* performance measure.

Table 2. DOE and Results

Exp	SP	RD	AR	SR	*S_CT* (min.)
1	1	1	1	1	0.512
2	1	1	1	2	0.511
3	1	1	2	1	0.582
4	1	1	2	2	0.581
5	1	2	1	1	0.465
6	1	2	1	2	0.464
7	1	2	2	1	0.516
8	1	2	2	2	0.514
9	1	3	1	1	0.434
10	1	3	1	2	0.433
11	1	3	2	1	0.475
12	1	3	2	2	0.473
13	2	1	1	1	0.492
14	2	1	1	2	0.467
15	2	1	2	1	0.570
16	2	1	2	2	0.503
17	2	2	1	1	0.510
18	2	2	1	2	0.470
19	2	2	2	1	0.636
20	2	2	2	2	0.515
21	2	3	1	1	0.543
22	2	3	1	2	0.480
23	2	3	2	1	0.765
24	2	3	2	2	0.538

The ANOVA was completed in the MINITAB statistical software at the 95% confidence level. To be able to interpret the ANOVA results, it is important to meet model adequacy which is based on three assumptions about residuals: they should have normal and independent distribution, they should have a mean of zero, and constant variance. In the case that even one assumption is not met, to achieve model adequacy, it may be necessary to apply a suitable transformation, such as inverse, logarithm, natural logarithm, square root, inverse, inverse square root, etc. In the current model, one of the ANOVA assumptions is not met (residuals are not normally distributed). Hence, we applied inverse transformation on the response.

To identify the significant factor effects, the *F*-test is used. The bigger the *F*, the more likely the factor is significant. The *P* value is computed from the *F* ratio, which is the ratio of two mean square values. For *P* value of < 0.05, we reject the null hypothesis and assume that this factor is statistically significant for the related performance measure. The ANOVA results are presented in Table 3. From the ANOVA results, it is observed that all the *P* values are less than 0.05 revealing that there is a four-way interaction effect on the inverse response. When there is four-way interection effect the presence of a three-way effect and the others is not necessarily useful or indicative so, we do not comment on those interaction effect results.

Table 3. ANOVA Results for Inverse of *S_CT*

Source	DF	Seq SS	Adj SS	Adj MS	*F*	*P*
SP	1	0.64195	0.64195	0.64195	176102,98	0.000
RD	2	0.15296	0.15296	0.07648	20980,24	0.000
AR	1	1.94699	1.94699	1.94699	534106,66	0.000
SR	1	0.61377	0.61377	0.61377	168372,10	0.000
SP*RD	2	1.66733	1.66733	0.83366	228693,66	0.000
SP*AR	1	0.04741	0.04741	0.04741	13005,98	0.000
SP*SR	1	0.56644	0.56644	0.56644	155388,37	0.000
RD*AR	2	0.02012	0.02012	0.01006	2759,36	0.000
RD*SR	2	0.06556	0.06556	0.03278	8991,77	0.000
AR*SR	1	0.08467	0.08467	0.08467	23227,75	0.000
SP*RD*AR	2	0.05310	0.05310	0.02655	7283,18	0.000
SP*RD*SR	2	0.06042	0.06042	0.03021	8287,37	0.000
SP*AR*SR	1	0.08222	0.08222	0.08222	22556,02	0.000
RD*AR*SR	2	0.01124	0.01124	0.00562	1542,27	0.000
SP*RD*AR*SR	2	0.01079	0.01079	0.00539	1479,51	0.000
Error	96	0.00035	0.00035	0.00000		
Total	119	7.04736				

CONCLUSION

In this study, a simulation-based experimental design was proposed in order to identify statistically significant factors affecting performance of an SBS/RS. First, the factors that could affect the average cycle time of storage transactions, then a DOE was applied to find these significant factors. The factors that could affect the performance measures were defined to be storage policy, rack design, arrival rate, and scheduling rule. Because the ANOVA assumptions were not met, the inverse transformation was applied on the *S_CT*. The results indicate the presence of four-way interaction effect of the factors.

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DIFFERENT APPROACHES FOR MINIMIZING TRANSPORT COSTS IN INTERMODAL NETWORKS

Radoslav Rajkovic[38], Nenad Zrnic[39], Djordje Stakic[40]

Abstract–*Container-based transportation services are an important part of intermodal transportation and the backbone of international trade. During the last decades, the container volume handled world wide has continuously increased as a result of globalisation, economical growth and geographical distribution of activities. In order to achieve competitive prices on the market all companies strive to minimize the final price of their products vigorously trying at any moment to reduce transportation costs. The goal of this paper is analysis and continuous monitoring of transportation costs during container transportation. The paper used different approaches for seeking optimal solutions. By using mathematical language MATLAB, as well as comparative analysis of software tools Lingo and genetic algorithms it was generated the most optimal transport routes.*

Keywords–*Genetic algorithms, Intermodal transport, Lingo, MATLAB, Minimizing cost*

INTRODUCTION

The major reasons for the growth in container shipping are, on the demand side, the increasing international division of labour in the course of liberalization and the resulting trade movements; and also the rise in importance of goods eminently suited to transport by container. On the supply side, the considerable expansion of the container ship fleets and faster loading and unloading of container ships are playing an important part; they allow short turnaround times in port.The fundamental idea of intermodal transportation is to consolidate loads for efficient long-haul transportation, while taking advantage of the efficiency of local pick-up and delivery operations by truck. This explains the importance of container-based transportation. Freight intermodal transportation is indeed often equated to moving containers over long distances through multimodal chains. Intermodal transportation is not restricted, however, to containers and intercontinental exchanges. For instance, the transportation of express and regular mail is intermodal involving air and land long-haul transportation by rail or truck, as well as local pick-up and delivery operations by truck. In this paper we focus on container based transportation[1].

Considering the large and constant struggle in the market in terms of competitive pricing of products, a very important and indispensable role represents the container transport with a clear task to define the final price of the product. In this paper was analyzed the costs of container transport flow on the Westbound network (Asia-Europe), using different liner shipping services, observing the world's largest container operators and inland (truck-rail-river) transport corridors. These corridors include distance between selected Mediterranean ports and final destination, landlocked area. As a result, in this paper was considered different approaches (mathematical model, genetic algorithm and software analyzes)that provide a comparative analysis of transportation costs on the different routes. It is observed already existing transport routes and it is also given hypothetical review to the development of new transport routes.

Selection of the best route in the intermodal network is a very difficult and complex task. The costs in all modes of transport and the quality of their services are not constant parameters and changes depending on a number of conditions and characteristics. The analysis of this model within combined maritime and land-

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based networks would prove helpful for the study of logistics chains, the hinterland-foreland continuum, intermodal transport systems, and market competitiveness.

The rest of this paper is organized as follows: Section 2 presents the literature review while Section 3describes the problem and presents the mathematical model. Section 4 reports and analyzes the results. Finally, Section 5 is devoted to conclusions and future developments.

BACKGROUND

One of the most important tasks in the transportation of containers is the integration of container networks into a single network using different modes of transport. In most cases it is developed an optimization model which is based on the minimization for just one objective. In this paper we optimize transportation cost as one of the main considered objectives during transportation.

The optimization aims at making the best choice from a number of variants of possible alternatives, or between a number of alternatives, which in mathematical sense means searching for functions’ extrema. The optimization is performed by using different methods, depending on a type of relation in the mathematical model, the criterion function and constraints, which determine the "best" solution to a particular mathematically defined problem. The selected "best" solution has a high probability of being truly the best, representing a satisfactory compromise between the conflicting interests of different stakeholders [2].

The focus of Infante et al.,[3] are on intermodal freight transport service in which containers represent the moved loading units, minimizing the total cost of the service. They formulated a ship-truck intermodal transportation problem as a Travelling Purchaser Problem (TPP). Computational results indicated that theirs algorithm is very efficient on a set of benchmark instances, quickly achieving optimal or near-optimal solutions.

Very similar study was conducted by Francesetti[4], who analyzed the costs of shipping containers from four Chinese ports to representative central European destinations. It is demonstrated that the sum of costs by sea and costs over land, using both truck and rail transport, clearly favours the Italian ports, above all those of Genoa and Trieste for a geographic range that does not include all the Northern countries of the European Union and Russia but does cover a considerable portion of the southernmost cities of these countries such as Milan, Munich, Vienna, Budapest, Bern, Lyon, and Kiev. The purpose of his paper was to define costs in each sector (shipping costs, port costs and inland distribution costs) and to compare the relative port positions.

The papers with main objective of minimizing the sum of shipping and inland transportation costs are presented by Kim et al., [5]. They solved the problem by mixed integer programming. A case study is performed on the container cargo data in Korea and they draw several implications to improve efficiency in the transportation of international trade cargoes in Korea.

Han et al.,[6] considered the problem of determining transportation quantity and mode in transporting international cargoes between Myanmar and her trading countries, especially focusing on the countries in South East Asia to check the extent of using short sea shipping, and inland transportation. The objective of theirs paper is to minimize transportation costs by mode between cargo origin and destination, subject to the maximum cargo volumes being handled at each seaport, in order to optimize the short sea shipping and inland transportation in Myanmar.

Payman and Robert[7] introduced analytical models for predicting the allocation to ports and transportation channels for containerized goods imported from Asia to the USA. The first model - the Long-Run Model, is a large mixed integer non-linear programming model, solved with a set of heuristics. The model objective was to minimize the total costs of transportation and handling, pipelining inventory, and safety-stock inventories.

The Short-Run Model uses the Long-Run model as a component and integrates it with a set of analytical queuing models that estimate the import container flow times through port terminals, rail intermodal terminals and rail line-haul channels as a function of traffic volumes, infrastructure and staffing hours.

Summarizing, in the past 20 yearscontainer transport make huge revolution,steadily increasingnumber of transported containers,reaching in that period the total increase of nearly 4.5 times [8].

PROBLEM DESCRIPTION

The considered network presented in Figure 1 includes three categories of nodes: origin terminal (port of loading), destination terminal (ports of discharge) and destination (place of delivery), and two categories of links, maritime and inland. The first one represents maritime transfers from origin terminal to destination terminal and the second the inland component of the distribution, in which containers are routed from destination terminal to final destination by road, rail and barge.

Gateway ports are connected with the origin port, but only by incoming links. It is possible to reach a gateway port from an origin port, but the opposite direction is not envisaged by the model, since it addresses only the incoming flows. A destination is connected to the gateway ports by a direct link, representing the shortest path to be reached from that gateway by road, rail and barge.

Maritime links are those between an origin port and gateway ports. As for intercontinental links, there may be more than one link connecting the origin port to the gateway port, and each such link belongs to a different service, with given travel time and frequency depending on different operators.

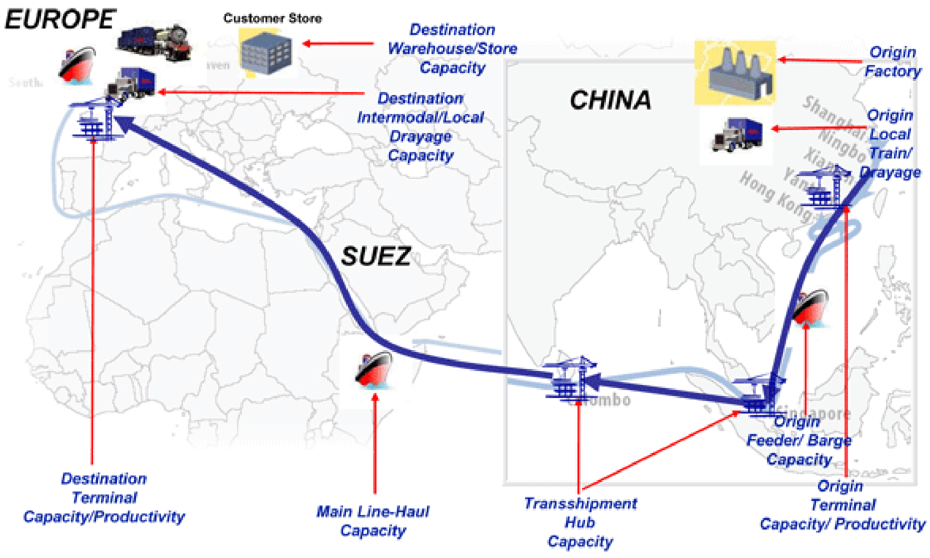

Figure 4. Container Transport Network
Source: World Shipping Council

The transport cost was considered for 20' containers in the container transport, and is based on the free on board-FOB term. Total cost includes, except the cost of transport from origin port to final place of delivery, local costs in the port of discharge, customs clearance and handling costs. During inland transport it was used different modes of transport, and because of more appropriate comparisons of the costs of rail and barge with truck, it was included also handling costs at the terminal in the final place of delivery and final delivery to users by truck (local delivery).

Mathematical Model

The model formulation and corresponding explanations are given as follows in Table 1:

Table 7. Model Formulation

Set	Description
N	set of nodes, let N = OT∪DT∪D, while OT stands for origin terminal, DT stands for destination terminal and D stands for final destination
A	set of routes connecting the origin and destination nodes, let A = FL ∪ SL, while FL presents first leg arcs (ocean leg) and SL presents second leg arcs (land leg)

Decision Variable	Description
f_{ij}	binary cost variable representing containers flow on first-leg arc, operator ″ i ″ to gateway ″ j ″,$1 \leq i \leq n_i, 1 \leq j \leq n_j, f_{ij} \in \{0,1\}$
s_{jk}	binary cost variable representing containers flow on second-leg arc, gateway ″ j ″, mode of transport ″ k ″, $1 \leq k \leq n_k, 1 \leq j \leq n_j, s_{jk} \in \{0,1\}$

Parameter	Description
n_i	number of operators
n_j	number of gateway ports
n_k	mode of transport
CFL_{ij}	transportation cost on first-leg arcs (expressed in €)
CSL_{jk}	transportation cost on second-leg arcs (expressed in €)
CP_{ij}	port cost (expressed in €)

$$(i,j) \in FL, 1 \leq i \leq n_i, 1 \leq j \leq n_j$$

$$(j,k) \in SL, 1 \leq j \leq n_j, 1 \leq k \leq n_k$$

Objective Function 1 (Z) minimizes the total transportation cost:

$$Z = \min\left[\sum_{i=1}^{n_i}\sum_{j=1}^{n_j}(CFL_{ij} + CP_{ij}) \cdot f_{ij} + \sum_{j=1}^{n_j}\sum_{k=1}^{n_k} CSL_{jk} \cdot s_{jk}\right](1)$$

Constraints:

$$\sum_{i=1}^{n_i}\sum_{j=1}^{n_j} f_{ij} = 1(2)$$

$$\sum_{j=1}^{n_j}\sum_{k=1}^{n_k} s_{jk} = 1(3)$$

$$\sum_{i=1}^{n_i} f_{ij} = \sum_{k=1}^{n_k} s_{jk}, \forall j(4)$$

Corresponding explanations:

The objective function (1) minimizes total cost of container import flow through the transport network. They include transport cost on the first leg-arc (ocean costs), port cost and transport cost on the second leg-arc (cost of using inland vehicles - truck, rail and barge. Constraints (2) and (3) define a single best solution for cost from a group of ordered pairs on the maritime and inland part. Constraint (4) selects the same port for the first and second leg-arc and defines one route from origin terminal to place of delivery regarding transportation cost.

RESULTS

The results are analyzed using three different approacheswhich are described below:

- MATLAB
- Genetic Algorithm
- Simulation Software - LINGO

MATLAB

Mathematical model which minimize transportation costs of container import from Shanghai to Belgradethrough selected Mediterranean ports (Koper, Rijeka, Bar, Thessaloniki and Constanta), observing the six world's largest container operators (Maersk Line - MSK, Mediterranean Shipping Company - MSC, CMA CGM, Evergreen Line - EMC, China Ocean Shipping Company - COSCO and Hapag - Lloyd) is developed. Serbia is hinterland country and container import from Far East to Serbia needs to use different transport modes on inland to link shipping transport in the sea leg including railway, barge and truck. We considered only import containers in Serbia given the negligibly small exported quantities.Optimization model was programmed in MATLAB and simulations were performed on an Intel Core i7-3612 QM 2.1 GHz computer. We use original input data regarding first half of 2014 (average cost for first six months).

Table 2.Input arguments

n_k	3
n_i	6
n_j	5

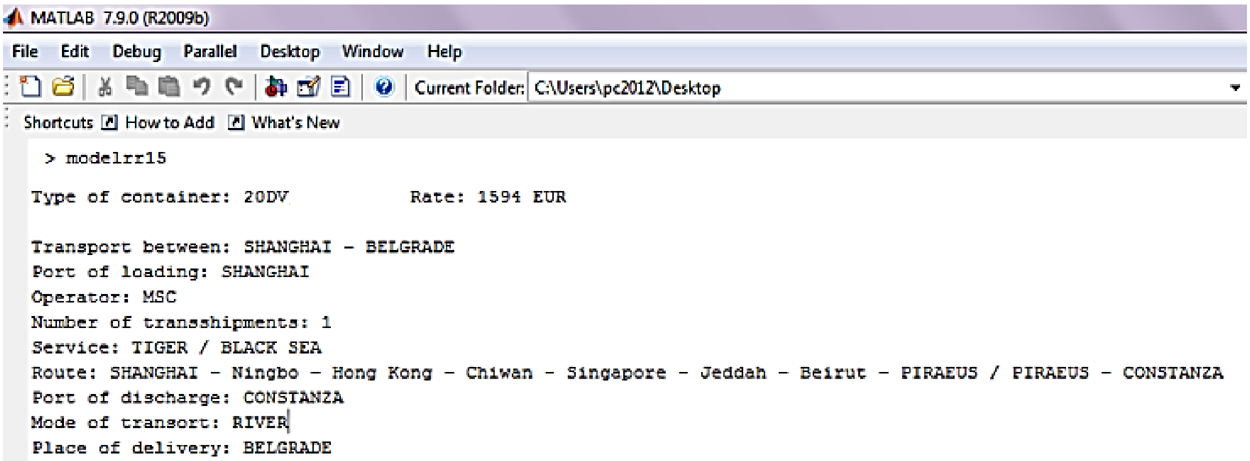

Figure 2. Simulation Results in MATLAB

In this scenario we analyze one objective optimization where the optimal transportation cost between Shanghai and Belgrade was 1594 EUR using see and land legs together. Operator MSC using Tiger service on the deep see shipping and Black sea service on the short see shipping continue with barge to the final destination Belgrade.

Genetic Algorithm

An individualis defined with certain number of shippers, port and type of transportation.We used one variant of the method of tournament selection. In each group, the worst individual is removed, and the best individual is repeated.The crossing was done so that in each pair of selected individuals choose a random part, the shipping company, port or transport types, and then this part was exchanged between them.Mutation is random selected one individual and one of her random gene (part parameter), which is mutated and got a new random value from a set of allowable values for that parameter.Genetic algorithms (GA) have proved to be very suitable for solving this problem. Increasing populations are usually obtained on better solutions. In addition, we monitored the influence of other parameters such as population and tournament size and number of iterations of the tournament. We are running the program 100 times for fixed parameters, counting how many timewasprovided the optimal solution comparing with simulation results in MATLAB.

Table 3.Simulation results using GA

No. of repetitions	Population size	Tournament size	No. of iterations	No. of optimal solutions
100	10	5	20	42
100	50	5	20	88
100	100	5	20	99
100	500	5	20	100

No. of repetitions	Population size	Tournament size	No. of iterations	Total number of optimal
100	100	5	20	95
100	100	10	20	100
100	100	20	20	100

No. of repetitions	Population size	Tournament size	No. of iterations	Total number of optimal
100	100	5	5	98
100	100	5	10	98
100	100	5	15	100

Software Analyses

Software Lingo proved to be a good tool for solving this problem. When the specified mathematical problem translated into formula in the package Lingo we got one linear system with the specified limits. The globally the globally optimal solution is guaranteed, and the resulting optimal value was equal to the known optimum value for this problem.

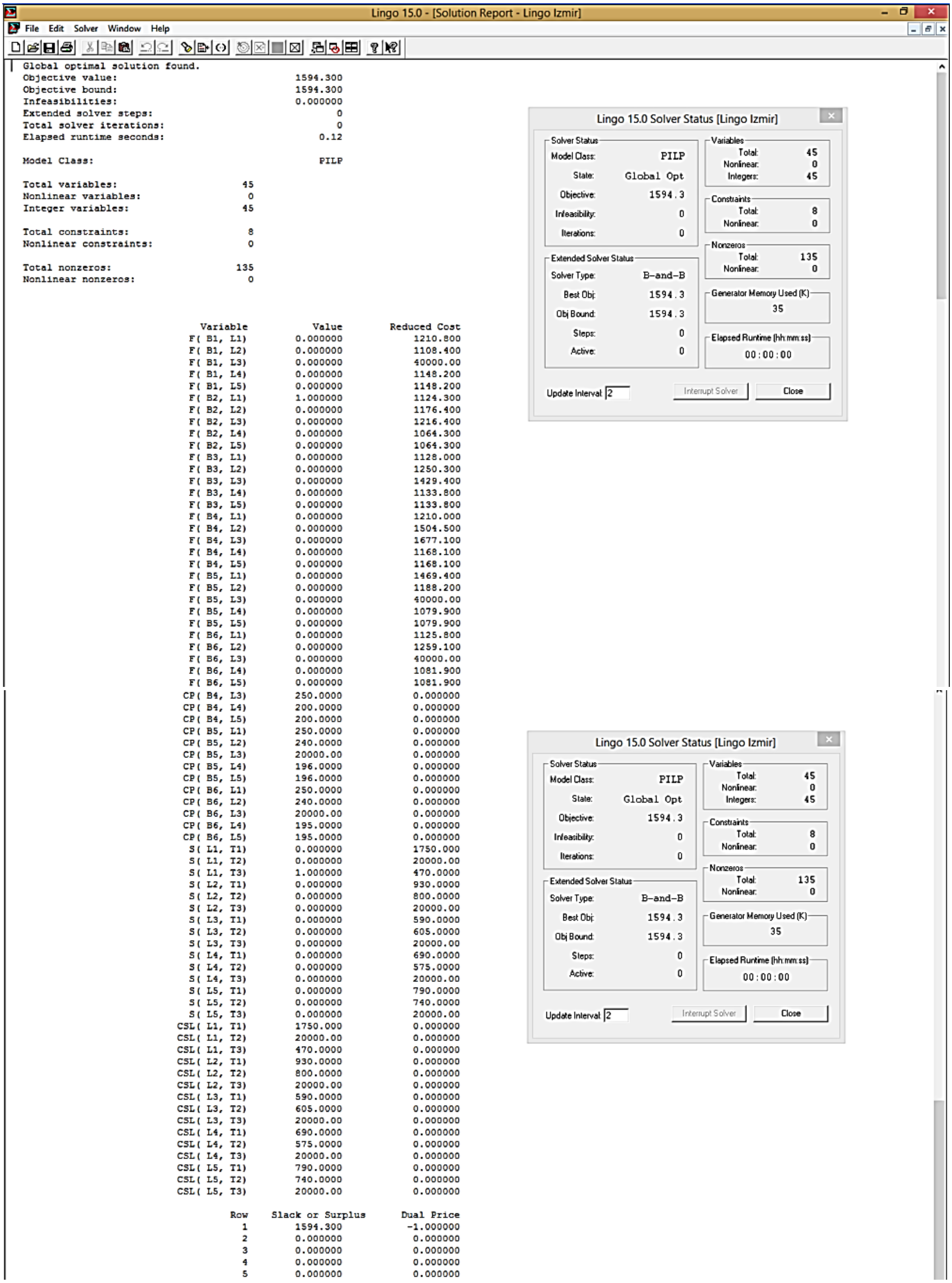

Figure 3. Simulation Results in LINGO

CONCLUSION

As well as the economic and structural reasons that favour the demand for container transport, on the demand side there are a number of specific advantages of this form of transport. Shorter loading and unloading times, compared with traditional cargo ships, and better opportunities for onward transport are particularly decisive factors behind the great success of container shipping. These save costs and, by virtue of shorter turnaround times, reduce capacity bottlenecks in the ports. For this reason the degree of containerization (as a proportion of the total volume of general cargo handled) has increased considerably in all the major world ports. Transportation cost in container transport takes a very important placedefining the final price of the product.

This paper analyzes the supply chain network with primary focus on import of containers from Shanghai to Belgrade through selected Mediterranean ports, observing the six world's largest container operators (Maersk Line, Mediterranean Shipping Company, CMA CGM, Evergreen Line, China Ocean Shipping Company and Hapag-Lioyd) with theirs different type of services. Serbia is hinterland country and container import from Far East to Serbia needs to use different transport modes on inland to link shipping transport in the sea leg including railway, barge and truck. The main goal of this research is to provide an optimal route with lowest transportation cost.

Computational results shows us that the lowest transportation costs between Shanghai and Belgrade, are reached using MSC operator on the maritime leg and barge transport on the land leg.The investigations were conducted using different approaches.

Further research is needed, because this research is recited only part of the problem. It can be extended in the future and can be imported with a lot of new nodes and new objectives such as transit time and emissions.

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ROUTING OF VNA MAN-UP TURRET TRUCKS AND VERTICAL ORDER-PICKERS

Goran Dukic[41], Tihomir Opetuk[42], Hrvoje Cajner[43], Tone Lerher[44], Ana Jelic[45]

Abstract − It is well-known that order-picking process is most laborious and most costly in today's most warehouses. One of the ways of increasing order-picking productivity is by optimizing routes of picking cycles, minimizing the total travelled distance or travel time. In this paper we analyze routing of Very Narrow Aisle (VNA) man-up turret trucks and vertical order-pickers in systems with high racks, characterized by not negligible vertical movement time between picking locations. Paper presents preliminary results of research, comparison between several heuristics for various configurations of racks (length) and order size (number of picking locations per route), limited to a single aisle. Analysis is done both for case of sequential movements and simultaneous movements in vertical and horizontal direction. The results may serve as guidelines to warehouse designers and managers for designing new or improving existing order-picking systems with picking from higher levels of racks.

Keywords − Order-picking, routing heuristics, man-up turret trucks, vertical order-pickers

INTRODUCTION

It is well known that logistics costs have an important influence on the business success of any company. The efficiency and effectiveness of logistics of a company are largely determined by design of logistics systems and operations performed in such systems. Warehousing systems are one of them. Since warehouses are in most cases non-avoidable places within the production site of industrial companies, and are also nodes in the distribution network towards final customers, proper warehouse planning and control have drawn full attention in literature ([4], [9], [11]). Warehousing costs are to a large extent already determined during the design phase, unfortunately highly complex task with many trade-offs between conflicting objectives and a large number of feasible designs. However, even in one selected and implemented design there are possibilities to reduce operational costs and increase productivity using various operational policies (methods) according to the operational demands.

In this paper we focus on very narrow aisle (VNA) design of storage area using man-up turret trucks for storage and picking operations, motivated by one real case in Croatia. Such design offers high storage area efficiency using very narrow aisles between rather high pallet racks, while in the same time allows picking of cases and items (not only full pallets) from all picking/storing locations. Order-picking process is most laborious and most costly in today's most warehouses, with up to 55% of warehouse total operating costs [10]. The time to pick an order can be divided on three components: time for traveling between items, time for picking the items and time for remaining activities. With the fact that about 50% of total order-picking time is spent on travelling [10], great possibility to reduce operational costs and increase productivity lies in reducing total picking time by reducing picking travel time using operational policies. Most methods of improving operational efficiency of order-picking focuses on reducing travel times, and can be categorized into one of three groups of operating policies: routing, storage and batching. Routing methods determine the sequences and routes of travelling, trying to minimize total travel distances. Storage methods or assigning items to storage locations based on some rules could also reduce travel distances compared to random assignment. Order batching methods or grouping two or more customer orders in one picking order, are also very efficient

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in reducing total travel distances. All methods mentioned are well-known and proven in improving order-picking efficiency. However, the performances depend greatly on the layout and size of the warehouse, the size and characteristics of orders and the order-picker’s capacity.

In this paper we focus on routing of VNA turret trucks during picking process. Characterized by non-negligible vertical movement time between location, routing of VNA trucks (same is applied to vertical order-pickers) differs from routing problem of pickers in low-level order-picking systems where only horizontal movement is considered (with the constant movement speed this problem could be considered as minimization of travelled distance in horizontal direction). Paper presents results of only first part of the project, comparison between several heuristics for various configurations of racks (length) and order size (number of picking locations per route), limited to a single aisle. In the next stage we will extend the problem to the routing of VNA trucks in multiple aisles design.

The structure of the paper is as follows. In the next section we describe VNA storage systems using VNA turret trucks together with the motivation of the research project based on mentioned real case in Croatia. After that we present four analyzed routing heuristics and results of the simulation analysis performed for various configurations. Conclusions and further steps of the project research are given at the end.

VNA STORAGE SYSTEM USING MAN-UP TURRET TRUCKS FOR ORDER-PICKING

VNA storage system’s main characteristic could be very well understood from its name. Using very narrow aisles between pallet racks (using VNA trucks) one can achieve higher storage space utilization compared to the storage designs with wide aisles (using counterbalanced forklifts) or narrow aisles designs (using reach trucks). With the width of the aisles of approximately 1.6 to 1.8 m compared to the widths of around 2.6 m for reach trucks or 3.3 m for counterbalanced trucks, VNA systems have much better storage space efficiency compared to the other two systems. Or for the same available storage space, using wide aisles as the baseline, one can expect to be able to store 20%-25% more product by going to a narrow aisle system and 40%-50% more by going to a VNA system [6]. VNA racking can also be substantially higher than other conventional racking systems. Today there are several types of VNA trucks offered by various manufacturers. Often abbreviated to VNA is turret truck, while other types are articulated truck and swing mast truck. Figure 1 illustrates mentioned VNA forklifts.

Figure 5. Various types of VNA trucks

Turret trucks could be man-down and man-up. Man-down turret truck, same as articulated truck and swing mast truck, operates in very narrow aisles rotating forks for pallet storage or pallet picking. However operator stays down having quite difficult positioning of the forks in greater heights. Order-picking of cases or items from higher locations should be done using other equipment, in this case vertical order picking truck (man-up order selector). On the other hand, man-up turret trucks have the ability to lift the operator to heights of up to 14 meters (depending on the model). This man up process means the driver sits within the carriage of the turret truck, giving them a clear and accurate view of the pallet handling process, hence improving handling times. Turret trucks often use guidance systems (wire, rail, optical) to travel within the aisles, allowing the turret truck to function at extremely high speeds which ensures extremely fast pallet handling with much higher productivity and handling times than reach trucks or counterbalance forklifts. The feature that operator is lifted up also allows the operator to perform case or item order picking, which makes another difference between VNA man-up turret truck and other types of VNA trucks.

Mentioned real case in Croatia is a warehouse consisting of main storage and picking area designed as VNA system using three VNA man-up turret trucks (model Yale MTC13) illustrated in Figure 2. Storage and picking area has 21 racks with 12 very narrow aisles and is divided into zones dedicated for different groups of raw materials and finished goods. There are to main groups of finished goods stored into zones with four and two aisles respectively. Orders are not mixing products from those groups therefore order picking for customer orders is always performed inside dedicated zone only. Depending on the customer order picking might be therefore from single or multiple (but just few) aisles. Routing order picker is managed by Warehouse Management System using heuristic method for low lever order picking from multiple aisles, considering only horizontal location of the required items in the order list. However, items to be picked are on various levels and vertical movement of operator in carriage influences picking time as well. The interest of the project is to investigate possibility to improve order-picking routing taking into account both vertical and horizontal movement between picking locations.

Figure 2. Man-up turret truck in VNA warehouse

For low-level order-picking systems there is developed optimal routing algorithm [7] (special case of travelling salesman problem solved with dynamic programming). However it considers only horizontal distance between locations and aisles. Optimal routing in multiple aisles considering both vertical and horizontal movement is more complex. Additionally, one can consider movement in both directions sequentially (first driving to the column of the location and then raising or lowering operator, known as rectilinear travel) but also simultaneously having traction and lifting in the same time. Hence, the time required to travel between locations is the maximum of the horizontal and vertical travel times, which is also known as Chebyshev travel. New models of VNA trucks can be equipped with navigation system, so when receiving the information on the next location the truck reaches this position by the fastest possible route.

Therefore, the motivation of the research is to investigate various heuristics that could be used for routing order-picker with VNA man-up turret truck, considering both single aisle and multiple aisle routes, with possible ultimate goal of developing an optimal algorithm. General results could be used then to propose improvement of the routing algorithm used in WMS of the mentioned case. In the first stage of the research, presented further in this paper, we are restricted to several heuristics for single aisle movement. Obtained results could be also used in selecting routing heuristics for vertical order-picking truck (man-up order selector) used for order picking in any other high rack system from all locations.

ROUTING HEURISTICS, SIMULATION ANALYSIS AND RESULTS

In this section analyzed heuristics are presented. Routes obtained by different heuristics are illustrated with one example (aisle represented by rack with 25x10 locations, start/end point in the lower left corner of the aisle, 10 picking locations which equals to the number of lines in a customer order). Of course picking in one aisle could be done from 2 racks on both sides of the aisle. There is no need for changing position of the truck while picking from both sides, hence travel time is not affected by whether a pick location is on the left or right side of the aisle. Therefore problem could be simply represented with one rack only. Simulation experiment is explained together with the assumption used in the analysis. Finally results of analysis are given as comparison of four heuristics.

Routing heuristics

Analysis of routing heuristics for VNA turret trucks was done for selected 4 heuristics. First heuristic, as a baseline, is so called "x-heuristic" where picking sequence (therefore the route) is defined based on the x coordinate of the picking location in the aisle. Therefore “x-heuristic” is very simple to perform transforming one customer order into a picking order ranking items by the horizontal distance from the starting point. After all items from the order are collected turret is travelling to the delivery point. Figure 3 and Figure 4 illustrate routes obtained with this heuristics for mentioned example.

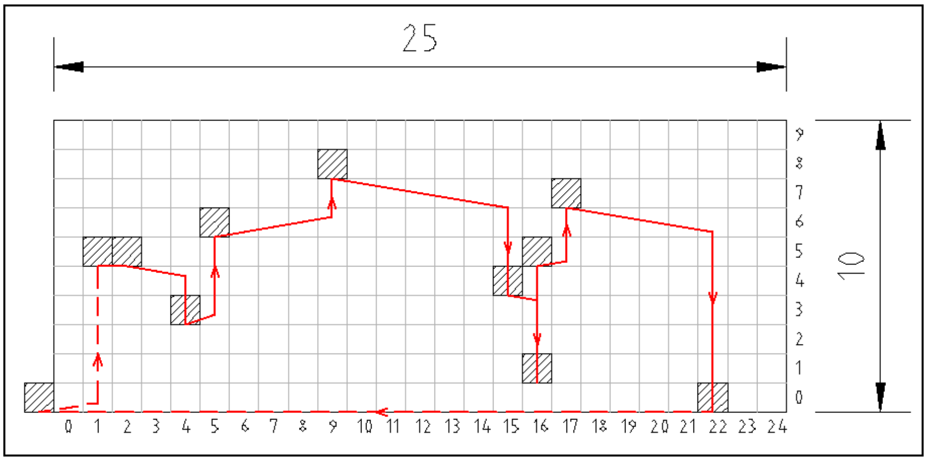

Figure 3. Route example with “x-heuristic” using simultaneous travel

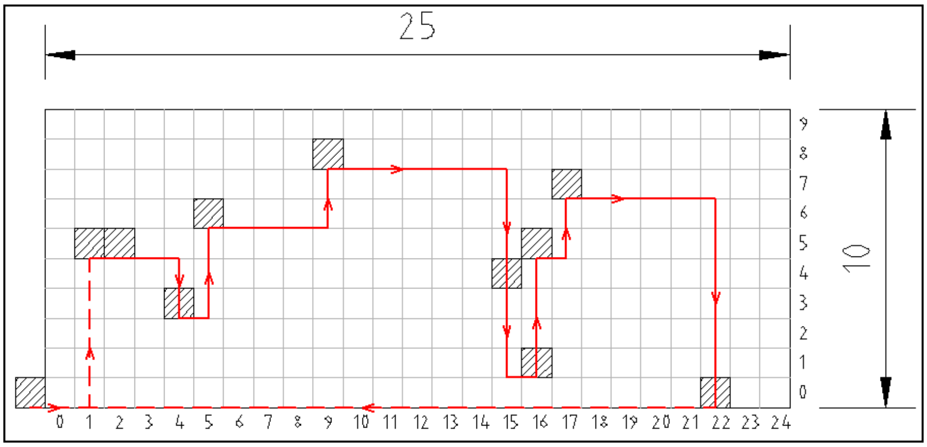

Figure 4. Route example with "x-heuristic" using sequential travel

The next analyzed heuristic is so called "band heuristic", motivated by routing of S/R machine in person-on board automated storage/retrieval systems (AS/RS). Sequencing the pick locations in person-on-board AS/RS is the same problem as sequencing locations in the VNA system with man-up turret using simultaneous movement and could be solved optimally. However obtaining the optimal sequence with the Chebisev metric can require a large amount of computer time [1], so simpler and faster heuristics as "band heuristic" could be used. With the "band heuristic", the rack is divided into *k* equal-sized horizontal bands, where *k* is an even number. Starting with the first band, the turret travels in a serpentine fashion picking sequentially along *x*-axis. After all picks are completed in the current band, turret proceeds to the next band. Optimum number of bands is defined for person-on-board AS/RS as a function of number of picks. Optimum number of bands is just two for 1 to 24 number of picking location in a tour, while 4 bands for number of picking locations between 25 and 72. However we were restricted in our analysis to only two bands in a VNA rack system despite the order size. The route examples for this heuristics are illustrated in Figure 5 and Figure 6.

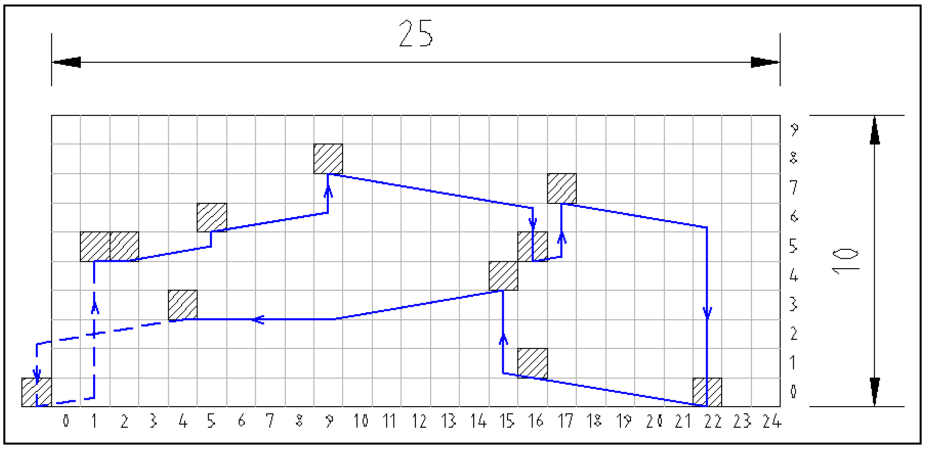

Figure 5. Route example with "band heuristic" using simultaneous travel

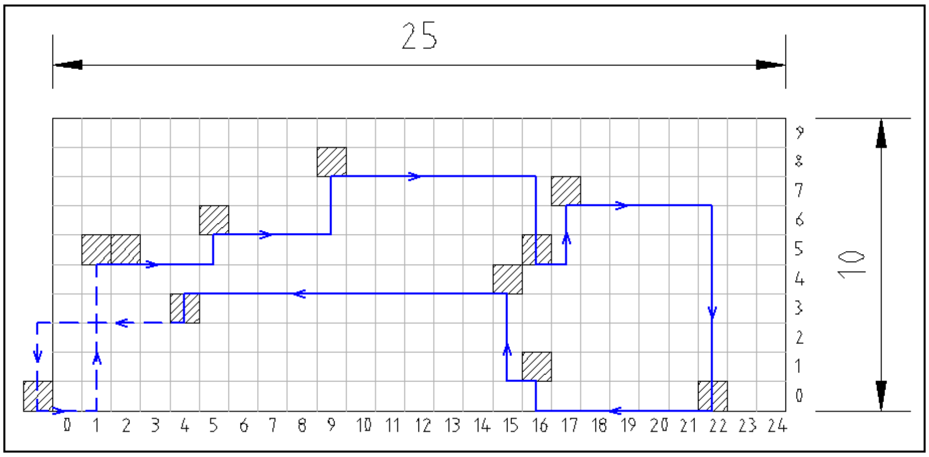

Figure 6. Route example with "band heuristic" using sequential travel

Third heuristic used in analysis is most simple heuristics for travelling salesman problem, Nearest Neighbor heuristic, applied considering Chebyshev and rectilinear travel, respectively. So the sequencing is again simple. Starting from the left corner, turret travels to the nearest picking location (nearest in travel time units) and then moves to the next nearest to the last visited. After visiting all locations turret is return to the delivery point. Route examples with this "NN heuristic" are given in Figure 7 and Figure 8.

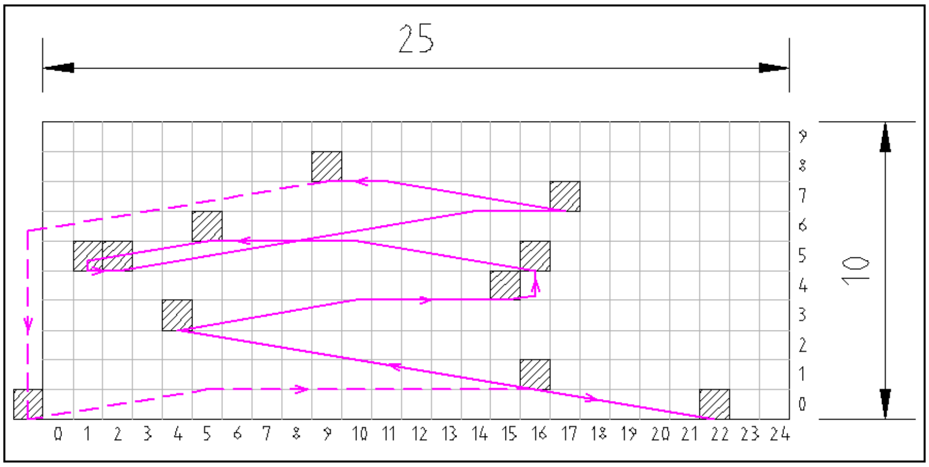

Figure 7. Route example with "NN heuristic" using simultaneous travel

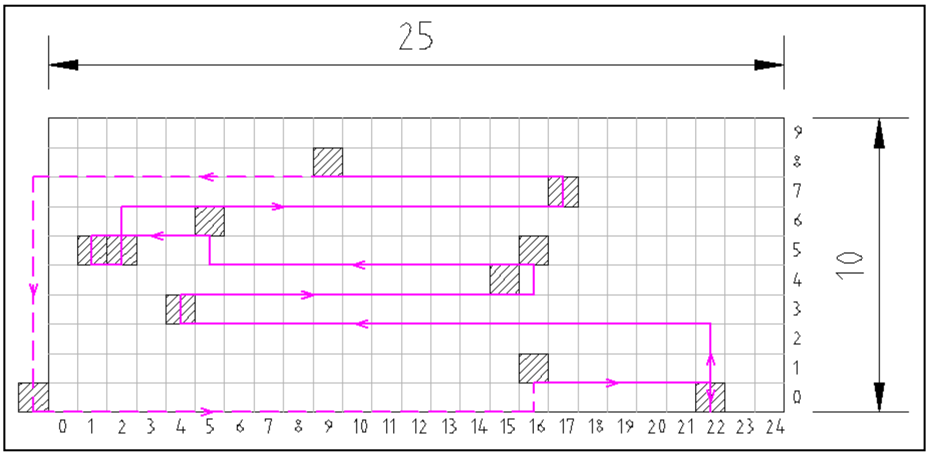

Figure 8. Route example with "NN heuristic" using sequential travel

The last analyzed heuristic is a combination of previous two heuristics. Having in mind that using "band heuristic" turret travels in all bands simply based on *x* coordinates of locations (while in each band there is still non-negligible vertical movement), we combined 2 heuristics in one called "NN band heuristic". Same as for "band heuristic", the rack is divided into bands. Sequence of visiting locations in bands is based on the route derived with "NN heuristic" for locations only in particular band. Of course there is no returning to the start/end point after last location in the first band, but turret proceeds to the nearest location in the second band being starting point of next partial route derived again from the "NN heuristic". After picking from the last location in second band turret is returning to the delivery point. Figure 9 and Figure 10 illustrates routes again for the same example.

As it is easily seen from the illustrations, different routing heuristics results in different sequence of locations visited in the route, therefore different times of travelling in a route. Even more, different routes could be obtained depending on the simultaneous (Chebyshev) or sequential (rectilinear) travel, while later requiring more time for travel. Some locations being very close to each other in horizontal direction but far in vertical direction might impose longer travels due to the much lower vertical speed of lifting compared to the horizontal speed of driving. While "band heuristics" tries to reduce this vertical difference between locations dividing rack in two halves, and also using second band for traveling in direction back to the delivery point, "NN heuristics" tries to sequence locations by their real closeness (in time), not just in *x* direction.

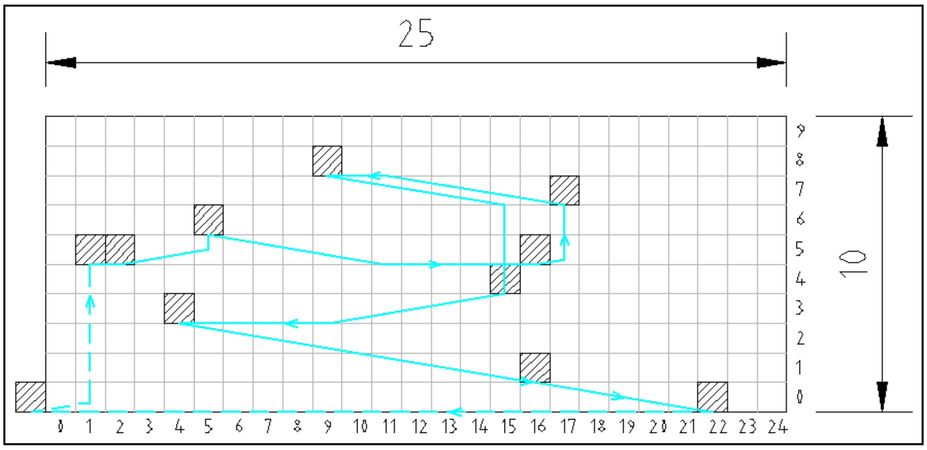

Figure 9. Route example with "NN band heuristic" using simultaneous travel

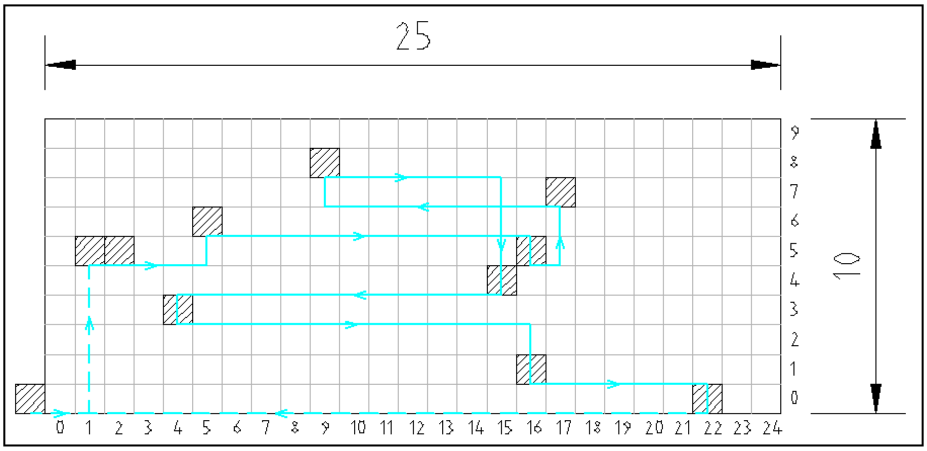

Figure 10. Route example with "NN band heuristic" using sequential travel

Simulation analysis and results

To evaluate performances of presented heuristics simulation analysis was used. All heuristics were used to generate routes of randomly generated orders (locations) in a rack simulating random storage policy (therefore all locations were equally likely to be included in the generated order). Various order sizes were used (x=10, 25 and 50 locations per order respectively), as well as various rack sizes (capacities). The size of the locations due to the simplicity was selected as 1x1 meter. However we were changing rack capacity only by length (L=25, 50 and 75 meters respectively, equals to the aisle length) while keeping the height equal in all experiments being 10 meters (10 levels). The reason for that was a wish to possibly correlate the results with the only one parameter – density of the locations defined as the average distance between picking locations in a rack (this could be simply represented as x/L). This is analogous to the density of the locations in the aisles for low level manual picking systems known as the indicator of the performances of the "S-shape" versus "Largest Gap" heuristics (for readers interested in routing heuristics in low level multiple aisle picking systems we point to the [2], [3], [5] and [8], among others). The speeds of movement in horizontal and vertical direction (therefore driving and lifting/lowering) were chosen for one particular man-up turret truck as v_x=2.5 m/s and v_y=0.42 m/s. Acceleration and deceleration for both horizontal and vertical movement were neglected.

For each analyzed combination of rack configuration, order size heuristic and movement type (therefore 3x3x4x2=72 instances) there were 10,000 orders generated. Results given in Table 1 represent average time of traveling per route generated with four analyzed heuristics both for simultaneous and sequential travel. Highlighted cell in each row marks best obtained result for corresponding combination of order size and rack capacity.

Table 8. Results of analysis (average travelling time in a picking route, in seconds)

Order size, aisle length	"x heuristic"		"band heuristic"		"NN heuristic"		"NN band heuristic"	
	sim.	seq.	sim.	seq.	sim.	seq.	sim.	seq.
x=10, L=25	85.33	99.74	61.88	75.33	50.95	69.27	52.35	70.69
x=10, L=50	92.85	117.54	70.46	93.80	67.08	94.62	70.86	98.56
x=10, L=75	105.47	136.35	82.44	112.34	84.41	118.39	87.56	119.94
x=25, L=25	187.62	203.35	112.29	126.83	72.22	96.56	76.97	101.96
x=25, L=50	197.96	225.05	119.54	147.11	98.69	138.32	105.73	144.58
x=25, L=75	210.23	245.18	128.98	166.83	122.68	172.12	131.37	178.72
x=50, L=25	342.62	359.43	194.08	209.09	96.65	125.47	101.06	128.71
x=50, L=50	368.84	397.54	202.9	232.64	134.6	183.86	143.43	191.01
x=50, L=75	383.67	420.42	210.11	253.22	166.54	230.73	178.69	240.20

From the results it is obvious that "x heuristic" is outperformed by all other heuristics. Simple TSP heuristic NN was the best one in almost all instances, while "band heuristic" being second best. Although might be surprising that "NN band heuristics" performed rather bad compared to previous two, this could be explained with the greedy nature of NN heuristic, ending with the partial tours in band in such locations that requires substantial travelling backwards.

Reduced average picking travel times expressed in percentages are given in Table 2 ("x heuristic used as a baseline), ranging from 17 to over 70% for simultaneous and 12 to 65% for sequential travel. Considering the mentioned density of locations, we can see strong correlation between density and percentage of picking travel time reduction. Advanced heuristics compared to the baseline have lower potentials to reduce picking travel times with lesser densities of locations.

Table 2. Reduced average picking travel times ("x heuristic as baseline, in %)

Order size,	"x heuristic"	"band heuristic"	"NN heuristic"	"NN band heuristic"

aisle length	sim.	seq.	sim.	seq.	sim.	seq.	sim.	seq.
x=10, L=25	-	-	27.5	24.5	40.3	30.5	38.6	29.1
x=10, L=50	-	-	24.1	20.2	27.8	19.5	23.7	16.1
x=10, L=75	-	-	21.8	17.6	20.0	13.2	17.0	12.0
x=25, L=25	-	-	40.2	37.6	61.5	52.5	59.0	49.9
x=25, L=50	-	-	39.6	34.6	50.1	38.5	46.6	35.8
x=25, L=75	-	-	38.6	32.0	41.6	29.8	37.5	27.1
x=50, L=25	-	-	43.4	41.8	71.8	65.1	70.5	64.2
x=50, L=50	-	-	45.0	41.5	63.5	53.8	61.1	52.0
x=50, L=75	-	-	45.2	39.8	56.6	45.1	53.4	42.9

Of course, simultaneous travel offers better performances than sequential travel for all instances, shown in Table 3.

Table 3. Reduced average picking travel times with simultaneous travel, in %

Order size, aisle length	"x heuristic"		"band heuristic"		"NN heuristic"		"NN band heuristic"	
	sim.	seq.	sim.	seq.	sim.	seq.	sim.	seq.
x=10, L=25	14.45	-	17.85	-	26.45	-	25.94	-
x=10, L=50	21.01	-	24.88	-	29.11	-	28.10	-
x=10, L=75	22.65	-	26.62	-	28.70	-	27.00	-
x=25, L=25	7.74	-	11.46	-	25.21	-	24.51	-
x=25, L=50	12.04	-	18.74	-	28.65	-	26.87	-
x=25, L=75	14.25	-	22.69	-	28.72	-	26.49	-
x=50, L=25	4.68	-	7.18	-	22.97	-	21.48	-
x=50, L=50	7.22	-	12.78	-	26.79	-	24.91	-
x=50, L=75	8.74	-	17.02	-	27.82	-	25.61	-

Simultaneous movement resulted with reduced picking travel time compared to the sequential travel in up to almost 30% in cases using TSP NN heuristic, leading to the conclusion that in this case those heuristics "have better way" of finding closer nearest location in generating routes.

CONCLUSIONS

In this paper we presented VNA storage systems using man-up turret trucks for order-picking. The problem of routing is emphasized, which should take into account both horizontal and vertical movement of the turret (picker) being possible either sequential (rectilinear) or even simultaneous (Chebyshev travel).

Paper presents preliminary results of the research, limited to the case of picking in only one aisle (single aisle picking). Results indicate that there is a good potential to reduce order-picking travel times in VNA systems with man-up turret trucks using advanced heuristics compared to the simple "x heuristics" that is neglecting vertical coordinates of the picking locations. In some case reduced travel time is over 70%. The results may serve as guidelines to warehouse designers and managers for designing new or improving existing order-picking systems with picking from higher levels of racks. "NN heuristic", although being the simplest TSP heuristic, appeared as the best solution. This also leads to thinking that more advanced TSP heuristics might perform even better, providing near optimal solution without the need to use complex optimal algorithm.

Comparison of average picking travel times for simultaneous and sequential travel justify new systems for navigation from location to location in an optimal way – Chebyshev travel with the minimal travel time. Simultaneous travel might provide reduction of travel up to 30%.

In the further research, heuristics for multiple aisles picking should be analyzed. This will require using combination of low-level order-picking routing heuristics with the ones presented in this paper. Finally, based on overall general results, proposed new routing heuristics for real case in Croatia will be verified using real data.

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PERFORMANCE MEASUREMENT OF ENERGY PROCESSES IN CZECH PRODUCTION PLANTS

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Abstract – *Performance Measurement sense has been rapidly increasing in the last years. Unfortunately, the energy area has not been touched by the benefits of process management yet. It is true, that some production plants declare that the process management has been implemented, but after the deep research it was only the prediction. The initial situation is described in the research result chapter. It contains main reasons which lead the author to focus on the energy processes area. Main reasons came from Energy concept of European Union and Czech Republic comparison which shows main differences in the type of energy sources exploitation (the nuclear energy vs. the renewable energy sources such as wind power, solar power, water power and energy from the biomass), analysis of selected energy sources (prices and consumptions development) and from the questionnaire survey and case studies which were made in energy departments. The article is aimed at energy Performance Measurement level in Czech industrial plants.*

Key words – Energy Management, Energy Processes, Key Performance Indicators, Performance Measurement (PM), Performance Measurement (PM) concepts

LITERATURE REVIEW

Energy Processes, Energy Management

Based on the reasons mentioned above, implementation of the Performance Management and Measurement along with its benefits was very important for the being of next successful companies. The energetic is the branch, which is aimed at development, forming, processing and transferring of energy.

Energy industries are described as the complex of supporting processes which ensure energy production operation, operation of administrative area and next core processes.

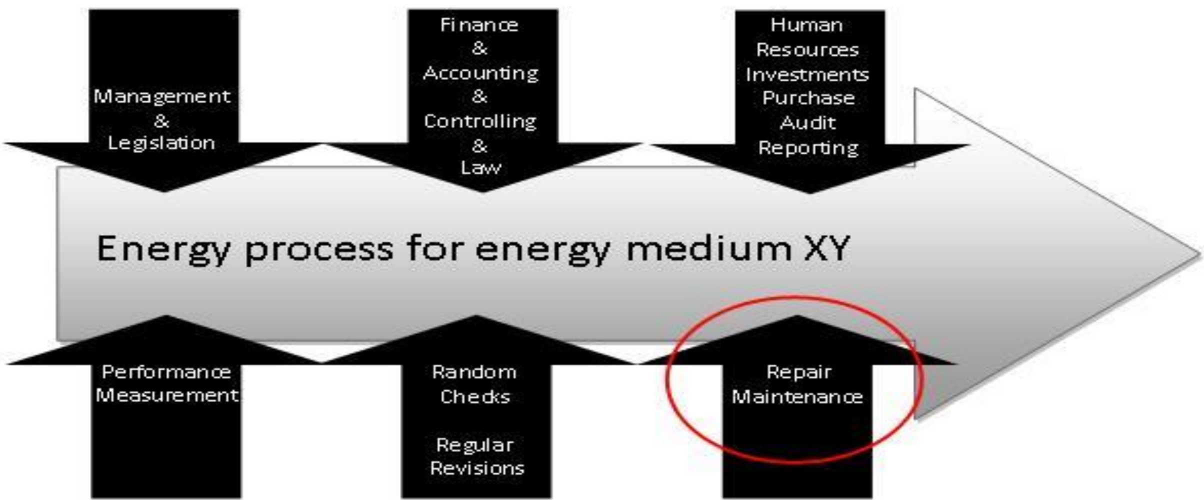

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Figure 1. Ensuring of Energy Processes [20]

Novak [20] wrote that energy process (such as supporting process) is the complex of activities and its output is increasing of added value of energy materials which are going through it and ensure connected activities. The aim is to increase the added value for final customer and ensure the production. This fact was confirmed by Edl at al. [9] in their study.

The complex methodology how we can divided and manage all business processes in companies define Závadská, Řepa and Závadský [30] in standard CEABPM 1001:2013.

The importance of energy processes should be found or described with help of Balanced Scorecard´s 4 perspectives as it was written by Kaplan, R.S., Norton, D. P [16].

Energy management is defined by Capehart, Turner a Kennedy [2] as reasonable and efficient energy use for profit maximization (cost minimization) and competitiveness increasing.

Colsys [3] describes Energy management as core control process ensuring the energy needs, regarding the working energy process.

The main target of Energy management is the ensuring of economic, reliable and environmentally thoughtful operation followed by covering all the energy needs.

The Performance Measurement

When you can measure what you are speaking about and express it in numbers, you know something about it, said Lord Kelvin, W. T. [18] Deming, W. E. [6] wrote that you can not manage what you can not measure.

From a quantitative point of view performance measures tell us something important about our products, services, and the processes that produce them. These are tools to help us understand, manage, and improve what our organizations do. Department of Trade and Industry in the United Kingdom defines that performance measures let us know: how well we are doing, if we are meeting our goals, if our customers are satisfied, if our processes are in statistical control, if and where improvements are necessary [7].

In the energy area, there exists plenty of metrics and measures defined in accordance to energy flow or to building heat cladding as declared in Torcellini et al [24]. However, it is not defined for sub- processes which ensure this energy flow (e.g. Full Time Equivalent, etc.).

Some appropriate measures should be learned and used from the Department of Trade and Industry – special defense project [7] or from Czech Technical Standard released by Czech Office for Standards, Metrology and Testing [4].

Bunse et al [1] writes in her research that only a few of relevant measures are used in energy area while the standardized ones are completely missing there.

Therefore it is important to be aware of the performance measurement. As the UK Department of Energy [7] recommends, it is essential to keep in mind all the external and internal consequences in view of the first law of performance: if you try to be the best at everything, you will be the best at nothing.

With regard to dynamic development of economy area, most of companies are looking more carefully for effectiveness increasing possibility and for product´s added value. Pilik [21] describes energy area as a branch which is aimed at gaining, modification, manufacturing and distribution of energy sources. In managing area, the plants are primarily aimed at core processes, mainly industrial ones. Even though there is a substantial optimization potential covered, the supporting processes, including energy, are being surveyed.

Regarding the process measurement performance, some authors, such as Rajnoha and Chromjaková [22] recommend implementation of Activity-Based-Costing (ABC) method in the enterprise.

Additionally, implementation of calculation based on processes and activities causes also non-quantified effects such as:

- transparency and rationalisation of performed activities and processes,
- more responsible proceeding of enterprise work,
- identification of enterprise's competitive advantages or disadvantages,
- information support for strategic management and goal oriented management,
- assignment of overhead costs to performance on case-by-case basis,
- support of price policy and production-sales program optimization [22].

Rajnoha and Dobrovic [23] wrote about basic elements of Process Management and process measurement performance the following premises:

- Companies' productivity is based on the individual processes productivity,
- Processes include individual activities, which can be described and measured,
- All the processes have specific inputs and outputs regarding internal and external customers,
- Processes can be innovated and this activity brings increasing of added value for the user.
- Processes changes have to lead to processes quality increasing and time consumption decreasing.

PROCESS APPROACH TO THE ENERGY PROCESSES

The Goals of the Quantitative Research

The aim of the article is to find and describe main impacts and actual approach of the Czech industrial companies in energy processes performance measurement (energy prices and consumption analysis, actual level of performance measurement utilization in plant at all and directly in energy area, PM methods utilization, KPI´s used). For this purposes, outcomes from quantitative research were used. The exact goals of this article are:

1. Analysis of the reasons for business process management usage.
2. KPI´s and performance measurement methods.
3. Concepts rank use in the Czech plants.

Research Methodology of Quantitative and Qualitative Research

Overall summary ofresearch results are listed in summary all of the researched Czech production plants, which were 59 at all (78 questionnaires were received but 19 of them returned incomplete). Parent population of the research was 4.830 companies (main criteria: min. 50 employees, CZ-NACE, category item 10-33 production activities). The selective group was 757 companies (criteria: energy departments inside the company and energy management availability). Questions were selected as semi-closed in order to be able to answer respondents´ own opinion by Gill and Johnson [13] methodology. Questionnaire´s return percentage was 8.7%. It may not seem much, but Eschenbach [11] presents the return from 7% to 47% in controlling researches which are near to energy area specification. These researches were much more general.

Case studies made in 12 big industrial plants were used as the next data source (qualitative research) for the whole research. Case studies included direct interview with energy managers. This questionnaire distributed to the main companies describes the level of process management implementation, KPIs indicators and performance measurement methods.

Research results

Based on the analysis mentioned above, there were set up main impacts to manage the energy processes and future decision making. Moreover, it was helpful for the formulation of research questionnaire. 1st Differences between EU and Czech energy concepts have a big impact on company´s energy planning at strategic level to hold the competition advantages.

2nd The analysis of the energy sources prices and its consumption showed the growth. This evokes requirement of manager’s approach to change energy processes managing. The automation and simulation of virtual plants by 3D models should be used.

3rd The analysis of heat energy proved requirement of additional investments to heat cladding of the buildings and machinery complement with regulation technology.

Table 1. Technician Function Activity Analysis – Savings [28]

	Before project		After Project	
Activity	**hrs./year**	**FTE**	**hrs./year**	**FTE**
Internal repairs, specifications and material ensuring	846	28%	282	16%
Machine maintenance	546	18%	156	9%
External repairs (tender procedures)	282	9%	282	16%
Small external repairs - organizing	235	8%	235	13%
Reporting	232	8%	118	7%
Investment department cooperation	141	5%	141	8%
Planning	184	6%	13	1%
Meetings	188	6%	188	11%
Improvements	24	1%	24	1%
Others	324	11%	324	18%
Total	3 001	100%	1 763	100%

Research results of quantitative research

This research results are only a part of quantitative research. This part of research had shown the significant differences between usage of the PM in business and energy processes areas.

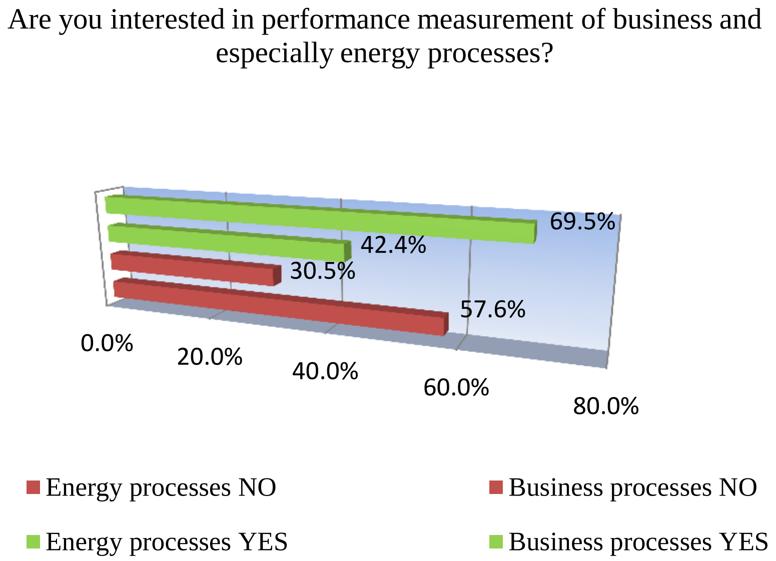

Figure 2. PM in Business and Energy Processes Areas. Source: own

The respondents were firstly asked whether theirs plants are interested in Performance Measurement of business processes.

41; 69,5% answered yes and the rest (18; 30,5%) no.

For the energy processes area the situation is opposite (2; 42,4% answered yes, 34; 57,6% said no). See figure No. 2.

It shows that companies are aimed at business process areas at all, but they are not so deeply interested in PM of the energy processes.

Another question was aimed at the issue whether the responsibility for energy processes measurement and its goals are defined.

The respondents answered in 25%; 15 said yes, but without the relation to employee´s rewarding, 33,9%; 20 answered yes with the relation to employee´s rewarding and finally 40,7% said that no responsibility is defined. It showed that even if the processes could be measured, either nobody was responsible for it, or someone was responsible but without the motivation, so there was not any impulse to increase the effectiveness by the employees in the energy departments.

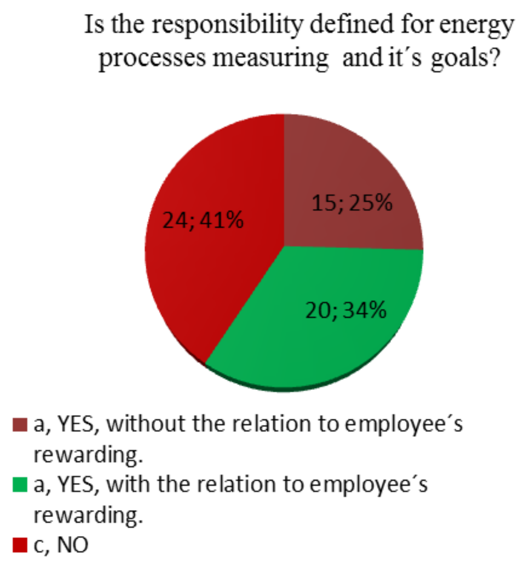

Figure 3. Responsibility for Energy Processes Measuring. Source: own

Table 2. Performance Measurement Concepts Comparison. Source [14]

Criteria Concept	Vision and strategy sequence	Stakeholder oriented targets differentiation	Showing of more performance levels	Indicators Manage-ment	Metrics Modality	Performance evaluation and deviation analysis	Showing of invitation aspects	Reporting concept	Institutional frame	Application of instruments in PM	Performance Management integration
Data Envel. Analysis											
PM in Ser-viceBusiness											
Balanced Scorecard											
Tableau de Bord											
ProMES											
PM - Model											
Performance Pyramid											
Quantum PM											
Koncept Ernst&You.											
Business Mgt.Window											
Koncept J.I. Case											
Koncept Caterpillar											
Koncept Honeywell											
K. Hewlett-Packard											

Black	Widely covered by the concept
Grey 75%	Covered by the concept
Grey 50%	Covered minimally / only conditionally by the concept
Grey 25%	Not covered by the concept
White	Impossible to evaluate for missing information

Gleich [14] compared Performance Measurement concepts (see Tab. 2 bellow). He compared and evaluated 14 concepts of Performance Measurement based on 11 decisive criteria. Each of these criteria characterizes an important part or the functionality of Performance Measurement concept. All the criteria should be evaluated in six concepts. All these concepts are widely described and used (e.g. Balanced Scorecard or Performance Pyramid), or its functionality is based on mathematical calculations (Data Envelopment Analysis).

The best concepts which fulfilled most of the criteria are: Balanced Scorecard, Hewlett-Packard company concept, Performance Pyramid and Quantum Performance Measurement.

We can see that Balanced Scorecard concept occurs in all the studies as one of the most used and the most suitable concept (for the whole plant and energy area, too).

Tuček a Zámečník [27] and Tuček, Tučková and Zámečník [26] asked respondents in their research, which concepts (concerning Performance Measurement System) are used in the industrial plants. Respondents introduced Activity Based Costing (ABC), Balanced Scorecard (BSC), Benchmarking, and European Foundation for Quality Management (EFQM), Performance Pyramid, Six Sigma and Value Based Management (VBM) concepts.

Authors used these concepts as the base to find out if the industrial plants use it in energy area, too (as mentioned above). The research showed that for the energy departments in industrial plants, there does not exist any universal method or concept. As it was found in the research, companies use either complex of the concepts, or their own method which comes out from the best concepts benefits but not in the energy area. 24% of industrial plants do not use any concept or its combination included in Performance Measurement system in the company. 76% of companies use concepts mentioned in Table 3.

Measurement system in the company. 76% of companies use concepts mentioned in Table 3.

Table 3. Concepts Rank Use in the Czech Plants. Source: own

No.	Concept	Share
1	Benchmarking	48%
2	BSC (Balanced Scorecard)	35%
3	ABC (Activity Base Costing)	24%
4	6δ (Six Sigma)	22%
5	EFQM (European Foundation for Quality	13%
6	VBM (Value Based Management)	9%
7	DEA (Data Envelope Analysis)	7%

For energy area the respondents recommended concepts mentioned in the table below.

Table 4. Concepts Rank in Energy Area. Source: own

No.	Concept	Share
1	Benchmarking	44%
2	BSC (Balanced Scorecard)	39%
3	ABC (Activity Base Costing)	27%
4	6δ (Six Sigma)	24%
5	EFQM (European Foundation for Quality Management)	15%
6	VBM (Value Based Management)	10%
7	DEA (Data Envelope Analysis)	5%

The research result showed that the first three most preferred concepts (for the whole company as well as for the energy area) are Benchmarking, Balanced Scorecard and Activity Based Costing. Knápková, Homolka and Pavelková define that BSC concept is more often use in production plants (16,2%). In services it is only 12,6 % and in sale companies only 7,4% [17].

KPI´s and Performance Measurement Methods

KPI used in energy departments in Czech production plants covers only the general energy flow and does not reflect other processes which ensure this flow. In addition to this, 50% of production plants do not deal with performance measurement with help of Key Performance Indicators.

As it was expected, companies mostly use KPI´s aimed at energy flow evaluation (costs and time 100%, physical measures 63%).

The respondents were asked which KPI´s they prefer in the case of its implementation from all processes point of view and especially from the energy process point of view.

As the results showed, the most mentioned indicators for both areas were the costs, growth, finance and the quality (see Fig. 4, 5 bellow).

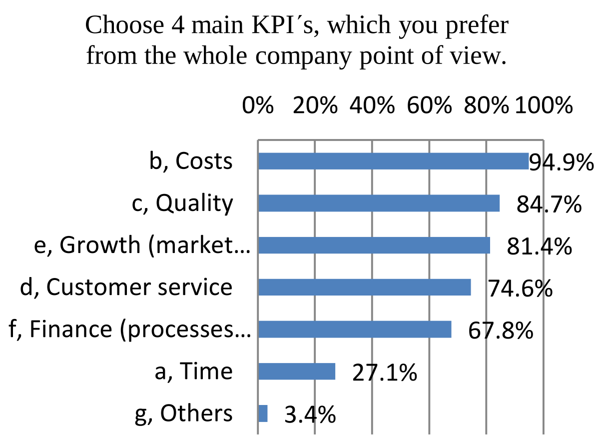

Figure 4. KPI´s Plants Area. Source: own

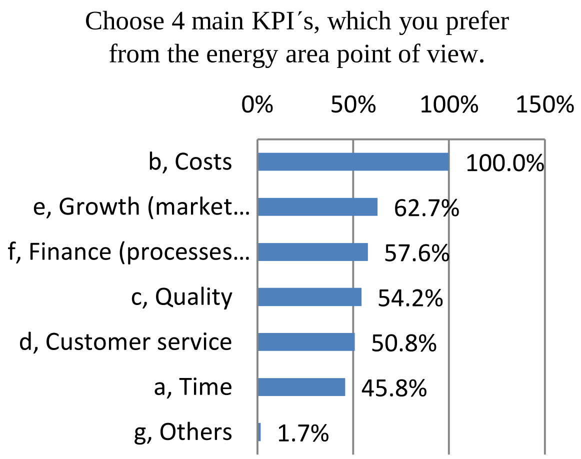

Figure 5. KPI´s Energy Area Proposal. Source: own

CONCLUSION

Actually, most of the Czech production plants are not prepared for flexible reaction to EU and CZ energy concept changes and differences with respect to energy flow ensuring.

Within the literature research it was found out that not many authors deal with energy processes with respect to ensuring of energy flow in the production plants. The best literature sources comes from the United States and United Kingdom, particularly from authors who made projects for the US Government and for UK Department of Trade and Industry. However we can still find and use the sources intended for repair and maintenance area (mostly Key Performance Indicators questions). The problem of the energy flow processes in general is much more described.

As the part of research in this article showed, main impact leading to industrial companies´ approach change is the increase in energy prices and unstable energy politics. Next findings showed that there exist big differences in performance measurement usage in the industrial companies at all and directly in energy area. The questionnaire research and case studies demonstrated the complete research, however it excluded energy process maps, description and existence of complex measures including energy sub processes. The process approach is missing even if the implementation of the BPM is mentioned. We can find physical measures and methods to increase energy efficiency and reduce the energy costs. However, it is not sufficient. Key Performance Indicators used in the Performance Measurement system are not stated. The measures are set only for independent energy medium flow but not for the whole process in its complexity.

The Energy Processes Management implemented clearly to the processes at the lowest level can mirror in increasing of the production plants and last but not least in added value to the customer.

Regarding Performance Measurement systems and methods usage, KPI´s setting and responsibilities, the research has opened a great spectrum of possibilities for improvement in the energy process areas.

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MANAGEMENT OF MEASUREMENT OF ENERGY PROCESSES IN CONTINENTAL BARUM COMPANY

Zuzana Tučková[48], Zdeněk Novák[49]

Abstract – The research was focused to the actual situation in Performance Measurement of the energy processes especially in Continental Barum Otrokovice. The results are back – upped by the previous researches which were aimed to performance measurement methods usage in the whole organizational structure of the plants. With a view to the continually changing the conditions in the energy area the authors analyzed that the industrial plants are not prepared for flexible reaction to EU and CZ energy concepts changes and differences. These represent the energy prices variation, the pressure to consumption reduction, reducing CO2 and the needs of fast reaction in various energy medium using. Next aim was creating of main guides and principles to be able to manage and measure energy processes performance with using of KPI´s and methods included to PMS. In the research results chapter the case study made in one of the biggest tires producing plant is presented.

Keywords – Business Process Management, Energy Process Management, Performance Measurement, KPI´s.

INTRODUCTION

The authors compared the Energy concepts of European Union (EU) and Czech Republic (CZ) which are very different and do not create any possibilities for manager's clear decision in the process management strategy of energy processes in their companies. Next step included the Energy department's analysis. The significant part of energy processes in the production plants is still not mapped, described and summarized to one methodical manual for managing and performance measurement. The performance measurement methods are not used for energy processes. Key Performance Indicators (KPI´s), which are used in the PMS, are not stated. The measures are set for alone energy medium flow only. Although the most of big industrial companies declared using of modern Performance Measurements methods, the previous researches shown that it is not purely true. The bigger differences were found in the energy area – energy processes.

There were a lot of possibilities of process management usage or its implementation to the industrial plants. Unfortunately, the energy area was not touched by the benefits of process management yet. It is true, that some production plants declared that the process management has been implemented, but after the deep research it was only the predication. The reality was other. Why is this area so interesting? Energy area of each of the production plants is key area for its operation and brings big costs with big saving opportunities. Management decision making is influencing by a lot of external and internal impacts, e.g. politics force which is applied during the energy legislative process.

Next impacts are variable prices in the market, business competition, etc. The internal impacts we could found in the production plan changes and the company growth. The initial situation was described in the research result chapter. It contains main reasons which lead the author to focus on the energy processes area. Main reasons came from the Energy concept of EU and CZ comparison which shown main differences in type of energy sources exploitation (the nuclear energy vs. the renewable energy sources such as wind power, solar power, water power and energy from the biomass), analysis of selected energy sources (prices and

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consumptions development) and from the questionnaire survey and case studies which was made in energy departments.

The article is aimed to energy process management level in Czech industrial plants.

LITERATURE REVIEW

The Business Process Management

Business Process Management (BPM) connects to reengineering of the business processes concept, which was formed by M. Hammer a J. Champy [13]. Since the time there have arisen a lot of BPM definitions.

Zuzák, Kříž and Krninská [32] characterized the Process Management as the maximum effort of activities integration between separate operative units, which operate separately in the specific measurement.

Hromková and Tučková [14] define the BPM as the methodology for measuring, analyzing and improving of core processes, based on Leeds and whishes of customers.

The BPM is the process by itself, which ensure continuing improvement of the company performance as wrote Burlton [1].

For example Aalst et al. [31] defined BPM as supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information. They argued that this definition restricts BPM to operational processes, i.e., processes at the strategic level or processes that cannot be made explicit are excluded. Note that systems supporting BPM need to be “process aware”, i.e., without information about the operational processes at hand little support is possible.

Fingar and Smith [10] divided BPM to the 4 development waves: the first wave was concentrated on constant improving of the processes and coincides in many ways with the philosophy of TQM, the second wave of BPM - consisted of a focus on BPR, or in short Reengineering, the third wave of BPM – refer to activities leading to the creation of a process focused organization and the fourth wave is a group of activities leading towards the achievement of competitiveness based mainly and exclusively on the processes.

So, we could define BPM as the complex of the procedures, methods and concepts which are used to processes effectiveness increasing in compliance with the company targets by using the appropriate metrics and measures, most called as KPI´s [23].

How is the process management philosophy, methods and tools known and used in production plants? Tuček wrote that some theirs researches demonstrated that the exploitation of certain of the business process management components (e.g. the measurement of the effectiveness and performance of processes, the exploitation of process teams, etc.) was still very low in Czech industrial manufacturing production enterprises and that this even held true for large-scale enterprises (as regards their number of employees and turnover) [26].

As author´s research shown, as well the energy processes are detached; even the company declared that it uses the process management in the whole company. The Process Modeling is recommended to use in BPM (because of the clear models creation, etc) [28] as well as the IT systems usage [29].

Energy Processes

For understanding energy processes we asked ourselves: What is an energetic? The energetic is the branch, which is aimed to development, forming, processing and transferring of energy.

Energy industries are the complex of supporting processes which ensure energy production operation, operation of administrative area, and next core processes. Novák [20] wrote that energy process is the complex of activities its output is increasing of added value of energy materials which are going through it and ensuring of connected activities.

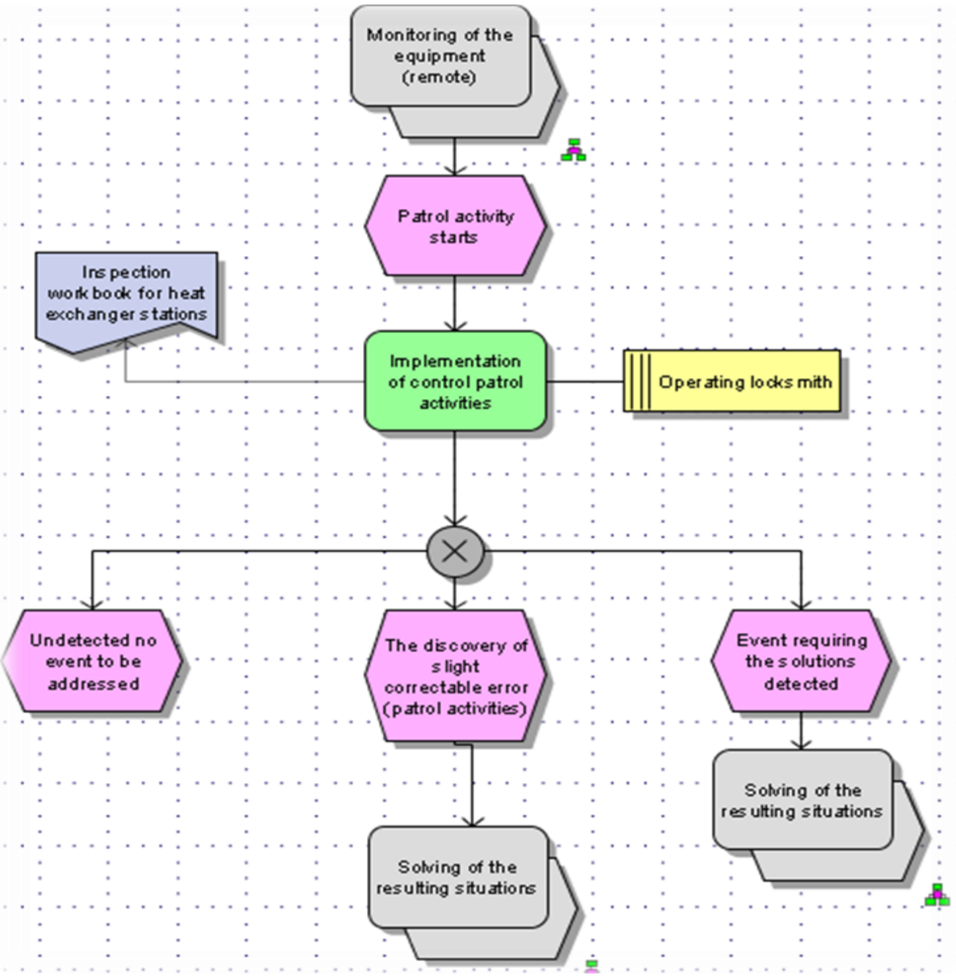

Figure 1. Process “Machine Monitoring” [30]

The aim is to increase the added value for final customer. Energy processes goes through the whole company organization structure, whether it´s an inputs point of view (finance, material management, logistic) or outputs point of view (e.g. heat and light delivery for all of business units). Figure 1. shows sub process “Machines monitoring” made in ARIS software.

Why are energy processes so important? The answer should be found with help of Balanced Scorecard´s 4 perspectives [15]:

1st perspective (financial): energy processes contain one of the important shares of company costs and its optimizing may result in high cost savings. Good approach showed Dickens and Gould (2010) with the idea of assigning of economic responsibility to managers to steer it as the corporate assets. Then they are under the top management pressure to make it more effectiveness.

2nd perspective (customer): the output is unique for customer and whatever variation has the big impact to the added value. The importance of energy processes rests in the machinery continuous operation on the part of customer, whose effort is directly depending on energy deliveries.

3rd perspective (innovation): new tendencies in renewable energy sources bring possibilities of process reengineering.

4th perspective (internal processes): as the energy processes are relatively easily measureable, it opens next reengineering possibilities. Because the energy processes run periodically it may be simply automated.

The Energy Management

Energy management is mostly defined with using of phrases such as energy efficiency, energy flow, energy medium conversion, consumption reducing, heat requirements, etc. Unfortunately, the processes are mentioned in accordance with energy flow only.

If we look to the energy management of buildings problem, the production area or any system, we can see that it is more or less complicated complex of energy and gas flow, its conversion, finances, etc. Our task is to manage this system with the aim of consumption reducing and energy usage [16].

The energy management is the base tool in the energy treatment area (in view of environment aspects). Energy management applied in practice present the complex of tools and measures, which are used to managing and influencing of processes in energy system [20].

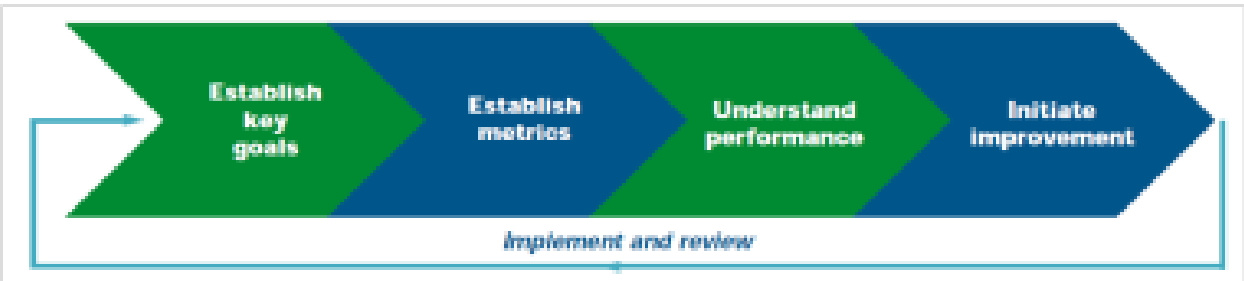

Figure 2. Performance Measurement Process [6]

The Performance Measures

In case the plant is using some Performance Measurement System (PMS), it´s based on financial performance measures mainly. As Tangen [24] stated: “To use a PMS that solely consists of financial performance measures can cause problem for company:

- Financial measures are not directly related to manufacturing strategy.
- Tradition criteria (such cost efficiency and utilization) may pressure managers for short-term results and, for that reason, discourage improvements.
- Financial measure do not report accurately on the cost processes, products and customers.
- Financial measures are not applicable to new management techniques.
- Financial measures do not penalize overproduction.

Neely´s [19] describing of the PMS brings the characters of measures. A PMS should:

- Support strategic objectives (in energy area e.g. to deliver the energy sources in time to right production machinery, author´s remark).
- Have an appropriate balance (covering all aspect, not only the financial), e.g. the energy repairs and maintenance flexibility).
- Guard against sub-optimization (go against employee´s evaluation behavior effects).
- Have a limited number of performance measures (more measures demands more analysis time).

- Be easily accessible.
- Consist of performance measures that have comprehensive specifications (e.g. collect the data, with what frequency, and how to act on the measure).

Performance measures should be by Neely and the other authors [19]:

- Transparent.
- Simple to understand.
- Have visual impact.
- Focus on improvement rather than variance.
- Visible to all.
- Be derived from the strategy.
- Provide timely and accurate feedback.
- Relate to specific, stretching, but achievable goals (targets).
- Be based on quantities that can be influenced, or controlled, by the user alone or the user in co-operation with others.
- Be clearly defined.
- Be part of a closed management loop.
- Have an explicit purpose.
- Be based on an explicitly defined formula and source of data.
- Employ ratios rather than absolute numbers.
- Use data which are automatically collected as part of a process whenever possible.
- Provide fast feedback.
- Provide information.
- Be precise – be exact about what is beginning measured.
- Be objective – not based on an opinion.

All the mention above is strictly valid in energy area, because of the measurable physical indicators and theirs big influence to final KPI´s. In energy area there are a lot of metrics and measures defined in accordance to energy flow or to building heat cladding [25]. But, it´s not defined for sub processes which ensure this energy flow (e.g. Full Time Equivalent, etc.). In the energy area the non-financial measures are mostly useful (except energy consumption with a view to budgeting, etc.). Some appropriate measures should be learned from the US Department of Energy [6] – special defence project or from Czech Technical Standard [2]. But it is important to be aware in performance measurement to keep in mind all the external and internal consequences.

PROCESS APPROACH TO THE ENERGY PROCESSES MANAGEMENT AND THEIRS VALUATION IN CZECH PRODUCTION PLANTS

At first the EU and CZ energy concepts were analyzed. Key indicators of EU energy policy contain Agreement between member states and the secondary policy which is concerned with competition and state support. The Policy is promoted with help of the Regulations. One of the primary targets of the EU energy strategy is creating of market conditions for electric and natural gas. This is followed by the Czech Republic, too. However if we look at energy concepts of EU and the Czech Republic, we can find fundamental differences in the future usage of energy sources. While EU is oriented to renewable energy sourcing usage, Czech Republic is oriented to nuclear energy source. This is the first impact which affects thinking of energy managers.

There could be expected next growth of energy sources for long time as Energy Regulation Office [8] showed in its analysis.

This project of authors Tučková, Novák and Hájková [30] showed in the common project (made in the big production plant, in 2012), that with using process approach, activity describing and process drawing, there can be saved nearly 50% of yearly working time of staff of energy department. Following Tab. 1 shows Energy technician activities before and reducing after the project. If we calculate only the employee controlling costs 500.000,- CZK per year (incl. salary, taxes, staff´s equipment), we can achieve 250.000,- CZK cost savings per year. This is accelerated with the other functions and reorganization of the department (reducing of redundant activities, describing and setting of checks, using process description for entry learning of new employee, effective reporting and planning sources, material and people, etc.). This approach may balance price increasing of energy sources and make the plants to be prepared for fluctuations. Some case studies were already published [30].

Based on the analysis mentioned above there were set up main impacts to energy management decision making. It was helpful for questionnaire creation. 1st EU and Czech energy concepts differences have a big impact to company energy planning in strategic level to hold the competition advantages. 2nd The analysis of the energy sources prices and its consumption showed the growth. This evokes requirement of manager's approach to change energy processes managing. The automation and simulation of virtual plants 3D models should be used. 3rd The analysis of heat energy showed requirement of additional investments to heat cladding of the buildings and machinery complement with regulation technology.

Process Approach in Energy Area of CZ Production Plants

The research results which came from the questionnaire answers demonstrated that even if companies declared the process management implemented, they do not use its benefits in energy area. The research presented by Šiška [22] in the Performance Measurement usage in the domestic (Czech) plants shown that more than 75% of companies is using the oldest managerial accounting form or the controlling (73,9%) for performance measurement. All the respondents were asked to choose from 10 methods including ABC, Balanced Scorecard, MVA, TQM, TOC, Lean management, and others. No modern methods were known or implemented.

As was mentioned by Skinner [21]: "…the general tendency in many companies is to evaluate manufacturing primarily on the basis of costs and efficiency…." There were founded that 59% of companies' do not use the Business Process Management and Performance Measurement concepts of energy processes. Main reason to think about using assets of BPM was introduced: delivered on account of prices increasing (80%), ISO certification (60%), competitors benchmarking necessity (70%) and company reorganization (15%). 41% as the rest of companies which do not use the Process Management declared that they are thinking about implementation of concepts such as Balanced Scorecard, Six Sigma, EFQM or Benchmarking. But the case studies have shown that the number of companies which do not use anything is higher (67%).

The Case Study in the Energy Department of the Tires Production Plant

The presented company was the biggest one in the research case study process regarding the area, turnover and the number of employees. The plant was operating in the chemical industry area, especially tires producing branch of activity. The type of the production was relegated to the mass production and the lot manufacture (flow production). This limited company plant was at the case study process owned by Multinational Corporation.

As was mentioned above, the research object was the biggest one from the industrial plants pool. The part of the production is oriented to foundry industry, respectively the mould casts. Its main customer was identified from the automotive industry, the wholesale warehouses as well as the outlets, car service garages and last but not least the national and private transport companies. The author discussed with head of the energy department as well as with employees of each of the sub-departments during the case study process. The plant was not audited by approved energy audit company and was not certified in the energy management area based on ISO 5001:2011.

The department was organized in view of the energy sources flow, it means to Heat Department (hot steam), Water and Air Department (water, pressured air and nitrogen) and Electro Department (electrical energy). Manager of the department said: ”Our organization is based on the process organization rules, but follows the energy sources flow too. So, partly it is combination of both. The structure of the organization is trimming with a view to cost saving needs.” This not follows the process approach and it is inhibiting to manage processes. The last one the Maintenance and Repairs Department was analyzed. This department was charge of the machinery repairs and maintenance in individual energy departments. The employee’s pool was strictly scaled 50% fix to 50% variable because of the headcount (HC) saving in budgeting process. This did not allowed making HC savings by the parent company and “went” across the right costs allocation and cost savings calculation.

The Repair and Maintenance Department employees made their job for the most part separately for the other individual departments, so they could be allocated directly to these departments. On the contrary, the specialists were relegated to the individual departments and were managed by the chief of these individual departments not by the main department manager. Theirs activities were blended across the whole structure of the department. The specialists are not multi-professional. They had not necessary competences. There raise upped the communication barriers. Manager of the main department declared that the communication and competencies manual is issued. But this document described only competencies to the individual machinery not to the processes. The process responsibility was not set-upped. There were rendered other activities concerning checks, revisions, measuring and regulation, posting, transport ordering, purchasing, training and certification in the main energy department. Some of these activities were doubled (e.g. the parallel physical and electronic reading of consumptions, reporting and more than one SW system with the same functionality). It was found a lot of inadequacies which could be eliminated:

- The process approach is missing in Energy Department even if the company declared that is using process management. The Performance measurement methods nor the Key Performance Indicators are not applied and used.
- The organizational structure is inappropriate to process management rules. By the departments restructuring and with help of employee’s multi-professional increasing the overall headcount should be decreased, so the cost should be decreased too (the consolidation of two specialists to one can be realized, and replacing of maintenance men (the consolidation of Heat Dept. specialist with Water and Air Dept. specialist to one position). The second alternative was to outsource the Maintenance and Repair Department. But with a view of know-how protection and production run.
- There was not set-upped the responsibility of the each process and some activities was doubled.
- The non-conceptual employee´s integration to the fix and the variable group didn´t allowed cost savings.
- During the discussions there were explained the benefits of the process analysis and organization structure change to the process one.
- The manager argued that the actual situation was based on historical needs and that it is measured by the freedom from disturbances and by the minimum of energy black-outs.
- But as was found, the right reason is on-coming generation exchange of the employees. The long-standing staffs of the Energy Department presented the resistance to any process’s changes because they were worry about to disclose the real situation not to be reduced themselves. There were doing checks without any round plan, so some machinery, distribution points and the other were double checked or wasn´t checked at all.

- Next analyzed area was the prices of energy sources. The plant reacted to growing prices of deliveries with the penetrative dealing to the suppliers with request of price reductions and the planned corridors of the send out chart. Next “weapon” in their hands was the argument of changing the supplier’s possibility.
- There were discussed next possibilities of price reductions such as new technologies investments (e.g. new compressor of lower input), deliveries process change (investment to steam distribution pipeline reduction – the volume losses) and sub processes reduction (the administrative – accounting, training, etc.).
- With a view to process description missing was very hard to do these changes.
- The Energy Department Manager was not informed periodically about the energy costs share of the overall plant costs (production costs).
- This fact not allowed to do or to manage activities more effectively (set-up processes right to save costs).
- Next problem (with which the author had met in a lot of companies during the discussions about the process management implementation) is that the staffs are worry about more work which (they think) will come from the process management. They presented that nobody is reading the manuals or the process maps and employees use the historical know-how. So they were not interested in the PM benefits (acceleration of activities, quick training new employees, higher effectiveness, etc).
- Main recipient of information which comes from energy systems is own energy department in the first phase for final customer´s reporting (CEO, CFO, parent company).
- The parent company´s purchase division was providing benchmarking between all the plants. According to energy manager statement this benchmarking is not true because of the different production of each of the plants (the energy intensity). The process benchmarking was not done.
- The energy consumption, repair and maintenance, and the investments planning processes were elaborated strictly regarding to the production plans.
- The company was presented the process management as established mainly in the production area, so it´s mean that the main processes were described and the maps existed in place. But the support processes were not took in mind.
- The energy processes, as was mentioned above, were not described, mapped and included to internal documentation (no handbook, manual or procedure).
- The process word-book was missing, so the communication problems occurred.
- The case study has shown that the Energy Department is using only KPI´s based on the energy flow. Other KPI´s were not set-upped. This constrained to start re-engineering of the processes and to set up the process responsibility of each employee with a view to motivation possibility.
- The industrial plant didn´t use any methods or concept or theirs combination included in Performance Management.
- It was argued that the unambiguous method does not exist. All the requests were subordinated to the production area.
- The next findings came from the case study:
- The energy strategy was not systematic; it was targeted only to individual production subsystems.
- The plant used only limited possibilities for energy prices grow.
- The employee resistance prohibited the effectiveness increasing, it follows:
- The employee motivation was not based on the real working output.
- The effort of using methods and concepts for performance measurement didn´t exist.
- The case study was discussed to the top management and based on the approval the Energy process analysis was started.

CONCLUSION

Within the literary research was found that not many authors deal with energy processes with a view to ensuring of energy flow in the production plants. Much more described problem is the energy flow processes in general as the main process. We can find physical measures and methods to increase energy efficiency and reduce the energy costs. Unfortunately, it is not sufficient. The questionnaire research and case studies demonstrated missing of energy process maps, describing and existing of complex measures which include energy sub processes. The process approach is missing even if implementation of the BPM is mentioned. KPI´s which are used in the Performance Measurement system are not stated. The measures are set for alone energy medium flow only.

Actually, most of the Czech production plants are not prepared for flexible reaction to EU and CZ energy concepts changes and differences with a view to energy flow ensuring.

Main benefits which could be useful for industrial plants are flexible managing of the energy departments, headcount decreasing, duplicate activities reducing, effective training of new staffs and of course the costs saving.

The Energy Processes Management implemented clearly up to the processes in the lowest level can return increasing of the production plants and last but not least added value to the customer.

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THE ECONOMIC ANALYSIS AND SPATIAL PROJECTION OF PERFORMANCE OF THE LOGISTICS SMALL AND MEDIUM ENTERPRISES IN OLOMOUC REGION IN THE CZECH REPUBLIC

Lucie Meixnerová[50], Eva Sikorová[51], Michal Menšík[52], Vít Pászto[53]

Abstract − *Aim of the paper is to connect the key performance indicators and spatial information logistic small and medium enterprises from the Olomouc region in the Czech Republic, because the Olomouc region has been perceived as lower logistic activity of sector according NACE. Paper is based upon the empirical research about standard accounting reports (balance sheet, profit and loss statement, cash flow statement) from collected from 40 logistic companies for years 2008 – 2012. The acquired data was recorded in the MS Excel and was subsequently transferred to the statistical processor IBM SPSS Statistics 19. We calculated return on assets, return on equity and cash flow/sales key performance indicators (KPI), which represent the performance of the logistic SME´s and we compared them as well as we used google map tools and we project these KPI´s on the map to reveal the spatial distribution of the performance. The paper shows how the descriptive statistics can be enlarged and how the performance can be shown as spatial information.*

Keywords − *Cash flow, key performance indicators, logistic small and medium enterprises, profitability*

INTRODUCTION

One of the prerequisites for the success of business activities is a perfect and flexible business management system and its close interconnection with logistics, where flexibility and a trouble-free progress of the corporate management process can be achieved by applying logistics in which the pre-production, production, distribution, trade and economic activities are integrated. Their importance grows with the development of transport systems and their combinations which are influenced by market economy in which new transportation options are constantly tested and developed. This is not just about the competition, but also off-market effects caused by individual states and regions under the pressure of internal, ecological or economic problems and also the nature of shipments, requirements for timely and accurate delivery due to the development of coordination and integration relationships in production, requirements of accompanying services and other specific needs of the carrier. The comprehensive concept of logistics is current and its importance for business activities which are the subject of logistics is growing. On the market, there are both specialised logistics companies which offer logistic services to manufacturing companies as well as outsourcing companies which ensure logistic-business activities. It is also crucial to mention that various types of transportation known as maritime, rail, road combined, and air transport still exist and are being upgraded; new transport systems are further developed and the combined and multimodal transport is being introduced.

At present, the slow development of utilization of various types of logistics is apparent in Czech small and medium-sized enterprises (SMEs). For these enterprises, it is typical that they affect the economic growth of the country and the region, respond to changes in the environment, they can resist and respond to the opportunities as well as disadvantages arising from the environment of the European Union (in 2004, after the Czech Republic joined, major changes occurred). Czech SMEs were affected by the transformation of economics and the privatization processes and their successful development requires reconciling the interests of the state, businesses and regions which create conditions for the establishment and development of businesses in the particular territory. The Czech Republic is very small (understood in terms of the area), it is considerably regionally differentiated and exhibits relatively small regional differences which are lower in comparison to many countries of the Western Europe. The causes of regional differences stem from the

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economic structure of the region, the position of the region, the natural conditions of the region, the interest or lack of interest of the government authorities. These regional differences are widening with time, which is mainly caused especially by the development trends in the regions. The deepening of regional differences is affected by the mobility of the population, industry restructuring, unemployment, qualification of the population, new business activities, allocation of research and development, and the environment.

Given the current development of small and medium-sized enterprises of the Olomouc region in the Czech Republic, primarily the analysis of the performance of logistics SMEs and their comparison with non-logistics SMEs are the aim of the paper. For the analysis of their economic activities three indicators are monitored: return on equity (ROE), financial leverage and cash flow to sales (CFS). In the first part of the paper, small and medium-sized logistics enterprises of the Olomouc region in the Czech Republic are defined, including geographical maps showing their spatial arrangement in the region. The second part presents the results of the research conducted among the logistics and non-logistics SMEs in the period 2008-2012 and it is a comparison of their performance based on the selected indicators: ROE, financial leverage and cash flow to sales. The final part of the paper is the evaluation of the performance of logistics and non-logistics business entities in the Olomouc region.

1. THEORETICAL FRAMEWORK

At present, small and medium-sized entrepreneurship in various economies is perceived differently with respect to their national context and the fundamental difference why SMEs are not comprehensively understood as companies which have an economic significance is that not even the legislation has set any specific rules so far e.g. in assessing their size [16]-[18]. For this reason, there is still no comprehensive, universally accepted definition of small and medium-sized entrepreneurship and the decisive criterion for the definition of small and medium-sized entrepreneurship is usually the number of employees. Within the National Programme for Preparation of the Czech Republic for the Membership in the European Union, the Czech Republic pledged to unify the definition of small and medium-sized businesses with the European Union and therefore in 2002 the Czech Republic adopted the Act no. 47/2002 Coll. on support of small and medium-sized businesses which clearly defines the concept of small and medium-sized businesses and unifies this terminology with standards applicable in the European Union (as amended as of 15.1.2005). The European Union characterises small and medium-sized enterprises on the basis of 3 fundamental criteria [4] - the number of employees, economic independence (the enterprise is independent when 25% or more of its capital or voting rights is not owned by another enterprise, or jointly by several enterprises) and the annual turnover of the enterprise (or the annual balance sheet total). The European Union (EU) limited the division into micro, small and medium entrepreneurship as follows [4]:

1. *Medium-sized enterprise* - employs less than 250 employees, the annual turnover does not exceed EUR 40 million or the annual balance sheet total does not exceed EUR 27 million, it is independent.
2. *Small enterprise* – employs less than 50 employees, the annual turnover does not exceed EUR 7 million or the annual balance sheet total does not exceed EUR 5 million, it is independent.
3. *Micro enterprise* – employs less than 10 employees, the annual turnover does not exceed EUR 2 million, it is independent.

A characteristic feature of the majority of logistics companies and business logistics is the ability to increase the value of the capital of a business, i.e. make a profit, which is achieved by fulfilling sub-goals such as a permanent ability of a company to deliver promptly and efficiently and permanently reduce the capital binding capacity of the company, i.e. gradually reduce the value of inventories of finished goods, work-in-process inventory, etc. Mutual relations between multinational companies interconnect and develop; the major obstacle on the market is the mutual cooperation and security of logistic activities among SMEs.
Specialised studies in the field of logistics SMEs in the Czech Republic and the world are the starting point for the elaboration of the theoretical framework of the paper. In 1600, we encounter the term "logistics" in literature for the first time. It was understood as the knowledge and skill to count [12]. In the sixties, this

concept was known and studied in Czechoslovakia as: materials management, material flows, inter-works transport and handling, warehouse management, etc. In Czechoslovakia, the concept of logistics appeared after 1998 for the first time as a tool of strengthening the competitiveness of a company. During the period prior to 1998, due to the centrally planned economy of this country, the concept of logistics as a tool of strengthening the market position of a company was not suitable for ideological reasons.

Issues of business performance, including an analysis of the financial health of the company in the Czech Republic deals with many monographic publications Corporate Finance [13]-[15]-[19] and Logistics [11]-[14], these publications are devoted to the issue of financial analysis and logistics in the sub-chapters. Societal discussions are still often become current issues regarding SMEs and the research process, performance measurement, which are the basis and prerequisite for the continuous improvement of company processes [17]. In currently is the problem to identify the factors influencing the development of the regions, the business environment and factors that affect it [6]. The issue of the research performance of SMEs are solved worldwide and based on a literature review are presented selected research SMEs. Authors [2] conducted a research by SMEs in the Czech Republic and Slovak Republic and they confirmed a similar development of SMEs in both countries and in 2013 was recorded declining business performance by up to 15% as confirmed by results of survey of SMEs' showed average decrease is represented by 15.80% in the Czech Republic and decrease was 18.78% in Slovakia [3]. Results of research confirmed that the deterioration are in the business environment by both Czech and Slovak entrepreneurs and it is necessary to form complex conditions for business development of small and medium-sized businesses in both countries [1]. It should be noted that an important factor in financial analysis is gain, which affects not only the business performance, but also productivity and profitability [7]. Company performance can be measured using EVA (economic value added), but this indicator is not sufficiently well known among SMEs [8]-[13]. It is necessary focus on the enterprise cost structure and the individual costing system utilization [10]. Even though the issue of performance has been solved by many authors, it is necessary to realize changing economic situation and business conditions of companies because companies are constantly under pressure of reducing costs and this is result of global expansion and developing Information Society, which asks still new requirements. That has important impact to structure of performed activities and the performance of companies [9]. Although there are many global publications dealing with the financial analysis on the market, these contributions are focused only on the analysis of entrepreneurial entity sector or activity domains of selected companies, etc. Neither in Czech nor foreign scientific publications we find issues covered in this paper focused on logistics SMEs in the Olomouc region in the Czech Republic.

1.1 SPATIAL ARRANGEMENT OF SMALL AND MEDIUM-SIZED LOGISTICS ENTERPRISES IN THE OLOMOUC REGION

From an economic perspective, it is interesting to have a look also at the geographic layout of logistics SMEs in the Olomouc region. The spatial arrangement characterised by the financial leverage of logistics SMEs, Figure 1, shows that the greatest degree of utilization of foreign capital is in the companies based in Lipník, Prostějov and Čeláchovice near the town of Přerov. It can be observed that companies show a greater return on equity at inflow of foreign capital and it is obvious that this situation is favourable for investors, and this is referred to as a positive leverage effect. For other companies, the effect of utilization of foreign capital is lower, which is confirmed by Figure 2 which shows the return on equity which is lower during the inflow of the foreign capital which from the perspective of ownership is not favourable and this situation may be influenced by a greater use of own resources of financing and it is advisable to determine whether there is room for debt financing. Figure 3 shows the CFS of logistics companies in the north of the region, indicating the cash flows difficulties. On the contrary, as far as companies located near large cities such as Olomouc, Přerov, and Prostějov, leading from the southeast to the northwest are concerned, this indicator is not affected by a lack of cash flows because these areas have a better infrastructure as well as links between businesses or populated areas, which is significant and has a positive impact on local businesses because they are able to generate financial surpluses which can be used for example to fund major investments and strengthen their position on the market.

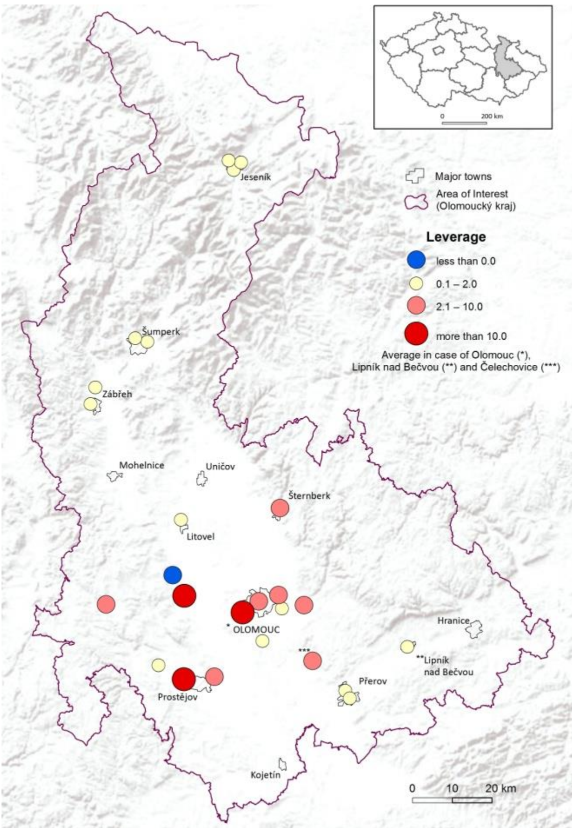

Figure 1. Spatial impact of the financial leverage of the logistics enterprises

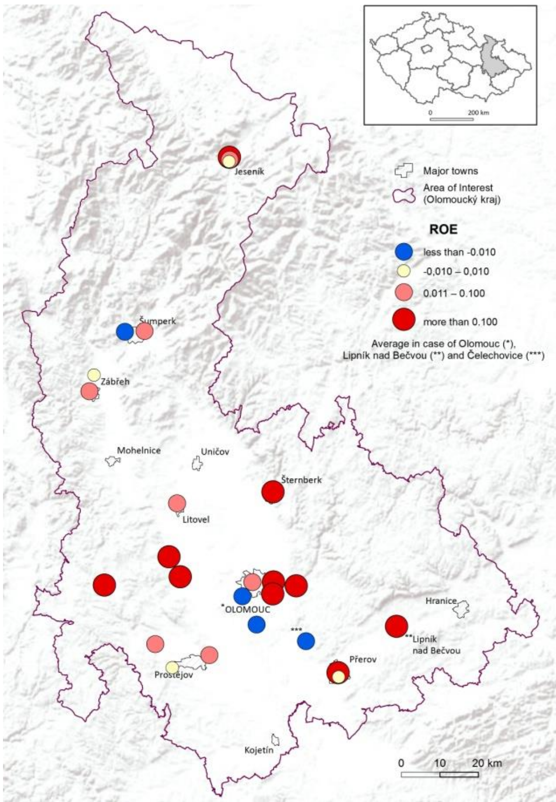

Figure 2. Map of the return on equity of the logistics enterprises

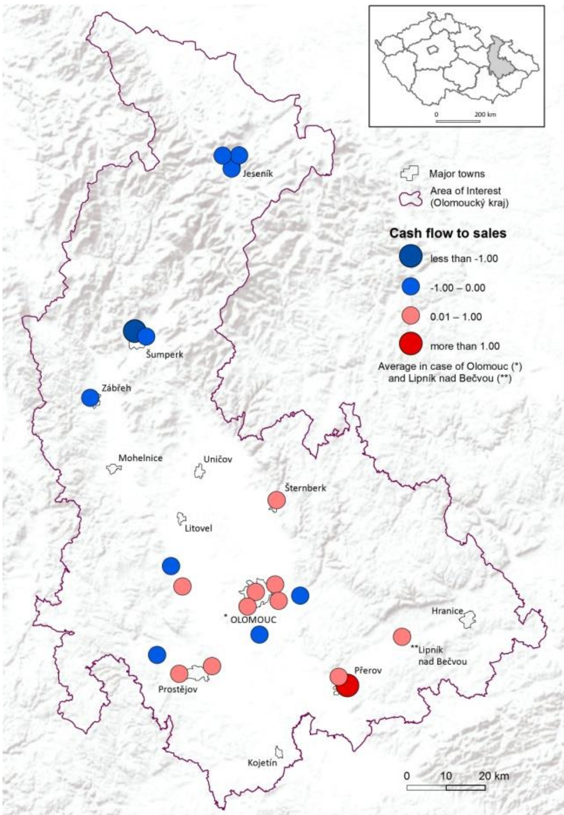

Figure 3. Map of the cash flows of the logistics enterprises

2. METHODS

The primary objective of the research was to explore the performance of the logistics enterprises, small and medium-sized enterprises of the Olomouc region in the Czech Republic. Taking into consideration the aim of the research, a short-term research of the primary information of descriptive character was chosen. A documentary analysis of the data was carried out. The data was obtained through a database accessible through the website portal www.justice.cz which is administered for the Ministry of Justice by the company Telefónica O2 Business Solutions. Additional data was obtained from the websites of companies (from their balance sheets and profit & loss statements) and from official lists and directories of the Czech Statistical Office [5]. The data was obtained from 40 logistics companies, cleaned and 36 business entities were used for the research. The research sample was structured according to the NACE into two groups - logistics companies and non-logistics companies. To avoid the impact of extreme values, we applied the Grubbs test for outliers based upon the standardized Z-score calculated for the ROE, financial leverage and CFS.

From the balance sheets of the businesses, the following indicators were evaluated:

- Return on equity (ROE) which measures the return on capital that is inserted into the enterprise by owners, in the paper marked as ROE for non-logistics SMEs and ROE L for logistics SMEs,
- Financial leverage which evaluates the benefits of debt financing, i.e. testifies whether there is a sort of influence of the leverage between return on equity (ROE) and return on assets (ROA), in the paper marked as Financial leverage for non-logistics SMEs and Financial leverage L for logistics SMEs,
- Cash flow to sales (CFS). The indicator cash flow (CF) is influenced by a number of economic factors, the sales indicator was chosen because it has a significant impact on the market economy and CFS characterises internal financial capabilities of a company. In the paper, it is marked as CFS for non-logistics SMEs and CFS L for logistics SMEs.

Based on these cleaned data we applied a descriptive analysis. Extreme values were neglected in our calculation of the descriptive indicators. Most indicators were focused on the level and variability mean, median, maximum, minimum, deciles, etc. calculated and analysed. Data was processed in the SPSS 19 statistical software some minor work was done using MS Excel.

2.1 RESULTS

Based on the collected data, we received the following statistics as shown in Table 1, key performance indicators calculated for logistics companies are marked with the letter L.

Table 1. Basic description of the sample

		ROE	ROE L	Financial leverage	Financial leverage L	CFS	CFS L
N	Valid	670	36	670	36	550	30
	Missing	0	0	0	0	1	0
Mean		,148	,005	1,803	4,328	,049	,166
Median		,057	,077	1,512	1,336	,001	,007
Std. Deviation		,911	,632	8,620	13,989	2,117	1,164
Variance		,830	,400	74,305	195,702	4,482	1,355
Minimum		-5,474	-3,371	-79,452	-19,536	-29,546	-2,084
Maximum		10,378	1,141	64,327	76,346	26,600	5,899

Source: Own calculations by the balance sheet of entrepreneurial subjects

In Czech Republic there is no obligatory requirement to report the CF, so the CF was calculated based on the balance continuity. For around 120 companies, it was not possible to calculate the CF, hence the drop of valid observations. The final number of valid observations is also the result of outliers elimination based on the Grubbs test.

We also calculated certain quantiles (deciles and quartiles) so we can understand the value distribution of the key performance indicators. The results of this are shown in Table 2, with the same impact of lower CF data collection from small and medium companies. Again, key performance indicators calculated for logistics companies are marked with the letter L.

Table 2. Percentiles

		ROE	ROE L	Financial leverage	Financial leverage L	CFS	CFS L
N	Valid	670	36	670	36	550	30
	Missing	0	0	0	0	1	0
Percentiles	10	-,1678	-,269	-,696	1,000	-,123	-,089
	20	-,0327	-,014	1,063	1,101	-,044	-,032
	25	-,0014	-,001	1,130	1,132	-,026	-,026
	30	,0037	,007	1,190	1,193	-,014	-,019
	40	,0264	,014	1,341	1,239	-,002	,000
	50	,0568	,077	1,512	1,336	,001	,007
	60	,0985	,107	1,794	1,933	,010	,023
	70	,1545	,157	2,373	2,539	,031	,048
	75	,1942	,202	2,697	2,898	,044	,054
	80	,2578	,227	3,206	3,426	,062	,058
	90	,4706	,358	6,372	12,023	,131	,119

Source: Own calculations by the balance sheet of entrepreneurial subjects

Again, results shown here are already after the outliers elimination based upon the Grubbs test, quartiles are highlighted for easier orientation in the Table.

3. DISCUSSION

As shown by the results of the Table 1, we will start with the ROE (which is EAT (earnings after taxes) / equity). We can say that in general the performance of logistics companies is lower than the rest of the market of the SMEs. The mean of non-logistics companies is 14,8% compared to logistics companies where it is 0,5%, so in general the performance of logistics companies is about thirty times lower compared to non-logistics. However, median shows 5,7% for non-logistics compared to 7,7% for logistics companies. This means that there is a higher variability within the two groups, which is also confirmed by the std. deviation or variance, as seen in Table 1. However, we cannot conclude that ROE is lower for logistics companies as the analysis of variance (ANOVA) did not confirm this conclusion, even though the percentiles mostly show the lower ROE in logistics companies.

From the perspective of the financial leverage, we see a similarly divergent picture. The mean for non-logistics companies is 1,803, for logistics companies it is 4,328. This suggests that logistics companies are more leveraged, however, if we look at the median we can see that these key performance indicators are quite comparable as they are 1,512 for non-logistics and 1,336 for logistics companies. It seems that as the sample of non-logistics companies is larger, it consists of more extreme (yet still acceptable by the Grubbs test for outliers) values, as demonstrated by the minimum and maximum in the Table 1. If we compare percentiles in the Table 2, we can see that the values match. So we can conclude that there is no significant difference between logistics and non-logistics companies.

From the perspective of CFS, we can see that the mean is 4,9% for non-logistics companies and 16,6% for logistics, however median 0,1% for non-logistics and 0,7% for logistics companies. The mean is three times higher, the median is seven times higher. This suggests that logistics companies have better CF on sales ratio. This conclusion is also supported by percentiles, as up to the third quartile, percentiles are generally higher (except for the third decile) for logistics companies, again, without ANOVA confirmation, the significance level is too high.

CONCLUSION

As a part of the research, we conducted an evaluation and comparison of the financial health of logistics and non-logistics SMEs of the Olomouc region in the Czech Republic and we provided the reader with the basic knowledge of financial analysis. The analysis showed clear results which, given the short-time horizon of the analysis, is not an unusual phenomenon.

We can state that the variability within the small and medium-sized enterprises (no matter whether logistics or non-logistics SMEs) among the ROE, financial leverage and CF on sales is so high that it is difficult to confirm any result as statistically significant. However, if we analyse certain percentiles (deciles, quartiles) we can suggest that logistics SMEs in the Olomouc region have a worse ROE than the rest of SMEs and a better CF on sales than the rest of the SMEs in the Olomouc region. The detected result about the lower year-on-year growth of the value of profitability of logistics enterprises is not in terms of ownership compared to non-logistics enterprises favourable but it is sufficient, which can be influenced by using its own resources of funding or upgrading of logistics, etc. This is significantly confirmed by the indicator CFS of logistics enterprises which, in the special arrangement in the northern region, indicates problems of cash flows and, on the contrary, in the surroundings of Olomouc confirms that companies are able to generate financial surpluses which can be used e.g. to fund significant investments.

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MULTI-AGENT SOLUTION FOR 6PL INTERMEDIARY PROVIDER

Anton Ivaschenko[54], Michael Andreev[55]

Abstract – Logistics parties represent different layers of logistics services in supply chain management and have recently become a challenging subject of research for managers and software developers in respect of implementing different aspects of outsourcing. A new concept of sixth party logistics (6PL) Intermediary Provider is given by analogy with fifth party logistics (5PL) provider, which is based on implementation of a number of services for customers and shippers provided by the specially designed software platform. 5PL and 6PL providers are virtual instances powered by information technology infrastructure; they own no resources themselves but make available a number of aggregated services able to link suppliers and buyers. As opposed to 5PL operator, that provides operative decisions in real time, 6PL Intermediary Provider develops stable and dynamic relations between the contractors. These relations are built on the results of Big Data analysis of various events that describe the history of interaction in integrated information space. The resulting knowledge base of dynamic relations between the contractors helps improving the quality of services integration and aggregation and declining of their costs for target consumers. The proposed solution for 6PL Intermediary Provider is implemented using multi-agent technology and is available on Internet as a specialized Web platform.

***Keywords** – 6 Party Logistics (6PL), Decision making support, Intermediary service provider, Multi-agent technology, Transportation logistics.*

INTRODUCTION

One of the most up-to-date trends in transportation logistics introduces 5PL (Fifth Party Logistics) concept, which is based on implementation of a number of services for customers and shippers provided by the specially designed software platform. This concept becomes popular in transportation logistics as an effective solution to allocate transportation orders to possible executors. 5PL platform is open for transportation companies and helps them negotiating with customers in integrated information space. To simulate this negotiation, generate effective allocation options and provide decision making support there can be implemented a multi-agent software solution [1], which provides the flexibility of actors' interaction and their self-organization and can deal with high uncertainty in number and time of resources available.

Still 5PL software platform supports only operative negotiation of customers and shippers. It is effective for situational management of allocation of new incoming orders in real time, but does not consider the partnership between the parties. However the knowledge of possible and existing cooperation can help improving the quality of services integration and aggregation and declining of their costs for target consumers. To capture this knowledge and introduce new features there can be proposed a concept of 6PL intermediary provider that develops stable and dynamic relations between the contractors. In addition to 5PL functionality 6PL platform provides the means of strategic management in transportation logistics over the comparatively long time horizon. In this paper there is proposed a model and solution for 6PL Intermediary Provider based on multi-agent technology.

STATE OF THE ART

The concept of Fifth Party Logistics (5PL) is introduced by analogy with 3PL that provides the process of outsourcing of transportation resources and 4PL that describes a concept of Lead logistics integrator (still

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there is no general definition of it in the business world) [2]. 5PL provider owns no transportation resources itself but makes available a special service able to link suppliers and buyers. This service is based on the IT infrastructure, which plays the general role in 5PL business. Customer representatives, transport managers, shippers, carriers, and even drivers become users of a certain IT platform. The purpose of this platform is to allocate incoming orders to appropriate resources, consolidate them improving consolidation and reducing idle time and generate efficient schedules for drivers and vehicles. This idea is close to the popular SaaS (Software as a Service) business model, according to which software and associated data are centrally hosted on the cloud. Such service becomes attractive for small transportation companies and allows outsourcing dispatching functions for large logistics operators.

Still to ensure high efficiency of 5PL service both for customers and executors in terms of time and costs there is a request to implement modern technologies of business processes management based on decentralized architectures, distributed intelligence and multi-agent technology. This happens because of the increasing number of decision makers, high uncertainty and dynamics of changes, and flexibility of decision making logic. The example of using multi-agent technology for business processes simulation can be found at [3, 4]. Also the described approach generalizes our experience of multi-agent solutions development for transportation logistics [5, 6].

As soon as the information space provided by 5PL software platform can be treated as a complex network of continuously running and co-evolving actors, the whole solution can be based on holons paradigm and bio-inspired approach [7]. This paradigm and approach offer a way of designing adaptive systems with decentralization over distributed and autonomous entities organized in hierarchical structures formed by intermediate stable forms. It’s implementation in practice requires development of new methods and tools for supporting fundamental mechanisms of self-organization and evolution similar to living organisms (colonies of ants, swarms of bees, etc) [8]. The actors compete and cooperate, coordinate and adapt their behaviors, aggregate their services to users and take various requirements individually. Each event that occurs here can influence the whole network and needs a collaborative reaction from all subjects that take into account personal objectives and constraints of each decision making member. Another requirement for the decision making process based on subject’ negotiation is that the final decision can require a complicated and time consuming process of data exchange between the actors. That’s why it should be managed to consider time factor and assure functioning in real time.

One of the recent developments in this area [9] introduces featuring a clear separation between the local planning performed by the individual vehicles and the global coordination achieved by negotiation. To solve such a kind of problems there can be implemented a special functionality for a statistical analysis based on recent developments in cross-correlation analysis of non-equidistant time series [10]. The models and methods of such analysis were successfully probated in social management and can be reused for management of multi-agent negotiations.

In many cases however, real-time awareness provided by event processing is not sufficient; real time actions need to be triggered not only by events, but also upon evaluation of additional background knowledge. This knowledge captures semantic metadata descriptions (the domain of interest), and the context related to critical actions and decisions. Its purpose is to be evaluated during detection of complex events in order to on-the-fly enriched events with relevant background information or to propose certain intelligent recommendations in real time. To provide this functionality there is proposed a model of intermediary service provider [11] – a software platform with Internet portal able to match service requests (orders or applications) and opportunities and generate profitable options of integrated services.

On the basis of analysis of the current trends of automation of logistics parties' interaction in integrated information space powered by intelligent multi-agent technologies there was identified a following challenge. Most of software solutions provide operative dispatching and allocation of orders in real time or automate scheduling based on the current resources availability. Optimization software tools provide long term scheduling for a concrete and limited set of resources. 5PL platform allow situational allocating of new coming orders to currently available resources with very limited planning horizon. In order to combine these two approaches there should be proposed a 6PL solution based on the flexibility of interaction with autonomous shippers provided by 5PL and getting new opportunities of contracts formation and execution, which allows long term scheduling.

6PL EVENT BASED MODEL AND PROBLEM STATEMENT

Let us consider a generalized business model where orders (or jobs) w_i are proceeded to actors u_j. Any actor can be assigned to perform any order, incurring some cost that may vary depending on the exact assignment. It is required to perform all the orders by assigning exactly one order to each actor in such a way that the total cost of the assignment is minimized. The centre is introduced as a solid dispatching agent that offers the orders to actors and ensures the effectiveness of the whole system.

The objective of the order agent is to be proceeded by any actor available on time (particular the KPIs can be formulated as "early average absorption"). The actor's objective is to receive the most corresponding orders with the highest relevance.

Let us set the following order lifecycle events, represented by Boolean variables:

$e*(w_i, t*_i) \in \{0,1\}$ – appearance of w_i, $t*_i$ is the time of its appearance;

$e(w_i, u_j, t_{i,j}) \in \{0,1\}$ – offer of w_i to u_j at time $t_{i,j}$;

$e'(w_i, u_j, t'_{i,j}) \in \{0,1\}$ – assignment of w_i to u_j at time $t'_{i,j}$;

$e''(w_i, t''_i) \in \{0,1\}$ – escape of w_i at time t''_i in case of order rejection.

These events describe the history of interaction in integrated information space and form a study subject for various technologies of Big Data analysis.

The cost of order w_i execution by actor u_j is $c_{i,j}$. It is determined by the actor and proposed to the center. Let us assume that one actor cannot execute several orders at a time. The allocation problem for this model can be represented as

$$\begin{aligned} &\sum_{i=1}^{N_w}\sum_{j=1}^{N_u} e'(w_i, u_j, t'_{i,j}) \cdot c_{i,j} \to \min, \\ &\sum_{j=1}^{N_u} e'(w_i, u_j, t'_{i,j}) = 1, \quad i = 1..N_w, \end{aligned} \tag{1}$$

$$\sum_{i=1}^{N_w}\sum_{j=1}^{N_u} e*(w_i, t*_i) \cdot e'(w_i, u_j, t'_{i,j}) \cdot (t'_{i,j} - t*_i) \to \min, \tag{2}$$

where N_w is the total number of orders and N_u is the total number of actors.

For the order flow $e^*(w_i, t^*_i)$ there should be developed a strategy (schedule of offers) $e(w_i, u_j, t_{i,j})$ for a set of u_j that will reach (1) and (2).

From the other side, each actor considering the order flow $e(w_i, u_j, t_{i,j})$ should decide on the strategy $e'(w_i, u_j, t_{i,j})$ that comes out at

$$\forall u_j : \sum_{i=1}^{N_W} \sum_{k=1}^{N_u} e(w_i, u_j, t_{i,j}) \cdot e'(w_i, u_j, t'_{i,j}) \cdot (1 - e'(w_i, u_k, t'_{i,k})) \cdot c_{i,j} \to \max. \quad (3)$$

In case the actor starts execution as soon as the order is allocated the following limitation is valid:

$$\forall u_j : \sum_{i=1}^{N_W} \sum_{l=1}^{N_W} e'(w_i, u_j, t'_{i,j}) \cdot e'(w_l, u_j, t'_{l,j}) \cdot (1 - \theta(t'_{l,j} - t'_{i,j}) \cdot \theta(t'_{i,j} + \Delta t_{i,j} - t'_{l,j})) = 0, \quad (4)$$

where $\theta(x)$ – Heavyside step function [12]: $\theta(x) = \begin{cases} 0, x < 0 \\ 1, x \geq 0 \end{cases}$.

The statement (1 – 3) is introduced as a problem of "proactive allocation". Its direct solution is not possible as soon as the number and availability time frames of resources and orders changes with time. To prove it there can be specified the following logic. Firstly, the statement (3), being summarized by u_j, results in a contradiction with (1). Secondly, to solve (1) one needs to fix the number of events considered, but at any moment of time t^* there is no information about the events $e^*(w_i, t^*_i): t^*_i > t^*$, and there cannot be proposed any substantial approach on how to pick-out the orders w_i accepted by the platform for scheduling in real time.

The solution of (1 – 3) problem is formalized as a schedule of allocation events $S(t^*) = \{e'(w_i, u_j, t'_{i,j}), t'_{i,j} > t^*\}$ that is generated at the moment of time moment of time t^* as a response to incoming order flow. The size of this set is an indicator of 6PL quality. In order to increase it the system should motivate the actors to give more determinacy and confidence in $e^*(w_i, t^*_i)$. To solve this problem there can be proposed an rule of rhythmical assignment: there is developed a schedule of assignment events that form time frames for contract agreements.

So the following challenges can be specified for a 6PL provider:

- attract customers and executors in order to increase the number of options for each order allocation;
- enforce interaction conditions to support competition and cooperation between the users of 6PL platform, which is beneficial for them;
- capture and reuse permanent allocations in a form of contract agreements that formalize stable and dynamic relations between the contractors;
- develop long term schedules based on rhythmical assignment.

SOLUTION VISION

On the level of 6PL there are formed the conditions of logistics supply chain members interaction in integrated information space that are being expressed in the form of contract agreements that reflect the cases of permanent cooperation between the actors. 6PL provider software platform (see Fig 1) can be introduced as a part of logistics supply chain resources management systems, manufacturing scheduling systems, Web portals, enterprise resources planning systems, business processes simulation and modeling and decision making support. 6PL intermediary provider, being based on the software platform for realizing the interaction of the participants of logistics supply chain in the integrated information space, forms the options of executing orders and offers them to actors. In contrast to the 5PL provider logic that does not change the conditions of interaction and does not limit decision making by the actors, 6PL provider can generate new contract relations that define long-term cooperation and competition between the actors. 6PL provider is also based on the software that realizes system management of interaction based on the analysis of interaction statistics.

6PL solution for intermediary service provider was implemented using multi-agent technology. Agents are introduced to represent the actors and orders in the integrated information space and can be triggered both for simulation of actors activity and for representing the real actors in the process of searching for the orders allocation options. The are introduced three types of agents for Orders w_i and actors u_j that can interact according to their objectives and constraints and establish the links of cooperation according to allocation options generated. The strategies of agents correspond to the goals (1 – 3).

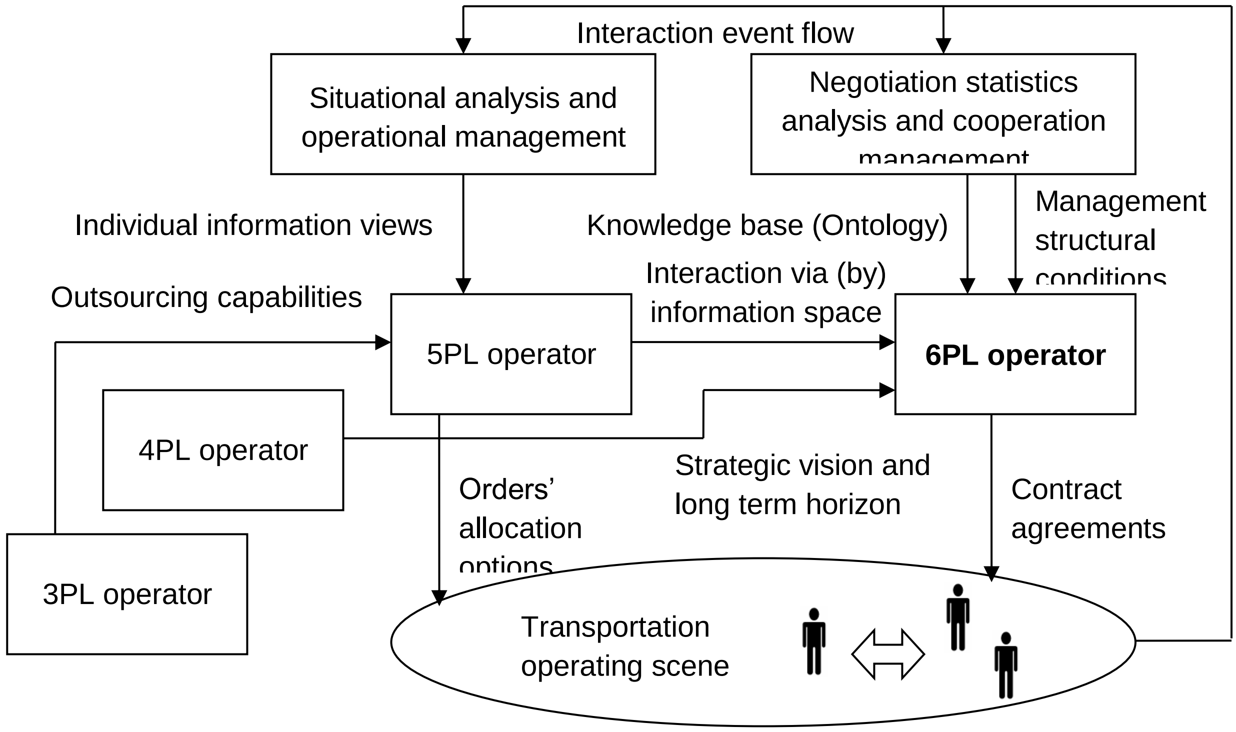

Figure 1. 6PL Solution Vision

The agents can act in real time under a continuous flow of incoming events. The main problem of optimizing algorithms is not only the possible failure to function in real time, but also the necessity to introduce a number of heuristics to process service routes that are partially delivered. The multi-agent solution can help to overcome these problems as soon as it operates the current scene which changes together with the real world. In order to make this process convergent we propose to introduce the following logic supplementary to the general negotiating strategies: the orders look for the possibility of allocation based on the statistics of generalized actors' capabilities.

Implementation of the proposed approach is illustrated by Fig. 2. In the given example the order 5 (that came later than others) is reduced from the view of Actor 1. Besides the set of orders 2, 3, and 4 are hidden from Actor 2. As a result both actors are interested in order 1. Is should be mentioned that the hidden data will appear for the actors with time, so in any case they retain an option to wait till the situation changes. In the Fig. 2 Actors 1 and 2 get independent description of the current scene in the form of an overlay network. This network is generated by the system by transformation of the actual situation citation based on multi-agent allocation at 5PL level considering priorities formed at 6PL level on the basis of long term contract agreements.

Implementation of the introduced solution allows solving the stated problem by giving the orders and actors an opportunity to look for each other. The system helps them to find the best combination of services, but the final decisions are made by the users themselves. Such an approach provides self-organization and therefore corresponds to the ideas of subject-oriented management. According to the current situation characterized by a number of orders and actors available, the actors will choose the following types of interaction peculiar to self-organized communities:

- Competition, e.g. a contest between the actors to get the order from the preferable provider earlier;
- Cooperation, e.g. collaboration between the actors to increase the number of contract agreements.

To meet this requirements 6PL operator should encourage either competition or cooperation between the actors according to the current situation. Competition can be organized in the form of auctions.

Auction is a public sale of a lot representing an order according to the rules predefined by the platform. The exact form of an auction can be different and depends on the features of exact logistics industry.

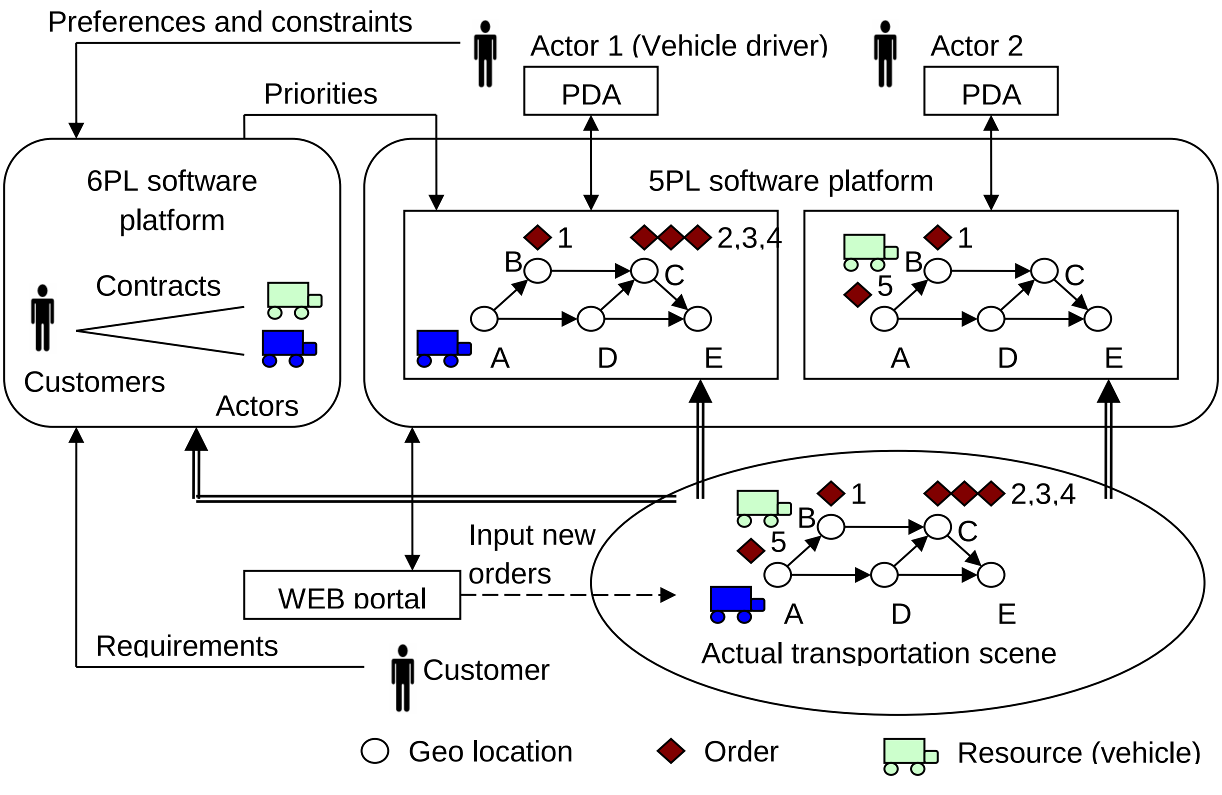

Figure 2. 6PL Multi-agent Implementation

ANALYSIS

The proposed solution was implemented in transportation scheduling platform based on SEC "Open Code" software components. Several simulation experiments were carried out using the datasets close to real event flows in transportation logistics. The results are presented in Fig. 3. Most benefits of using the 6PL intermediary provider concept are generated in allocation time and capacity with approximately the same transportation costs.

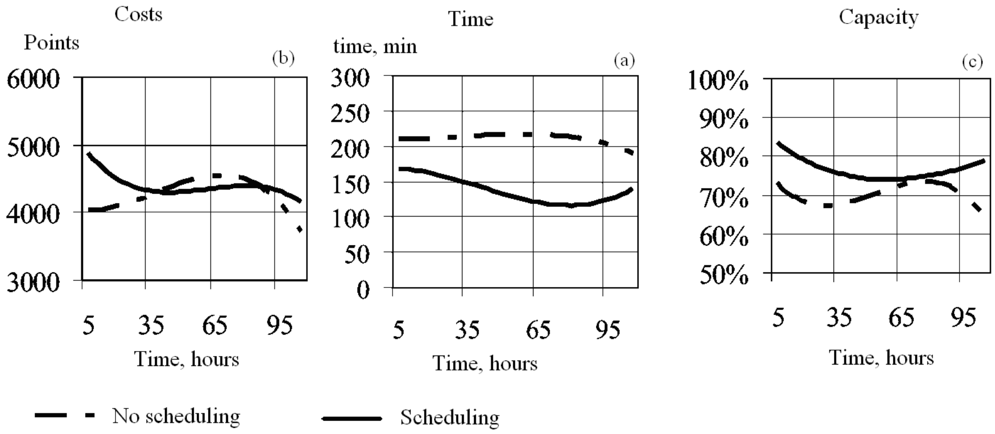

Figure 3. Probation Results

However the introduced functionality of 6PL provider can result mostly in higher attractiveness of software scheduling solution to possible customers. Table 1 illustrates the features of party logistics in the aspect of working with the resources. 6PL operator provides both high autonomy of resources together with high reliability, which makes it reasonable for transportation logistics.

Table 1 Features of logistics parties

Logistics type	**1PL**	**2PL**	**3PL**	**4PL**	**5PL**	**6PL**
Resources	Own resources	Separated department	Outsourcing	Long term cooperation	Mobilization of new resources by Internet	Web-based cooperation with shippers
Interaction with resources	No autonomy	Low autonomy	High autonomy	High autonomy	Variety of available resources, Multiple possible options, Low predictability	Variety of possible allocation options, High autonomy, High reliability

CONCLUSION

In this paper a new concept of sixth party logistics (6PL) Intermediary Provider is given by analogy with fifth party logistics (5PL) provider, which is based on implementation of a number of services for customers and shippers provided by the specially designed software platform. 6PL Intermediary Provider develops stable and dynamic relations between the contractors that are built on the results of the analysis of event flow that describes the process of interaction in integrated information space.

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VISUALISATION OF PROCESSES IN WAREHOUSE ON WEBSITE WITH X3D

Gorazd Hren[56], Andrej Predin[57]

Abstract − *Understand the dynamic behaviour of the systems and verify implemented designs or processes in particular time frame the use of simulation studies are necessary. Although the amount of time and data used to produce such studies are substantial, the 3D representation of the system produces a more complete understanding of system behaviour. This paper describes the use of 3D animation to visualise workflows in warehouse using standardised techniques within Web browsers. Success of 3D applications on the Web depends on object behaviour and the level of interaction. Based on X3D node concept, object-oriented features and event driven approach suits well to virtual environment. An XML is used as interface definition of nodes and their behaviour characteristics parameters. Automated nodes and code generation of a dynamic XML Schema simplify the implementation. The behaviour nodes are used as scene graph elements. The study of a specific application enables us to highlight the possibilities of the X3D language to model, visualise and to do interactive parameters changing for actions in the warehouse. Key features of X3D are exposed and new approaches are proposed in order to achieve a better realistic behaviour inside the virtual warehouse. The information from simulations in virtual warehouse is directly used to optimize performance and further operational planning in warehouse.*

Keywords − *warehouse, simulation, virtual, X3D*

INTRODUCTION

The information technology (IT) evolution is currently dominated by the Internet. It widespread use of technologies and the development of proprietary Web-based 3D formats resulted in the increased number of 3D-enhanced Web applications. Global and intra-corporate access, platform independence, maintenance minimization, reusability and interoperability are among the significant aspects and requirements. These present challenges for all fields of IT application. The 3D technologies and availability on consumer platforms is continually growing.

This paper describes the architecture of a new tool addressing mainly the visualization of activities in warehouse adopting the framework tools developed for sharing of virtual prototypes over the Web with standard programming tools [1]. The framework was further developed for integration of CAD and desktop VR with kinematic mechanism simulation [2] offering wide possibilities of variation via configuration file in XML form.

The evaluation of activities in warehouse are time dependent and results in time frame modifications. Consequently, solutions are changed due many parameters. The developed model enables cooperation of a broad set of participants in the process, irrespective of tools used for modelling. This tool gives the opportunity for interactive modifications in configuration from a prescribed set of parameters, including their functionality description. The desktop VR system is used inside Web browser or as standalone application visualised with X3D using XML as configuration data carrier.

In order to share the product or process solutions a lot of manual work to transfer the simulation into virtual environment as virtual prototype. The present work describes the staring research to adopt developed solution for VR assembly and kinematics of models for warehouse activities using the same principle but different parameters, as goals of the research are different. The architecture of the application addressing the warehouse

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VP is using on the Web standard programming tools. The proposed approach enables cooperation of broad set of participants in process, irrespective of tools used for modelling the product.

BACKGROUND

3D visualization is becoming increasingly popular for discrete event simulation. However, the 3D visualization of many of the commercial off the shelf simulation packages is not up to date with the quickly developing area of computer graphics.

There are several purposes for visualization, which can be categorized as validation, analysis and marketing [3]. Displaying graphical images of dynamic behaviour of a model during execution enables the user to discover errors by seeing. Following the animation of the model as it is running and comparing it with real life operation helps the user to identify discrepancies between the model and the system. Analysis refers to the process of gathering information and drawing conclusions from the simulation. Where statistics can show that a production line is inefficient, visualization can be used to locate the bottlenecks. The third term, marketing, refers to increasing the confidence of people in the provided solution. This means both convincing companies to buy the software, and convincing non-engineers of the validity of the result.

Warehouse simulation is the computer-based modelling of a real warehousing system. Simulation enables an organization to analyse and experiment with its warehousing process in a virtual setting, reducing the time and cost requirements associated with physical testing. Storage, docks, conveyors, forklifts and even personnel can quickly be introduced and adjusted within the simulation model, allowing companies the opportunity to determine how best to fully utilize their equipment and maximize efficiency. The need for efficiency in industry has never been greater, with personnel, fuel, transportation and material costs continuing to rise each year. Simulation provides a way to put a warehouse to the test in a risk-free environment without disturbing the existing warehouse system. It also enables users to determine minimum actual costs without sacrificing the required output.

Looking into object geometry, a variety of excellent modelling and authoring tools and format converters already exist. There are many interesting proprietary Web technologies to build rich 3D content. However, most of them are tailored for specific application domains and limited in producing dynamic 3D scenes. Necessary behaviour extensions are not easy to accomplish. Scrip languages are basically the only way to achieve applications with complex behaviour. VRML as the standard for 3D graphics on the Web and its successor X3D [4] offer more flexibility with inbuilt behaviour related nodes, script nodes and extensibility mechanisms. X3D is an ISO ratified open standards file format with run-time architecture to represent and communicate 3D scenes and objects using XML. It provides a system for the storage, retrieval and playback of real time graphics content embedded in applications, all within an open architecture. X3D has a rich set of componentized features that can tailored for use in engineering visualization, training and simulation.

XML is a public neutral format that can be used in Web applications with the ability to separate the content and form of data. XML is attractive choice as the representation language since the parsers are easy to obtain and satisfies the dual nature needed: It is well suited for data exchange over the Web and for creation of user interfaces in various formats. XML file is hierarchically structured document where the objects are denoted by tags containing plain data or additional objects or combination of both. Attributes are name-value pairs that occur inside tags after the object name. The properly nested objects define hierarchical structure and may contain references. With DOM parser it is possible to read the input file in XML, check formatting and semantic validity, built and presents a complex hierarchical object structure with few lines of code.

VP techniques require a significant computer power to provide basic requirements, as viewing and interactions with real-time response. The problems of global cooperation over the Web are reduced with more or less specialised viewers surveyed in [5]. In order to integrate the virtual world heterogeneous data sources should be composed. At the data level it means converting and processing different data formats. That part of the process is very important and intensive. The process needs to raise precision of appearance and illustration, to raise presentation performance and to reduce the information loss. It has to be pointed out that virtual models are tessellated models, because only a polygonal representation allows fast rendering in a real-time. The VP systems use different dataflow for manipulating virtual models in real time and converting data into the VP format is maintained differently from the system to the system, mainly depending on application as discussed in [6]. With other words, the conversion is not standardised, and proposals do not exist in this direction, since in applications virtual environments functionalities vary severely. Simulation is the process of designing a model of a concrete system and conducting experiments with this model in order to understand the behaviour of the concrete system and/or evaluate various strategies for the operation of the system [7]. Although the simulation experiment can produce a large amount of data, the visualization of a simulated system provides a more complete understanding of its behaviour. In the visualization, key elements of the system are represented on the screen by dynamically change position as the simulation evolves through time

Large companies lack the time and small companies lack the resources required to implement the technology and automation needed to compete in the market place. Desktop non-immersive VR systems features are far from possibilities of immersive VR technologies, but a key advantage in desktop systems are that standardised computer techniques could be used.

SYSTEM ARCHIECTURE

In the research the focus is on automatic generation of animation of warehouse activities from CAD system modelling into X3D environment for Web-based distributed environment. The main issue is that the process automatically generates simulation for Web services and no additional knowledge or work is needed to perform simulations. To investigate and evaluate more than one solution the change of parameters in provided that is easy enough that the visualization is straight forward task.

The applications for simulation software managing problems typically presents two conflicting issues. Pure simulation applications are user friendly and lucks in flexibility and accuracy. While, simulation languages greatly improve model flexibility and accuracy, but ease-of-use is sacrificed. By utilizing a simulation language and limiting the problem domain with user friendly interface, both fields could achieve great potential. Using templates is limiting the domain of a typical warehouse layout, and the parameters implied by the data input files. These parameters include a wide range of operational functions for all areas of the warehouse. The warehouse XML model implement a lot of possible parameter combinations. The simulation provides the flexibility needed to accurately develop the warehouse model. The interface associated with the software provides for ease-of-use in setting up scenarios and running the model.

The Web-based framework provides a convenient platform for users to view and evaluate a model. A distributed design system can generate design models in an XML-style feature representation to allow a Web-based system to perform viewing and manipulation, leading in two main features:

- Taking advantages from the effective utilizations of the Web and Java technologies makes the system independent of the operating system, scalable and service-oriented. The services located on the Internet provide an accessible way for the evaluation of warehouse activities.
- The configuration file represents an integrator with the definition suitable for X3D presentation.

A XML-style representation has been used to carry out some features for visualization and manipulations in the Web-based system. This format incorporates the characteristics of X3D and features to support Web applications. The XML-based information representation enables the system to be effectively adaptable to meet the new development of the Internet technology. The system and services are based on the Java-Servlet mechanism. With the development of some new Internet integration technologies such as the Web service, it is necessary to explore new alternatives to integrate the current functions under the new system infrastructure.

The system is organized as databases of files. The structure of the product and all links are defined in configuration file using XML. The X3D is used for viewing the VPs. The system is shown in Figure 1.

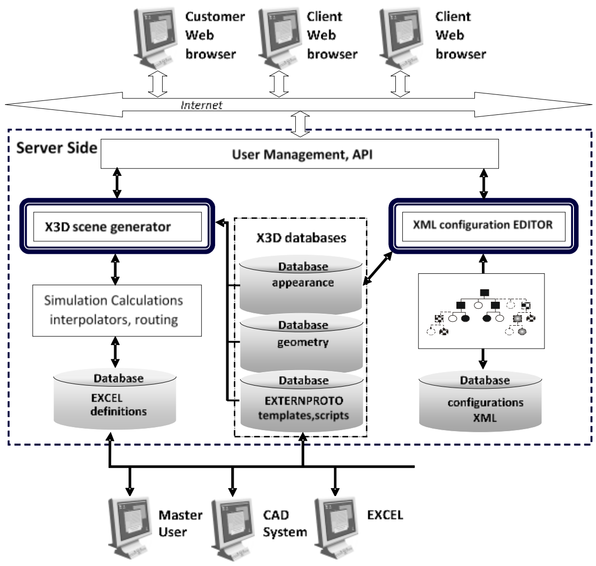

Figure 6: System architecture [1]

All geometrical information, complete warehouse model with walls and shelfs configuration is extracted from the CAD system with macro programming using CAD system programming interface. X3D models generated directly from CAD systems in general are composed from many nested, complex and repeated structures. To accelerate the rendering performance of a system, a global optimization of a polygonal data is necessary. The application was coded to rearrange and optimize the X3D model; the geometry of parts is separated from appearance and additional information as view, background and navigation definitions. All data is stored in files. Since the direct translation from CAD systems into X3D models differ a lot, an individual interface is needed for every modelling system. Generally, the modelling systems offer only VRML translation, the translation from VRML to X3D is necessary. The macro program was coded in order to perform all needed actions: generate the hierarchical structure in XML, separation of geometry and appearances of parts, combine separated surfaces of the part into single geometry file including optimization of geometry data. The optimization of the geometry data uses adopted algorithm described in [8] based on removing nodes, performing triangular mesh decimation and undecimation. The optimization of data is necessary caused by huge amount of data from modelling systems to be reduced for working on Internet applications.

The properly nested objects define hierarchical structure and may contain references. With DOM parser it is possible to read the input file in XML, check formatting and semantic validity, built and present a complex hierarchical object structure with few lines of code. The configuration file represents an integrator with the definition suitable for X3D presentation. The semantic of the configuration file is following the X3D specifications and syntax. The basic object is defined, that could be a part, a grouping element or an element enabling multiple choices of objects at the same level. The structure of configuration file is described in [1]. Here is shown basic approach to record the geometry specifications and added specifications for dynamic simulations.

The XML configuration file is built from Excel the data sheets, which is commonly used in warehouse activities description, with all necessary data for parameters to define each simulation scenario. We plan to develop an inbuilt editor that will allow easily change of parameters after every simulation run defining new scenario. For now the change of time is considered, start time of different activities, manipulation times, moving velocity, etc.

The basic object is defined with following object classification [1]:

object B(b_{id}, A, C(c_{id}, c_{def}))

b_{id} – unique object identifier,
A – set of attributes represented by names and values,
C – set of object constrains,
c_{id} – object constrain identifier,
c_{def} – object constrain definition with relationships.

Following the XML syntax, the object has a general form:

<obj$_{id}$ attributes>
<c$_{id}$> c$_{def}$ </c$_{id}$>
</obj$_{id}$>

The syntax of XML tags defining the position of the object:

```
<poz>
    <translation x="0.0" y="0.0" z="0.0"/>
    <rotation x="0.0" y="0.0" z="0.0" ang="0.0"/>
    <scale x="1.0" y="1.0" z="1.0"/>
    <center x="0.0" y="0.0" z="0.0"/>
</poz>
```

When all the structure is completed the macro program proceeded to simulation information. The macro appends to the configuration file the object definition of activity data with prescribed parameters with time frames. Macro allow the user to input the number of steps for interpolation of the motion (default value is 10). More steps result in smoother simulation and higher amount of data. The first line example could be seen in Figure 2.

```
Path.1 loLim=0 upLim=25 keynum=10
[1,0,0,0,1,0,0,0,1,0,0,0]
[0.999,-0.039,-0.002,0.039,0.995,0.097,-0.002,-0.097,0.995,-1.743,1.084,-4.287]
[0.997,-0.078,-0.008,0.078,0.978,0.193,-0.008,-0.193,0.981,-3.434,2.646,-8.445]
[0.993,-0.116,-0.017,0.116,0.951,0.286,-0.017,-0.286,0.958,-5.055,4.668,-12.429]
[0.988,-0.153,-0.03,0.153,0.914,0.377,-0.03,-0.377,0.926,-6.587,7.129,-16.196]
[0.981,-0.188,-0.047,0.188,0.866,0.463,-0.047,-0.463,0.885,-8.013,10.002,-19.703]
[0.973,-0.221,-0.067,0.221,0.809,0.544,-0.067,-0.544,0.836,-9.319,13.254,-22.914]
[0.964,-0.252,-0.09,0.252,0.743,0.62,-0.09,-0.62,0.78,-10.489,16.851,-25.792]
[0.953,-0.28,-0.115,0.28,0.669,0.688,-0.115,-0.688,0.716,-11.511,20.753,-28.305]
[0.941,-0.305,-0.144,0.305,0.588,0.749,-0.144,-0.749,0.646,-12.374,24.918,-30.427]
[0.929,-0.326,-0.174,0.326,0.5,0.802,-0.174,-0.802,0.571,-13.069,29.299,-32.135]
```

Figure 2: Example of the file with interpolation data.

```
<TimeSensor DEF='TS_Path_1' clockInterval='10' loop='false'/>
<PositionInterpolator DEF='PozIntvrti_1' key='0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1'
 keyValue='0 0 0,-1.743 1.084 -4.287,-3.434 2.646 -8.445, -5.055 4.668 -12.429,-6.587 7.129 -16.196,
-8.013 10.002 -19.703, -9.319 13.254 -22.914,-10.489 16.851 -25.792,-11.511 20.753 -28.305, -12.374
24.918 -30.427,-13.069 29.299 -32.135'/>

<ROUTE fromNode='TS_Path_1' fromField='touchTime' toNode='Mech1Cmd1' toField='startTime'/>
<ROUTE fromNode='Mech1Cmd1' fromField='fraction_changed' toNode='PozIntvrti_1' toField='set_fraction'/>
<ROUTE fromNode='PozInt_vrti_1' fromField='value_changed' toNode='vrti_1' toField='translation'/>
```

Figure 3: Generated interpolators and route definitions from Figure 2.

Finally, the configuration file is finished and at the end of the main object, the routing definitions are included.

These preparations were firstly done manually with a lot of tedious and time consuming work, but when all objects and scripts are prepared, the task is not so complicated if the configuration file structure is obeyed. To increase the efficiency of data preparation the editor will be developed to manipulate parameters in configuration file more interactively. The extended database consists of geometry, simulation definitions and the configuration file that keeps the structure of the product with attributes.

All the data are organized in files: geometry description, sensors, routing definitions, scripting nodes, interpolation data and material appearances with colours, textures, sounds etc. The objects are represented with attributes pairs; the attribute name refers to the purpose and the attribute value refers to the name of the file, which contains appropriate description to be included.

The simulation run is triggered by start button to starts the simulation in browser window. During the simulation run, a full 3D animation of the warehouse scenario is shown from different viewing possibilities. This application provides input capabilities for setting up a number of customer scenarios, and provides 3D graphical output for each. Because the application is developed to handle parameter input combinations, the user not need to edit or compile model code. Scenarios can quickly be set up and run to get comparative results and see what would likely happen in the real warehouse. When the simulation has completed running the defined scenario and the scenario is positively evaluated the XML file could be used to update the Excel data sheet. Two scenarios are presented in Figure 4 and 5 as snapshots.

CONCLUSIONS

The last decade has seen the increasing use of computer technology to prototype engineering designs and processes before manufacture or deployment. Providing the means of representing these systems as software programs enable multiple simulations to be run based on various inputs to the system. This methodology presents opportunities for the simulation engineer, such as the ability to vary system parameters or environmental inputs to reflect possible scenarios, and to do so exhaustively. Early verification through simulations minimizes the risk inherent in the design process by reducing the probability of discovering errors late in the development process. In engineering the visualisation of processes are of crucial importance. The use of simulation studies to better understand the dynamic behaviour of a system under investigation is at the core of verifying models early in the development process. Despite the amount of data that such studies produce, a 3D representation of the system creates a more complete understanding of system behaviour. The costs involved in virtual prototyping are essentially smaller than doing a similar test on real objects. As an alternative for 2D simulations, more computer techniques are incorporated for visualising and testing the functionality of the objects in 3D world. Usage of standard Web-based technologies leads to easier, effective and more general applications suitable for small and medium size companies with limited resources in that field of research. Our approach is showing how Web application could be used to transfer models with structural and behaviour features directly to Web environment for evaluation. The use of single XML file covering the various configurations, is found very suitable for versatile downstream applications. The future work is focused on implementing the possibility for user to add alternative partial solutions directly into the model, as fully defined sub-objects on remote location. We will further investigate the possibilities to optimise the loading time in order to share the behavioural simulation via Web with no extra tedious work of preparing virtual prototypes for particular solution.

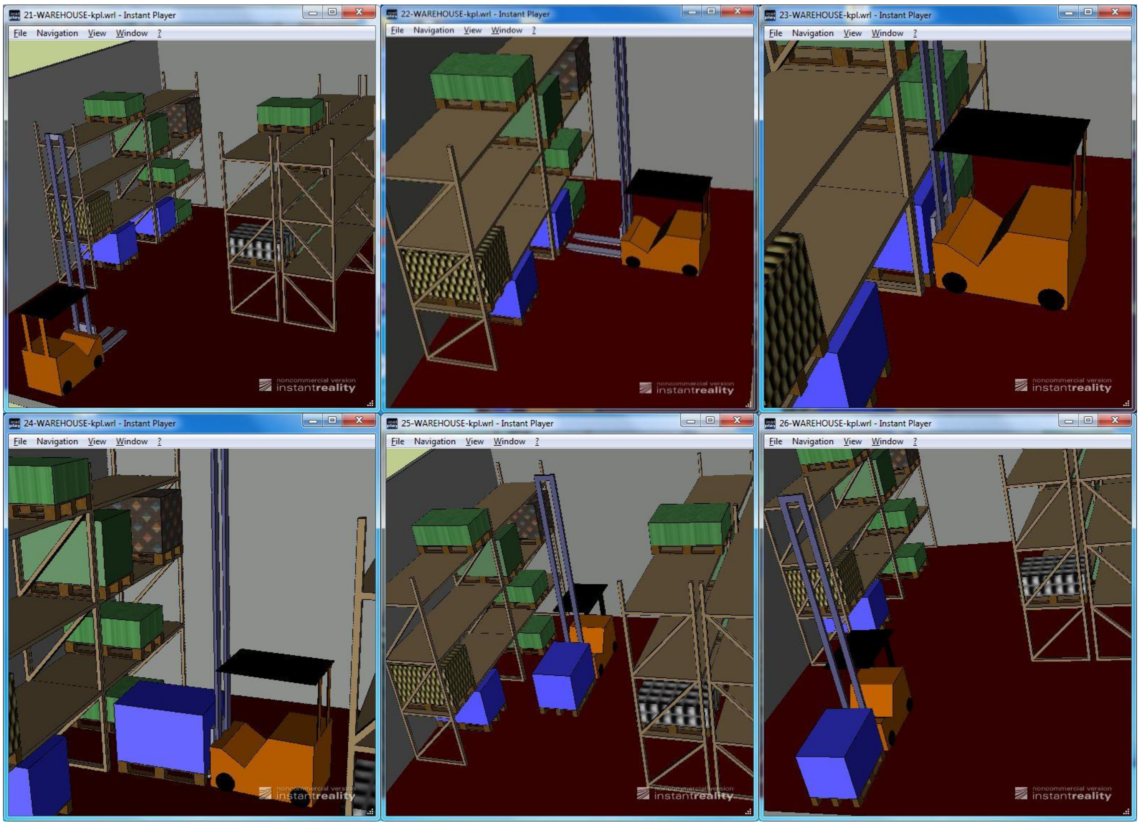

Figure 4. Snapshots of simulation in warehouse with no object lift

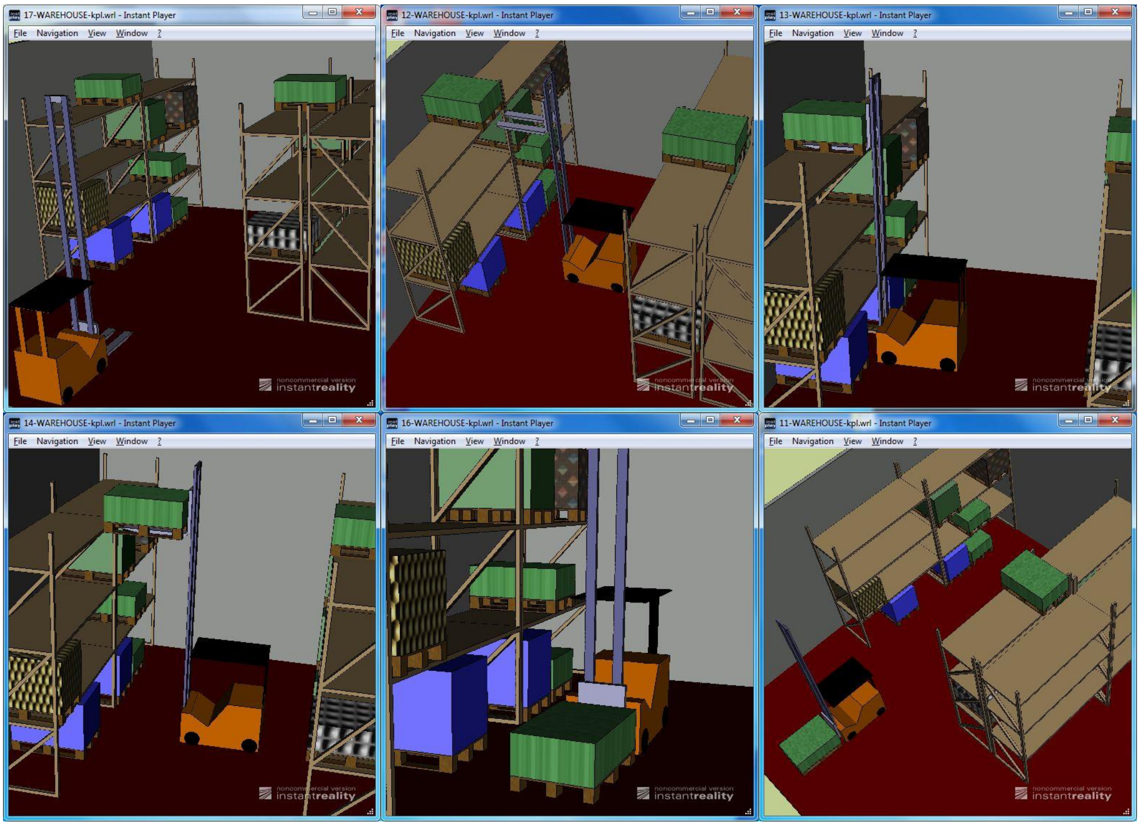

Figure 5. Snapshots of simulation in warehouse with lifting

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ANALYSIS OF STACKER CRANE OPERATIONS

Boris Jerman[58], Nenad Zrnić[59],Tone Lerher[60],Jurij Hladnik[61]

Abstract − *Despite of the fast development of transportation technologies and implementation of JIT/lean production in majority of complex production systems warehouses remain the important links of various transportation chains of external and internal transport. Automated high bay warehouses are appropriate choice for many types of goods and for many warehousing purposes. Electrically powered automated stacker cranes are the most common transportation devices used in such warehouses. Because the intralogistics can be defined as a method of management and optimization of internal production and distribution processes, the optimization of warehouse operations can be recognized as one of intralogistics' core topics, from which on one hand benefits the company by reduction of costs, and on the other hand also the sustainability of the process by reduction of power consumption. In the paper the data for deployment of stacker cranes in the high bay warehouse of bigger dairy is introduced. The usage of the introduced data for determination of cranes' working cycles and for estimation of energy consumption is discussed. Further, the usage of the gathered data for supporting the lean and green concept, which includes speed, flow and energy efficiency of material handling equipment, is also discussed.*

Keywords − *High Bay Warehouses, Stacker Crane Deployment, Sustainability, Energy Consumption, Optimization of Crane Operations*

INTRODUCTION

Intralogistics can be defined as a method of management and optimization of internal production and distribution processes, therefore the optimization of warehouse operations can be recognized as one of intralogistics' core topics, from which benefits both, the company by reduction of transportation times and costs, and the sustainability of the process by reduction of power consumption.

Despite of the fast development of transportation and production technologies in majority of complex production systems warehouses remain the important links of various transportation chains of external and internal transport. Automated high bay warehouses are appropriate choice for many types of goods and for many warehousing purposes. They are typically high-rise storage units with a relatively small ground plan, using traditional Crane-Based Automated Storage and Retrieval System (CBAS/RS), which usually consist of conveyors, racks and automated Storage/Retrieval (S/R) machine (crane) [1]. In recent times instead of CBAS/RS also Autonomous Vehicle Storage and Retrieval Systems (AVS/RS) which is a relatively new technology for automated Unit-Load warehouses, has been implemented, primarily in Europe [2]. Primarily for mini-load warehouses a Shuttle Based Storage and Retrieval System (SBS/RS) was developed, which is a branch of AVS/RS technology [3, 4].

Performance evaluation and comparison of AVS/RS and CBAS/RS material handling systems of automated high bay warehouses is an actual research theme. AVS/RS is first studied by Malmborg [2, 5]. Kuo et al. [6, 7] developed a computationally efficient cycle time model for AVS/RS for estimation of resource utilization. Zhang et al. [8] studied variance based approximation for AVS/RS waiting times. Ekren et al. [9, 10, 11] evaluated performance of AVS/RS by means of simulation. Lerher et al. [12] studied multi-objective optimization for automated warehouses. Recently, Lerher [13] and Lerher et al. [4] have studied energy

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regeneration and energy efficiency models for SBS/RS. The comparison of effectiveness of CBAS/RS and AVS/RS was studied by Sunderesh et. al. [14] and Banu et. al. [15].

AUTOMATED HIGH BAY WAREHOUSE

In this chapter the layout of the high bay warehouse of bigger dairy and the data for deployment of its stacker cranes is introduced.

The warehouse technical data

The studied automated high bay warehouse consists of 4 aisles with racks on both sides (Figure 1). There is one stacker crane (Figure 2) in each of the aisles.

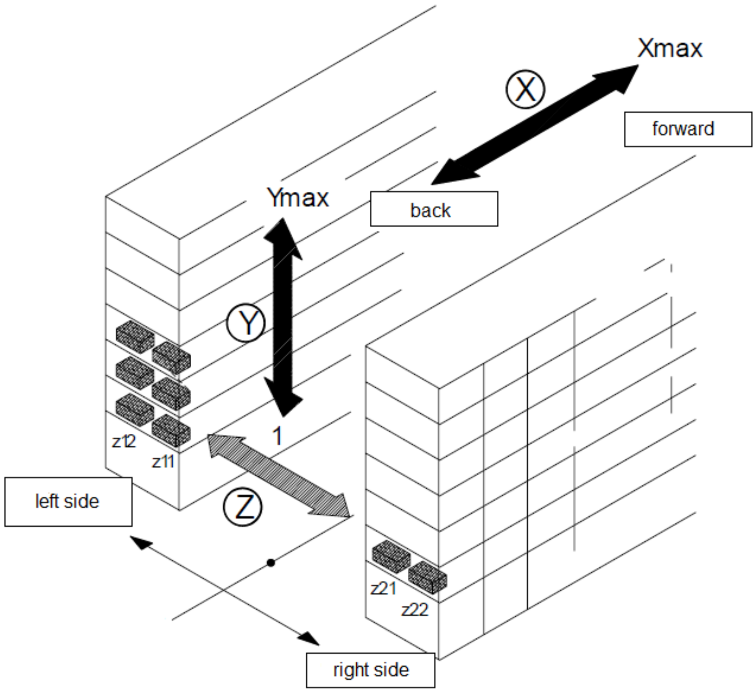
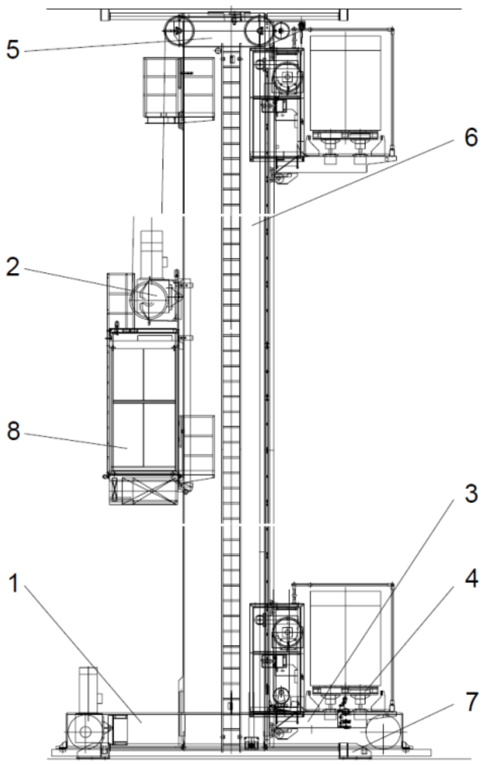


Figure 1. Warehouse aisle with coordinate systems [16]

The load, which must be stored (the tote) is located on the cargo pallet and transferred to the corresponding stacker crane by means of the automated conveyor. The crane takes over the cargo and transports it to the empty location in the rack. Retrieval of the load goes with the opposite order of operations. Storage and retrieval operations are fully automatized and the material flow is controlled by the computer program.

The warehouse is of approximate dimensions of 60 x 25 x 20 [m] (length x width x height). It has 4 aisles every of which has single or double rack on each side (together 13 single racks, see Figure 3). There are 7 tiers (rows) and 61 columns in each double rack. The warehouse has around 5500 storage positions in the racks (13 x 61 x 7 = 5551).

As a system pallet the Euro-like pallet of dimensions 1200 x 800 x 144 [mm] is used. The maximal load dimensions (including the pallet) are 1350 x 900 x 1900 (or. 1500) [mm] (Fig. 4).



1 … bottom beam
2 … lifting mechanism
3 … lifting platform
4 … extracting device
5 … top beam
6 … column with equipment
7 … aisle equipment
8 … electric cabinet

Figure 2. Stacker crane [16]

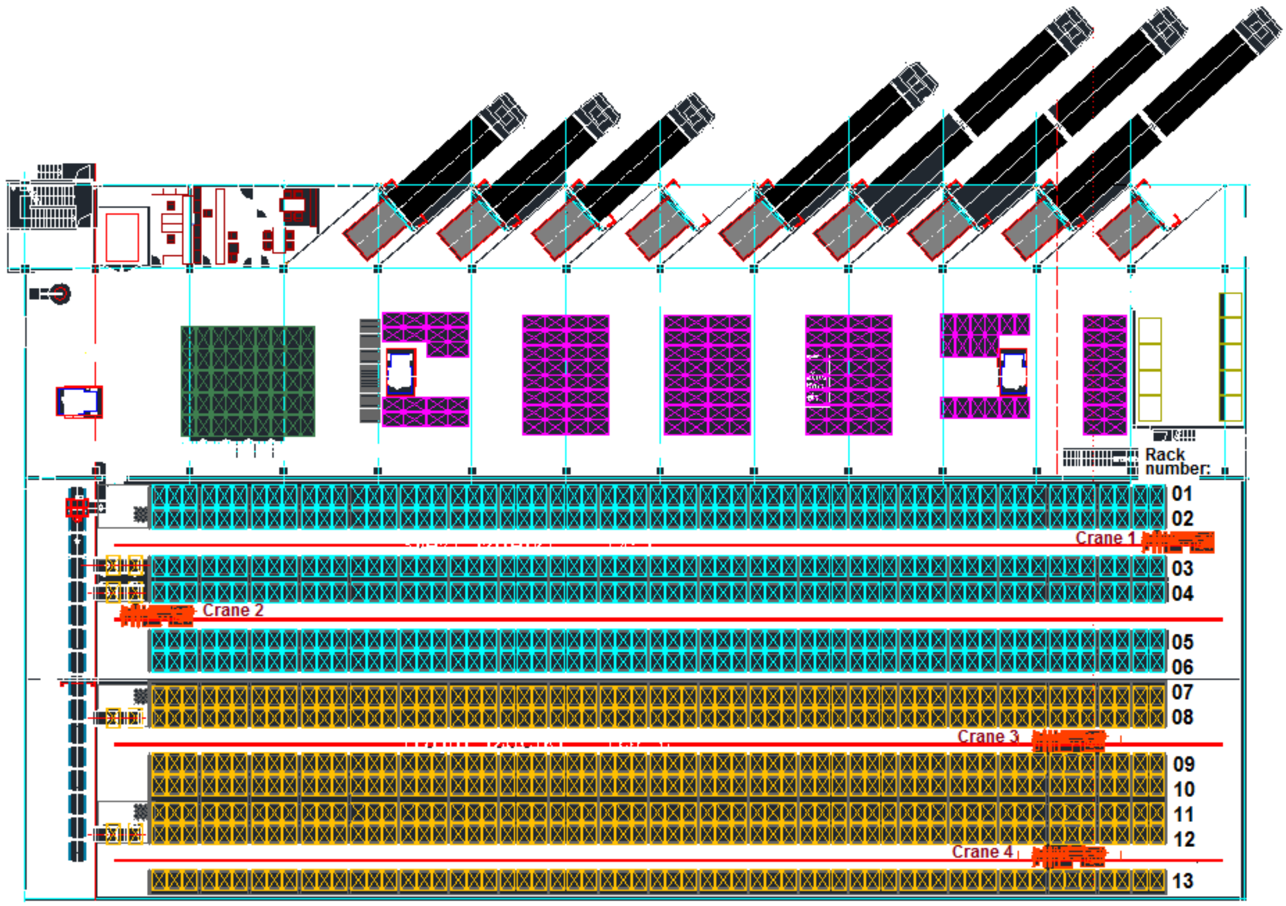


Figure 3. Layout of the warehouse with 13 racks [16]

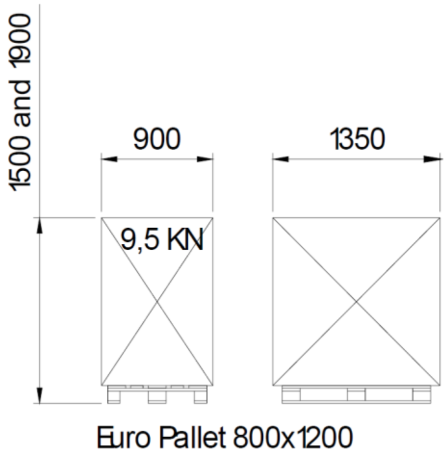


Figure 4. System pallet with the load (dimensions) [16]

The accelerations and speeds of crane movements are introduced in Table 1, where also the allowable ED of the crane's driving motors is shown. The stacker crane is intended to be used for 24 hours 6 days per week. The crane capacity is 950 kg.

Table 9. Accelerations, decelerations and speeds of stacker crane movements

	Crane travelling	Platform lifting	Pallet extraction
Speed	135 m/min	45 m/min (normal) 2 m/min (positioning)	73 m/min (empty pallet) 42 m/min (fully loaded pallet)
Acceleration/ deceleration	0.5 m/s^2	0.6 m/s^2	2.0 m/s^2 (empty pallet) 0.6 m/s^2 (fully loaded pallet)
ED of the driving motor	100 %	100 %	100 %

Deployment of stacker cranes

In this chapter the data of the real life deployment of all four stacker cranes in the high bay warehouse is introduced. The data for the period of 38 consecutive days is available. The structure of the data and data samples are shown in Table 2.

Therefor the following data on movements of separate load (tote) is available:

- position of the source storage location in the rack or on the entering/retrieval location of the warehouse;
- position of the destination storage location in the rack or on the entering/retrieval location of the warehouse;
- overall distance of the movement of the load (calculated);
- operation starting time;
- operation ending time;
- time elapsed during allocation of the load (calculated);
- crane movements accelerations, decelerations and maximal speeds;
- transportation time of the load on the crane (calculated);
- transportation time of the load on the conveyor (calculated).

Furthermore, if some assumptions are stated the necessary movements of the empty crane can also be estimated and therefor overall deployment of the four stacker cranes is determined.

Table 2. Available data of stacker cranes deployment

Day	Source aisle	Source tier (row)	Source column	Destination aisle	Destination tier	Destination column	Time started	Time finished	Time ela-psed [s]	Crane deployed
1	3	7	1	0*	0*	0*	sep 02, 20** 04:09:42 PM	sep 02, 20** 04:10:06 PM	24	3
1	0*	0*	0*	3	9	10	sep 02, 20** 04:09:45 PM	sep 02, 20** 04:10:35 PM	50	3
1	3	7	1	0*	0*	0*	sep 02, 20** 04:11:15 PM	sep 02, 20** 04:11:39 PM	24	3
…	…	…	…	…	…	…	…	…	…	…
2	1	5	5	0*	0*	0*	sep 03, 20** 12:02:59 AM	sep 03, 20** 12:03:20 AM	21	1
2	0	0	0	1	2	35	sep 03, 20** 12:03:01 AM	sep 03, 20** 12:03:57 AM	56	1
2	2	7	20	0*	0*	0*	sep 03, 20** 12:03:09 AM	sep 03, 20** 12:03:44 AM	35	2
…	…	…	…	…	…	…	…	…	…	…
38	3	4	19	0*	0*	0*	okt 07, 20** 11:59:47 PM	okt 08, 20** 12:00:22 AM	40	1
38	0*	0*	0*	3	5	1	okt 07, 20** 11:59:56 PM	okt 08, 20** 12:00:48 AM	68	1
38	1	3	47	0*	0*	0*	okt 08, 20** 12:00:04 AM	okt 08, 20** 12:00:44 AM	38	1

* … When source or destination aisle, tier and column are numbered as 0, the corresponding source or destination location is entering/retrieval location of the warehouse.

** … The year of the cranes movements is hidden on purpose.

CONCLUSIONS

In this paper, the data of the real word high bay warehouse are introduced, consisting of the warehouse and the racks dimensions, of the crane capacity, crane movements' speeds and accelerations, and of the crane deployment data. It is shown how raw data from the warehouse controlling software can be prepared in such a way to enable further studies.

The following researches are planned in the future, using the presented data. First of all the appropriateness of the warehouse configuration for supporting the current logistic needs will be estimated. Furthermore, the maximal storage/retrieval capacity of existing CBAS/RS will be determined and comparison with comparable SBS/RS will be carried out. The data introduced will also be used for determination of energy consumption of the existing warehouse and solutions will be proposed for energy consumption optimization. The ecological aspects as well as the economic aspects will be included.

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MODERN APPROACH TO THE DESIGN AND CONTROL OF LOGISTIC PROCESSES

Jozef Hnát[62], Jozef Herčko[63], Milan Gregor[64]

Abstract – Design of the logistic systems represents an important part of the production system design. Therefore it is necessary to think and to find right strategy for logistics. Not only technologies directly connected to execution of different logistic operations, but also technologies used in the preproduction phase of planning and in the control of logistic processes play important role as enablers for the high efficiency in the logistic processes. In our organization we use different digital factory tools in preproduction phase and this article is focused on some of them. In the conceptual planning we use software Tecnomatix Process Designer which facilitates the design and validation of manufacturing processes from concept and detailed engineering through production planning. Detailed design of production and logistic systems and material flow optimization is done subsequently in Tecnomatix FactoryCAD/FLOW tools. Very important part is control and monitoring of the system. This is especially important in case of using autonomous and intelligent systems in logistics (for example AGV - Automated Guided Vehicle). By using virtual plant models and their linking to the real objects in production system we can talk about virtualization which is one of the basic principles in Industry 4.0.

Keywords – Automated guided vehicle, Control of logistic processes, Design of logistic processes, Intelligent logistic

INTRODUCTION

Production can`t exist without supply of material from the warehouse to the workplace and transport of products from the workplace to the warehouse of finished products. Therefore it is necessary to create appropriate routes, to define appropriate transported quantities, to choose the technology to be used in warehouses for transport, etc. Proposed solutions have to be verified and validated in the preproduction phase. Different powerful software solutions are available and can be used for modeling and simulation of our ideas.

In the first phase of modeling of production system an ideal layout of workplaces is designed. In the ideal layout the real space requirements of workplaces, input – output points of the production system or other constraints (e.g. space restrictions) are not taken into account. Different algorithms can be used to find optimal solution for ideal layout. These algorithms usually minimize the total transport capacity and intensity of transport between all workplaces.

In the second step ideal layout is transformed into real conceptual layout and respects:

- real shape and dimensions of the machine / workplace and workplaces operating areas (represented by 2D / 3D model),
- basic material flow in the production hall and its connection to the material flow between different halls (input, output, stores location),
- transport and material handling needs (handling units in production, transport network and streets dimensioning, cranes paths, etc.),
- placement of building elements (columns, walls) and permanent [3].

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CONCEPTUAL DESIGN OF LOGISTIC SYSTEM IN TECNOMATIX PROCESS DESIGNER

Tecnomatix Process Designer facilitates the authoring and validation of manufacturing processes from concept and detailed engineering through production planning. Process Designer enables manufacturers to develop, capture and re-use process plans. Furthermore, process design teams can compare alternatives to develop and select best manufacturing strategies that meet specific business requirements. In a 3D virtual environment, Process Designer is a collaborative platform that enables distributed enterprise teams to evaluate process plans and alternatives, optimize and estimate throughput and costs, plan for variants and changes and coordinate production resources [5].

Part of this solution is the Logistics module which provides users with a basic data model of logistic objects, allowing them to build logistics-specific planning projects and manage the relevant data.

In the first phase we can start with network planning. In this phase logistics planners are allowed to define logistic networks and to calculate production rates per part family. This requires to use following steps:

- Setup the network structure.
- Setup the part structure (BOM).
- Setup one resource per logistic plant.
- Assign the resource which represents the logistic plant to the logistic plant of the network structure.
- Assign the produced parts to the logistic plant project and define the production rate.
- Create part families automatically out of the BOM. One part family is created for each part in the BOM, and the relevant part is assigned to the part family. Alternatively, the part families can be defined in a library and copied below the logistic project. Based on the information you defined, the system calculates the required transportation relations between the plants. The calculated transportation relations include the calculated number of products and required parts.

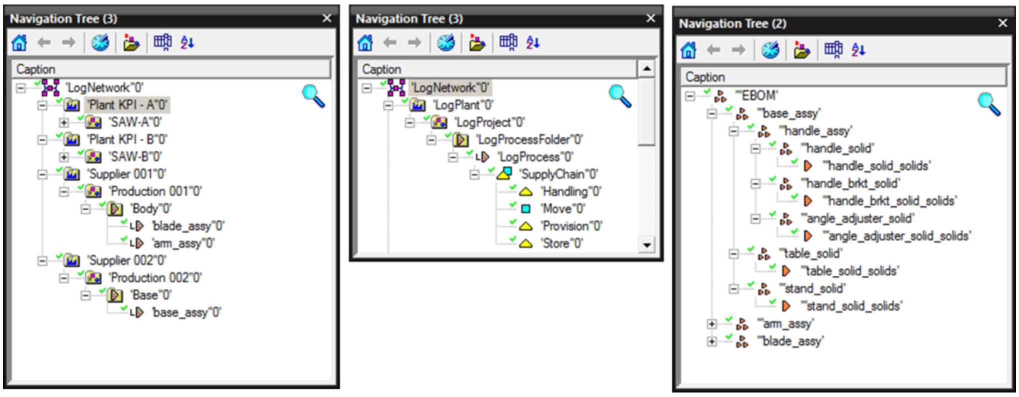

Figure 7. Network and part structure (BOM)

Logistics planners can open the Process Check tab (Fig.2.) to view progress of the logistic planning. The Process Check tab offers the following predefined checks:

- Parts assigned to LogProcess: Is there at least one part assigned to the LogProcess object?
- Container assigned LogProcess: Is there exactly one Container assigned to the LogProcess object?
- Container assigned to logistics operations: Is there exactly one Container assigned to the Move/Store operations of the supply chain of the LogProcess?

- Supply Chain defined: Is there a supply chain defined for the LogProcess?
- Supplier assigned: Is a supplier assigned to the LogProcess?
- Areas assigned to store operations: Are there LogAreas assigned to the store operations of the supply chain?
- Times assigned to logistics operations: Are there times assigned to the logistics operations (do all logistic operations of the supply chains have an allocated time > 0).
- General check that assigned container, supplier, areas, etc., are from the correct defined library: The system checks whether all assigned resources of the following types - LogArea, LogContainer, Supplier, Vehicle, Transporter, SupplyChains (for linked supply chains) belong to the respective library of the plant, under which the LogProcess resides. The libraries are taken from fields such as LogPlant,LibrarySuppliers, etc.
- Consistency check to verify the logistics plan against the production plan to find any inconsistencies. The check is based on the use of the same parts and logistics areas by both production planning and logistics planning. A logistics plan is consistent if the parts and the corresponding logistics areas are assigned to the same station as in the production plan.

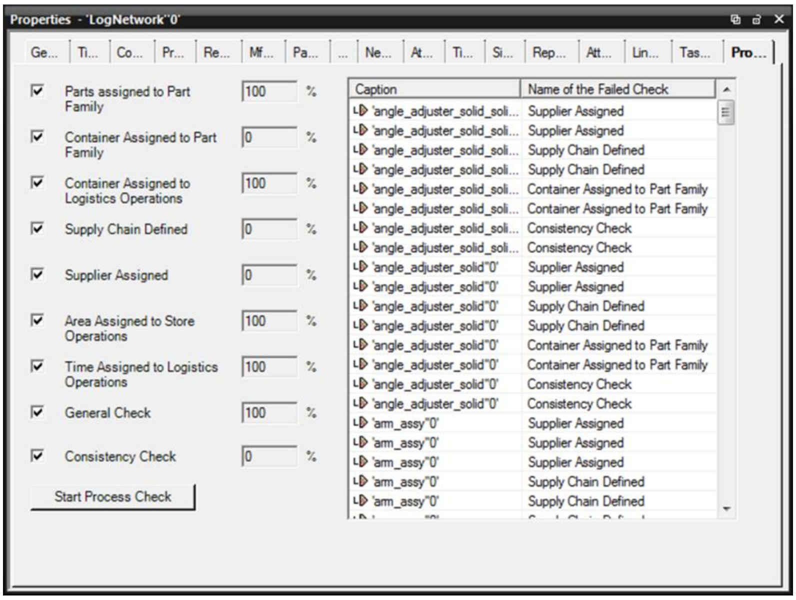

Figure 8. Process Check tab

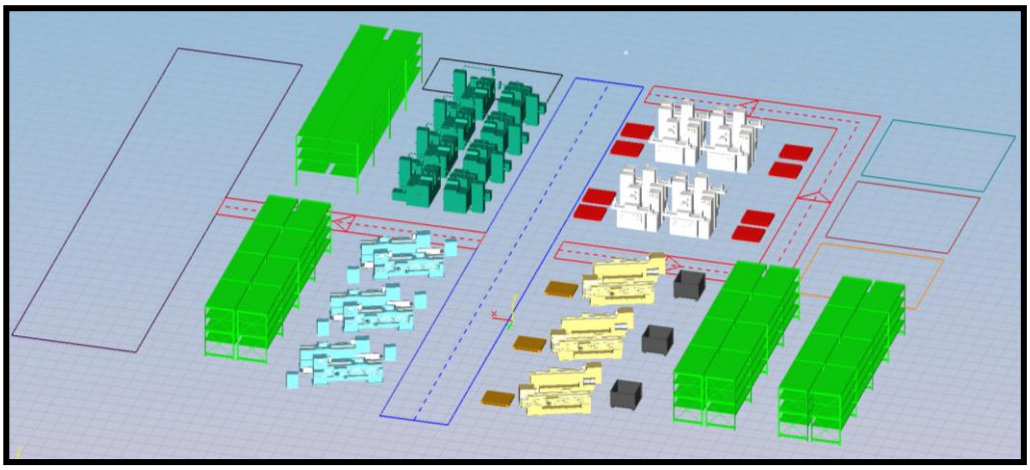

Figure 9. 3D layout of production system with logistics areas and tracks

Logistics areas and tracks features enable to build a logistic path network and logistics areas. Logistics planners can describe full area and path networks by drawing areas and tracks and connecting them, using connection points, to other logistic areas or tracks. Using these commands logistics planners can define the direction of the tracks, and to set them as one-way or two-way. Defined path networks can be used as the basis for calculations of route and transport time.

Basic commands for drawing, deleting, showing and hiding all logistics areas and logistics tracks can be seen and designed directly in the 3D layout of production system (Fig.3.).

DETAILED DESIGN OD LOGISTIC SYSTEM IN TECNOMATIX FACTORY CAD/FLOW

After conceptual solution has been proposed, we can start with detailed design of logistic and production system. In this phase we use software Tecnomatix Factory CAD and Factory FLOW. Instead of having to draw lines, arcs, and circles, Factory CAD allows us to work with "smart objects" that represent virtually all of the resources used in a Factory, from floor and overhead conveyors, mezzanines and cranes to material handling containers and operators. With these objects, we can "snap" together a layout model without wasting time drawing the equipment. Tecnomatix FactoryFLOW graphical material handling system helps us (industrial engineers) to optimize plant layouts based on material flow distances, frequencies, and associated costs. Here they are used the analysis of transport routes, requirements for storage of materials, specifications of equipment for materials handling and information about components handling units for a given production system layout.

Using the application FactoryFLOW we can reach much better decisions, effective plant layouts can be designed, with shorter distances for the transport of components, optimal batch sizes and inventory levels. Also better communication can be achieved. All this makes for higher efficiency and productivity of manufacturing. The connection between FactoryCAD and FactoryFLOW software is probably the most straightforward of all Siemens Tecnomatix software solutions. They represent extension of the AutoCAD and run under its interface. Using libraries and FactoryCAD tools, 3D model of the production system is built. In the production system there are defined various "Activity points", i.e. points where specific activities are running (workstations, storage, networks of material flow, input-output places and others. Tecnomatix FactoryFLOW uses production layout drown in the FactoryCAD. Another source of information for analysis is a tree structure that contains information concerning the product and its parts, information about activities carried out and information on the transport and handling equipment.

Basic data needed to carry out analyzes in FactoryFLOW are:

- production layout in the form of AutoCAD drawing,
- information on production volumes,
- material flow of individual products and its parts,
- information on handling equipment,
- information on the handling material activities.

FactoryFLOW is a software application that generates material flows, aisles utilization charts and various output reports. Graphical representation of information flow allows us to easyly identify following:

- critical path,
- flows of production activity,
- requirements for storage rooms,

- requirements for the handling of materials,
- potential barriers in the material flow.

Such presentation of material flow and material handling operations can significantly increase understanding of production system. FactoryFLOW enables quick and easy modeling of changes in the production and logistics system layout, material flow direction, volume of production and systems for material handling.

Main goals of FactoryFLOW analysis are:

- evaluation of requests for material handling,
- reduction of not value adding operations,
- reduction of the overall transportation length,
- improvement of transshipment,
- reduction of work in process level,
- modification of material flows for JIT or for group technology
- identification of requirements for storage space,
- analysis of the feasibility of pedestrian pathways.

Between the main Factory-FLOW outputs belong Sankey diagram of material flow in the production layout, Distance Intensity Chart (DI Diagram), utilization diagrams and reports.

Sankey diagram of material flow in the production layout. Generally Sankey diagrams are a specific type of flow diagram, in which the width of the arrows is shown proportionally to the flow quantity. In our case Sankey diagram is a complex picture of material flow that shows the direction, length, intensity and cruising. It demonstrates the suitability of the proposed transport system. Sankey diagram chart formation is preceded by filling chessboard table of transport relations. The thickness of lines is displayed in the default scale, e.g.: pcs / month. For better orientation in the diagram, FactoryFLOW uses different color for material flows of different products. Sankey diagram is updated along with changes done in the production layout (Fig.4.).

Figure 10. Sankey diagram in 3D layout of production system with logistics areas and tracks

Distance Intensity diagram (DI diagram) - is a tool for the evaluation of material flows. This tool sorts the material flows depending on the intensity and distance of transport. Each point represents the relation between two objects. Body lying on the upper right are high transport costs and are considered to be unfavorable.

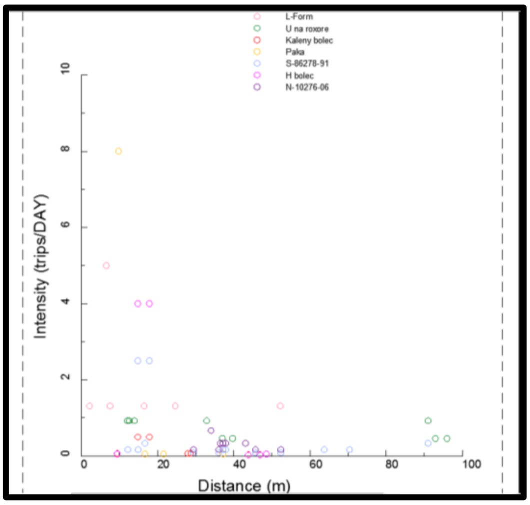

Figure 11. DI diagram

Utilization diagram - tool draws material flow in different colors according to the level of its utilization. Critical places are shown in the red color, as it is shown on the figure above.

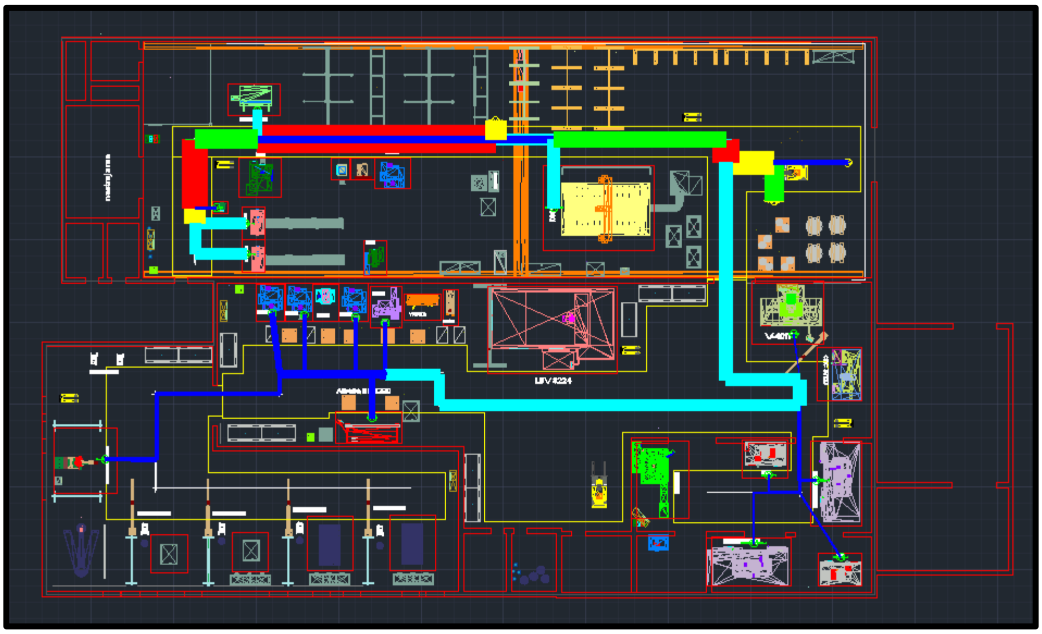

Figure 12. Utilization diagram

Reports - besides producing color-coded flow diagrams and graphs, FactoryFLOW allows you to create many types of detailed reports on the layout, material flow, time and cost saving comparisons.

CONTROLL AND MONITORING OF LOGISTICS

After implementation of designed production and logistic system it is necessary to choose right strategy for its control and monitoring. At our laboratory ZIMS (Zilina Intelligent Manufacturing System) we have developed our own solution. AGV Monitor & Control System is a system for monitoring and control of logistical resources. The system provides logistical resources with the ability to pass on information about their condition, current work, problem situations and positions within the allotted space. Collected information is displayed in a user-friendly form, mainly in the form of graphics that visualize the conditions and positions of logistical resources. AGV MCS uses this information for decision-making and subsequent management of individual parts of the logistics process for these logistical resources. The user has the possibility to influence and modify the elements of decision-making process in real time, and control their activation/ deactivation. System records and collects all information, operations (e.g. automatic/manual), and setting changes for later analysis (e.g. errors) or use in optimizing the process. On the following picture AGV monitor 3D can be seen.

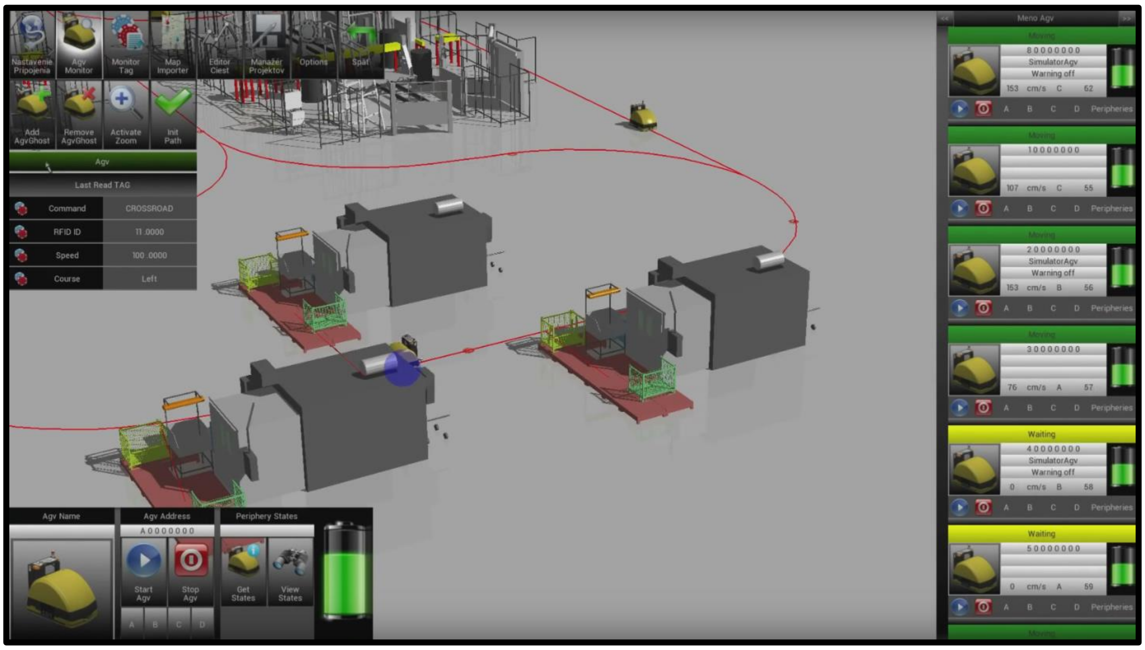

Figure 13. AGV monitor 3D

AGV monitor 3D provides an overview of activities, positions and events of AGV system in the production hall. AGV Monitor 3D is enhanced with 3D visualization of production hall with possibility to use a touch screen interface. Information can be shown in text, graphic or combined form. This information provides an overview of emerging events and their position in the production area, with the possibility of logging in real time. The added value is the possibility of mutual interaction between applications.

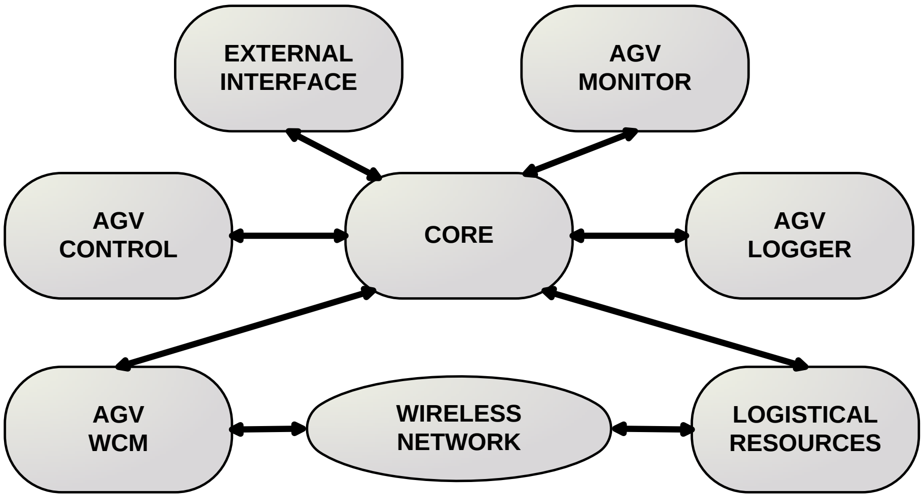

Figure 14. Structure of AGV Monitor & Control System

AGV Monitor & Control System is built on 6 main system modules (Fig.8.):

- Core - Central module, which connects the other modules.
- AGV Wireless Communication module - Communication between the Core and Wireless Network.
- AGV Monitor System - Monitoring and Supervision of Logistical Resources.
- AGV Control System - Automatic Control of AGV System Elements.
- AGV Logger - Records events and performed operations.
- External Interface - Provides communication with external applications.

CONCLUSION

Although many different software applications and modern technologies for the field of logistics exist, human with his knowledge is still the most important element for the successful design and planning of logistics systems. His early logistics analysis and optimal definition of supply chain is a key to the effective logistic processes. But using these technologies, companies can prevent unintended failure in case of improper design of material flows and verify their designs before it`s integration into reality. In the laboratory of Zilina Intelligent Manufacturing System (ZIMS), common workplace of University of Zilina and Central European Institute of Technologies (CEIT) we are implementing these existing software and developing new solutions for industry.

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GRAPH-BASED SOLUTION FOR PERFORMANCE EVALUATION OF SBS/RS

Banu Y. Ekren[65]

Abstract – The aim of this study is to provide a graph-based solution for performance evaluation of shuttle-based storage and retrieval system (SBS/RS) under various design concepts. By graph-based solution, it is aimed the decision maker (i.e., warehouse manager) to evaluate a pre-defined system's performance promptly and decide on which design concept to work with based on his/her requirements. The design concepts include number of bays (NoB), aisles (NoA), and tiers (NoT) for the rack design and arrival rate of storage/retrieval (S/R) transactions to an aisle of the warehouse (AR). The performance of the system is evaluated in terms of utilizations of lifts and average cycle time of S/R transactions. Simulation is utilized for the modeling purpose. Seven NoT, seven NoB and six AR scenarios are considered in the experiments. Hence, 294 experiments are completed to obtain the graphs. By this study, to the best of our knowledge it is the first time, a graph-based solution including comprehensive design concepts of SBS/RS is presented, where these graphes allow a user to evaluate thousands of alternative design scenarios of SBS/RS, promptly.

Keywords – Automated storage and retrieval system, SBS/RS, graph-based solution, simulation, automated warehouse

INTRODUCTION

Automated warehouse technologies are used by distribution companies to cope with high transaction throughput rate and so to meet customer expectations. Advances in automation technology have created a new technology in automated warehousing known as autonomous vehicle storage and retrieval system (AVS/RS). Warehouses using AVS/RS usually have high-bay area with a small footprint. AVS/RSs are typically used to process unit-load transactions (e.g., pallets, totes) whose main components are a fleet of autonomous vehicles (AVs), lift(s) and storage racks. AVs provide horizontal movement within a tier and travel between tiers using lifts. There are several design concepts of AVS/RS: AVS/RS with tier-captive AVs or tier-to-tier AVs, AVS/RS with aisle and tier captive AVs, etc. AVS/RS with tier and aisle captive AVs is mostly designed due to high transaction throughput requirement and is also known as shuttlle-based storage and retrieval system (SBS/RS) in the literature [1-5]. Although it seems a warehouse design concept of AVS/RS, SBS/RS is developed for small-sized transactions carried in small containers (i.e., totes).

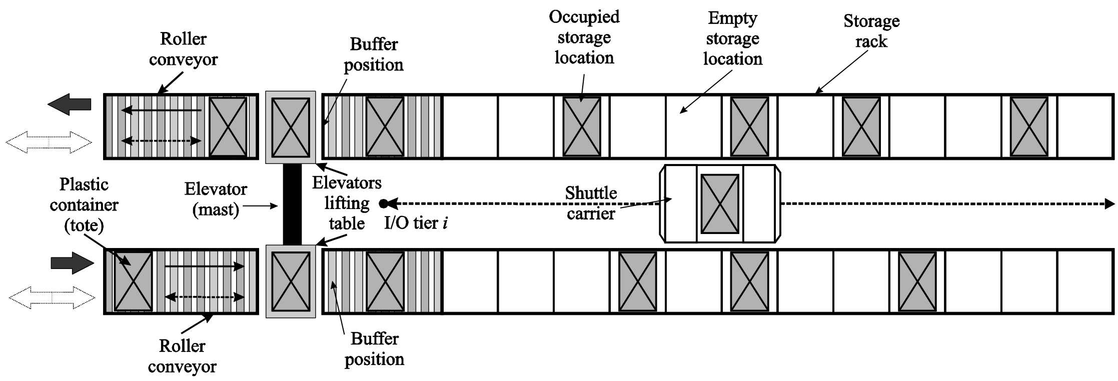

Figure 15. SBS/RS Top View

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Typically, an SBS/RS is comprised of multiple tiers of storage with dedicated shuttles for each level and dedicated lifts for each aisle (see Figure 1). Hence, loads are stored and removed from the shelves by SBS/RS at high speed, and the shuttle's load handling equipment is designed for short handover times. In this system lifts are usually bottleneck and they affect the throughput rate of the system, significantly. Hence, an alternative SBS/RS design with a lifting mechanism having two lifting tables is developed. In this design, the capacity of the lifts are doubled by the two lifting tables attached on both side of the lifting system. In this paper, an SBS/RS design with doubled capacitated lifting machanism is studied. The aim of this study is to provide a graph-based solution for performance evaluation of SBS/RS under various design concepts. By a graph-based solution, the decision maker will be able to evaluate the pre-defined system's performance and decide which design concept to work with promptly. The design concepts include number of bays (*NoB*), aisles (*NoA*), and tiers (*NoT*) for the rack design and arrival rate of storage/retrieval (S/R) transactions to an aisle of the warehouse (*AR*). The performance of the system is evaluated in terms of utilizations of lifts (*UL*) and average cycle time of transactions (*CT*). Simulation is utilized for the modeling purpose of the system and detailed in the following sections.

LITERATURE SURVEY

The earliest study on SBS/RS is completed by [1] where a type of SBS/RS with two non-passing lifting systems mounted along the rack is studied. In that study, the authors focused on scheduling problem where two (piece-wise linear) functions are introduced to evaluate candidate solutions.

An analytical model to estimate the performance (the transaction cycle time and waiting times) of SBS/RS is estimated by [2]. The model is based on an open queuing network approach. The model effectiveness in performance estimation is validated through simulation.

Later, in [3] Marchet et al. studied main design trade-offs for SBS/RS using simulation. They complete their study for several warehouse design scenarios for tier captive shuttles. They provide several performance measures from the pre-defined designs including cost.

Recently, Lerher [4] and Lerher et al, [5] have integrated energy efficiency concept into the model of SBS/RS. They consider energy regeneration and energy efficient models for SBS/RS. The proposed models enable reduction of energy consumption and consequently the CO_2 oscillation, which is vital from economic and environmental point of view.

None of the above studies include a graph-based solution and an extensive design concept for SBS/RS considering numerous *NoB*, *NoT*, *NoA* as well as *AR* scenarios. To the best of our knowledge, it is the first time AR is also considered as a design concept in SBS/RS. By the provided graphs, it is believed that the decision maker will be able to evaluate a pre-defined system's performance propmtly. Hence, he/she will be able to decide on the right SBS/RS design first, based on his/her requirement before investing on these systems. By that, the practitioner will also increase its operational efficiency and will save money. It is obvious that increased efficiency and decreased cost will also result with decreased energy consumption. Hence, this study will also contribute to environment.

It should be noted that the provided graphs summarize 294 experiments that are run in the simulation model. The performance of the system is evaluated in terms of utilization of lifts (*UL*) and average cycle time of S/R transactions (*CT*).

SIMULATION MODELING OF THE SBS/RS AND THE DESIGN SCENARIOS

The SBS/RS warehouse considered in the simulation model consists of racks, lifts, and shuttles. Shuttles are tier-captive and their main duty is to store and retrieve totes to/from the storage locations. Racks (on either side of an aisle) consist of bays, and each bay can hold one tote. Because each aisle of the studied SBS/RS is identical in terms of *NoT* and *NoB*, we simulate a single aisle. The lifts are located at the end of aisles and can carry two totes, independently. Transaction seizes the available lift based on the dual command (DC) scheduling rule. Each aisle has an I/O point. Hence, transactions arrive to pre-assigned aisle's I/O point. The other assumptions that are used in our simulation model are summarized below:

- Arrivals follow a Poisson process and the mean arrival rates for S/R transactions are equal ($\lambda_S = \lambda_R$) totes/hour.
- Pure random storage policy is considered.
- The time for loading and unloading the totes to/from shuttles/lifts are assumed to be 3 seconds each.
- The shuttles' and lifts' acceleration and deceleration delays are considered to be 2 m/sec^2.
- If the S/R transaction is located at the first tier then, lift is not used.
- The I/O location is located at the first tier of each aisle.
- There are two buffer positions at each tier where lifting tables discharge and charge the loads.
- The maximum velocities of shuttles and lifts are considered to be 2 m/sec.
- The length and the height of a bay is considered to be 0.5 m. and 0.3 m., respectively.

We consider the velocity of lifts and shuttles as well as the distance metrics of the warehouse from Lerher et al., (2013). The simulation model is completed using ARENA 14.0 a commercial simulation software and assumed to be a non-terminating system, allowing us to conduct a steady state analysis. The length of each simulation run is one year. The warm-up period is defined to be three months by the eye-ball technique. The model is run for 10 independent replications.

The verification of the simulation model is completed by debugging the model via the trace module in the simulation software. The validation of the model is completed by comparing our average travel time of lifts with the analytical model results in Lerher et al., (2013).

Design Scenarios

The simulation runs are completed based on seven *NoT* and *NoB* scenarios and, three *AR* scenarios. For the *NoT* and *NoB*, the levels are considered to be: 14, 15, 16 and 30, 35, 40, 45, 50, 55, 60, respectively. In SBS/RS lifts are mostly bottleneck and affect the system's throghput rate, significantly. Therefore, the *AR* levels are selected so that the utilization of lifts are obtained to be around 95%, 90%, 85%, 80%, 75%, 70%. The completed experiments and their results for *NoT* = 14 are provided in Table 1 as an example. For instance, in that table, the *AR* levels are considered to be 395, 375, 353, 333, 313 and 290 totes/hour that are providing the *UL* values around 95%, 90%, 85%, 80%, 75%, 70%, respectively. It should be noted that the *UL* and the *CT* values are the averages of ten replications and *CT* is measured in minute unit.

Table 10. Font Sizes and Type Styles

NoT	*NoB*	*AR*	*UL*	*CT (min)*
14	30	395	0.950	1.061
14	35	395	0.950	1.095
14	40	395	0.950	1.125
14	45	395	0.950	1.154
14	50	395	0.950	1.190
14	55	395	0.950	1.215
14	60	395	0.950	1.240
14	30	375	0.903	0.730
14	35	375	0.903	0.754

14	40	375	0.903	0.781
14	45	375	0.903	0.806
14	50	375	0.903	0.833
14	55	375	0.903	0.860
14	60	375	0.903	0.887
14	30	353	0.850	0.601
14	35	353	0.850	0.625
14	40	353	0.850	0.649
14	45	353	0.850	0.673
14	50	353	0.850	0.699
14	55	353	0.850	0.724
14	60	353	0.850	0.751
14	30	333	0.803	0.544
14	35	333	0.803	0.567
14	40	333	0.803	0.590
14	45	333	0.803	0.614
14	50	333	0.803	0.638
14	55	333	0.803	0.663
14	60	333	0.803	0.689
14	30	313	0.753	0.506
14	35	313	0.753	0.528
14	40	313	0.753	0.551
14	45	313	0.753	0.574
14	50	313	0.753	0.598
14	55	313	0.753	0.623
14	60	313	0.753	0.648
14	30	290	0.699	0.478
14	35	290	0.699	0.500
14	40	290	0.699	0.522
14	45	290	0.699	0.545
14	50	290	0.699	0.568
14	55	290	0.699	0.592
14	60	290	0.699	0.617

The completed 294 experiments are summarized via graphs and provided in Figures 2-5. Figure 2 illustrates *UL* versus *AR* graph based on tiers. Based on this graph, for instance if the company expects $\lambda_S = \lambda_R = 3400$ totes/hour arrival rate to the warehouse and the manager considers *NoA* = 10, then $\lambda_S = \lambda_R$ becomes 340 totes/hour per aisle (3400/10). And, if the manager prefers to work with 85% *UL* value, then using the Figure 3 graph, it is found that he/she should have 16 tiers in the warehouse. Another way of evaluating Figure 2 graph is that, the decision maker may want to check the *UL* values for different tier options when $\lambda_S = \lambda_R =$ 340 totes/hour per aisle. For instance, the *UL* value is around 91% when *NoT* = 20.

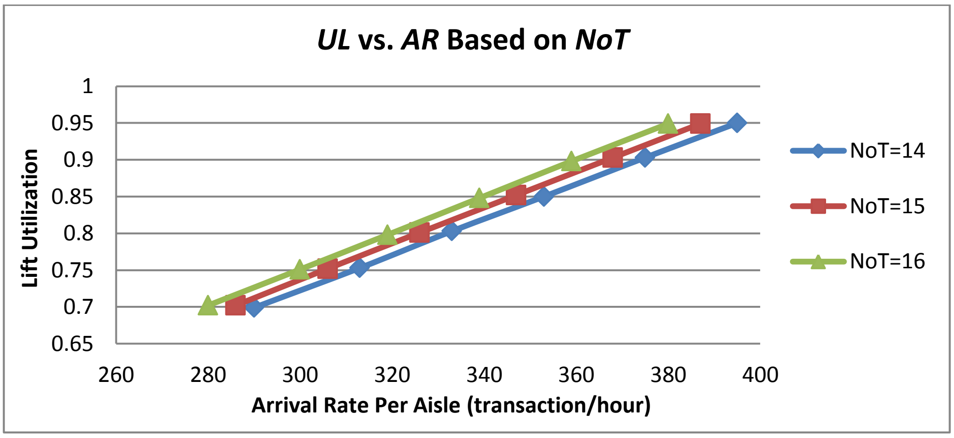

Figure 2. *AR* versus *UL* based on tiers

Although there are some other *NoT* options not simulated, one can estimate these *NoT* options' *UL* values by considering the trends of *UL* values in Figure 4. For instance for *NoT* = 21, it is most likely that the *UL* = 0.70 will be obtained at around 255 *AR* value. This is because from the figure it is observed that when the *NoT* is increased by one to obtain the *UL* = 0.70, around 5 number of items is increased.

Figure 3 shows *NoB* versus *CT* graphs when *NoT* = 14. It should be noted that the graphs in that figure illustrate the *CT* values, for each *UL* values – 0.70, 0.75, 0.80, 0.85, 0.90, 0.95 - separately. From this figure, we can obtain the average S/R transaction cycle time information for several *NoB* scenarios. By considering Figures 2-3, one can estimate the *UL* and the *CT* values for a pre-defined warehouse design or can determine the warehouse design for a pre-defined *UL* and *CT* values. As a summary, to estimate the *UL* and the *CT* values from a pre-defined SBS/RS warehouse design, one can follow the below four steps:

1- The decision maker estimates the S/R transaction arrival rate ($\lambda_S = \lambda_R \text{tote/hour}$) to the warehouse.
2- Based on the pre-defined *NoA*, he/she estimates the arrival rate to a single aisle (*AR*) by, λ_S/NoA.
3- Using Figure 2, *UL* is estimated based on the *AR* value calculated in the previous step, for a pre-defined *NoT* value. For instance, in the previous case when *AR* =340 and *NoT* = 14, *UL* becomes around 0.83.
4- After deciding on the *NoT* by Figure 2, the decision maker can estimate the *CT* value for different *NoB* scenarios. For instance, in the previous case when *AR* =340 and *NoT* = 14 (*UL* = 0.83), *CT* can be estimated as around 0.67 minute when *NoB* = 50, by Figure 3.

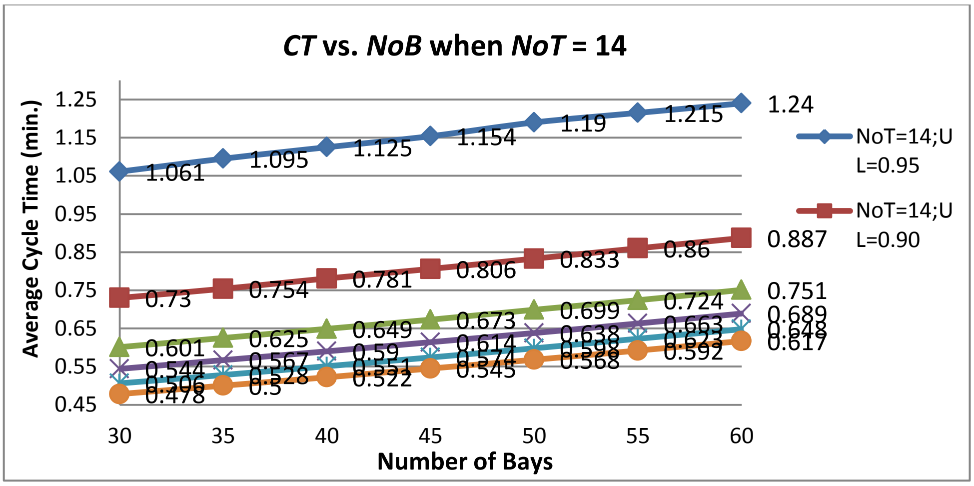

Figure 3. *CT* versus *NoB* and *UL* when *NoT* = 14

As in Figure 3, Figures 4-5 also represent *NoB* versus *CT* graphs when *NoT* = 15, 16, respectively. The *CTs* can be estimated for several *NoB* values by using those graphs after determining the *NoT*. For instance, when *AR* = 340 and *NoT* = 18, *CT* can be estimated around 0.72 min. (should be between 0.686 and 0.751) when *NoB* = 60.

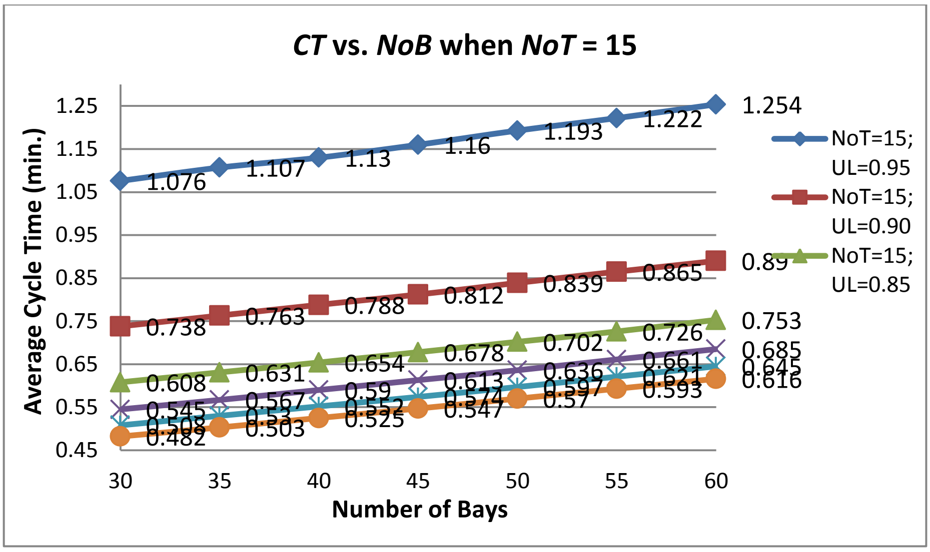

Figure 4. ***CT*** **versus** ***NoB*** **and** ***UL*** **when** ***NoT*** **= 15**

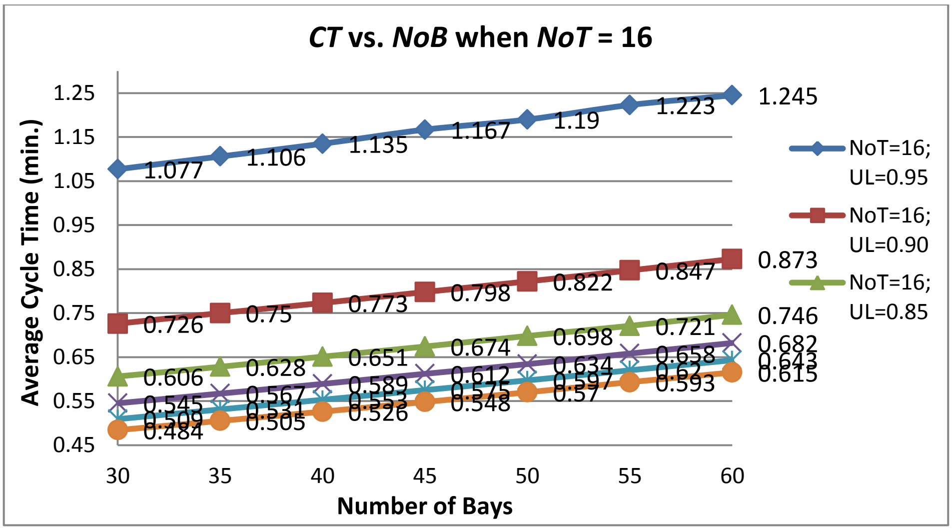

Figure 5. ***CT*** **versus** ***NoB*** **and** ***UL*** **when** ***NoT*** **= 16**

CONCLUSION

In this study, a graph-based solution for design of an SBS/RS is provided. Different from the existing studies an extensive design concept by considering several number of bays, tiers as well as arrival rate scenarios is provided via graphs. By graph-based solution, it is aimed the decision maker (i.e., warehouse manager) to evaluate a pre-defined system's performance promptly and decide on which design concept to work with based on his/her requirements. The provided graphs present thousands of design solutions for SBS/RS. The design concepts include number of bays, aisles and tiers for the rack design and arrival rate of S/R transactions to an aisle of the warehouse. The performance of the system is evaluated in terms of key performance measures: utilizations of lifts and average cycle time of S/R transactions. Simulation is utilized for the modeling purpose. Seven *NoT*, seven *NoB* and six *AR* scenarios are considered in the experiments. Hence, 294 experiments are completed to obtain the provided graphs. By this study, it is aimed that the practitioner will increase its operational efficiency and hence save money. By the increased efficiency and decreased cost, it is believed that this will also result with decreased energy consumption. Hence, this study will also contribute to environment.

This study can be extended in many directions. For instance, different velocity and acceleration/deceleration profiles for lifts and shuttles may also be considered in the design concept. In addition, different operating policies e.g. storage policies, scehduling rules, etc. may also be considered in the design options. Hence, the number of graphs may be increased for different design options and these graphs may be provided in a booklet to the practitioners.

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CALCULATING THE PROFITABILITY OF URBAN MASS TRANSPORT LINES USING ACTIVITY-BASED COSTING APPROACH: AN EVIDENCE FROM THE CZECH REPUBLIC

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Abstract − *The objective of this study is to present the analysis of the individual lines profitability in an urban mass transport company which operates the land public transport via buses and trolleys inside the city using Activity-Based Costing method. The Activity-Based Costing approach had been applied, in order to calculate the more accurate costs of individual operations to measure the profitability of particular transport lines. The performed study showed the possible effects of the Activity-Based Costing application for an urban mass transport company as well as the limitations of the method use in the field of service industry. Final part of the study analyses the problems related to data acquiring and processing in urban mass transport company.*
As far as different ABC applications, the primary limitation of the analysis accuracy is the quality of the non-financial information necessary for the analysis. Study analyses also limitations related to the used fare system which does not allow the identification of the route taken by individual passenger. The study presents the possible utilization of the ABC in the urban mass transport provider and shows a real company example of information outputs of ABC system.

Keywords − *Activity-Based Costing, urban mass transport, profitability, overhead cost allocation.*

INTRODUCTION

Analysis of the decentralized business unit profitability is one of the crucial roles of management accounting [4], [6]. The objective of the analysis is to support managers of an organization by providing data for the decision-making process; to provide accurate information on the profit generated by the individual segments of the business is highly crucial. Recent decades we can observe a rise in the application of various managerial techniques in different kind of service organizations. They often rely on profitability analyses, performance measurement or accurate costing techniques in order to inform decision-making, increase profitability and heighten the cost efficiency of the various activities conducted.

One of the greatest difficulties experienced by such an establishment when measuring profitability is the ability to perform accurate cost assignment using a proper cost calculation or costing technique. Traditionally used costing methods are often criticized for the inaccuracy a many limitations. Those shortages or limitations had been very closely described in the scientific publications [4], [12]. It is widely known that traditional costing methods have caused distortions in indirect costs, and accounting reports normally do not provide for management interpretation and actions determining the control of deviations related to specific problems. Strong criticism of the traditional costing concept was voiced by Kaplan and Johnson [12]. Even so, traditional costing methods are still frequently used in practice, mostly because of their simplicity and minimal data input requirements. The limitations of such traditional costing methods could prove more crucial when applying costing systems in service organizations. Rotch [16] defined several reasons why cost allocation and implementing a costing system in a service organization might turn out to be more complicated.

The problems associated with traditional costing methods resulted in the creation of Activity-Based Costing (ABC), first presented by Kaplan and Johnson [12], which allocate the overhead cost of organization to the

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products via defined structure of activities. ABC brought with it important benefits in the accuracy of cost allocation, as well as facilitating measurement of the outputs of organizational activities. Important difference between traditional costing and ABC is that overhead costs are not allocated using an inaccurate allocation base, but through the activities actually performed within an organization.

In general, ABC is based on the concept that performing a service consumes activities that in turn consume resources [8]. According to Wodchis [20], traditional costing techniques allocate costs to all units based on an average unit cost, or they pool indirect costs and allocate them to services, this in proportion to the volume of services or direct costs. Andrade [1] states that ABC more precisely reflects the costs of operations in a company; doing so in a more consistent manner than traditional methods. Therefore, it comes as no surprise that it has proven increasingly popular as an alternative to traditional costing. The biggest disadvantage presented in many studies is that traditional methods of cost accounting could over- or underestimate the costs of services, as overhead costs could vary with the complexity of delivering services and not due to the volume of services. [12], [14].

Implementing an advanced costing system, such as ABC, results in collecting accurate data on profitability or facilitates precise analysis for covering the costs of the cost objects analyzed, such as the transport lines in the case of urban mass transport company. Early applications of the Activity-Based Costing approach in the industry sector [11], [7] have been followed by many applications in the service [18], logistics [2] [5], healthcare [19] and other specific areas. But the direct application of ABC to urban mass transport companies is not a frequent case in the literature.

Although using ABC brings many advantages from the viewpoint of management, the implementation of ABC to a service organization, especially to urban mass transport, poses several challenges which do not generally exist for ABC applications in manufacturing. There are several reasons for this challenge of the ABC implementation which was defined by Rotch [16] for a logistic company, but which could be accepted also for application in urban mass transportation: Output is harder to define; In many cases determining activities and cost drivers is not straightforward; Data collection and measurements is more complicated than manufacturing; Activity in response to service requests may be less predictable. Joint capacity represents a high portion of total cost and is difficult to link output related activities.

Urban mass transport could be considered as the very specific filed for application of sophisticated costing methods and performing the effective profitability analysis. One of the important issues that limit the application of modern costing system is the fact that urban mass transport companies usually do not operate in fully competitive environment. Companies operating the urban mass transit usually provide their services in a highly regulated environment. De Borger et al. [3] point at that government intervention in the sector is widespread and has traditionally been justified by reference to a series of market failures. In the past two decades, however, concerns about possible regulatory failures have led to a reassessment of the role of the state in the organization in the sector.

One of the primary objectives of every service provider is to achieve the efficiency of the existing operations. Elementary efficiency in the operations could be generally measured by the quantity of the output and the inputs consumed, which could be quantified as the company costs [4] [13], in other words, when production proceeds at the lowest possible per-unit cost.

Efficiency and profitability analysis in the conditions of urban mass transport companies are, despite these simple relations, restricted for several reasons. Firstly, the companies which operate the urban mass transport usually work with a very complicated structure of customers, lines, services and other cost objects. Secondly, the fare technology usually does not allow obtaining the information about the passenger behavior, which means that the company is unable to get the information about the specific route taken by individual passenger. And thirdly, the above described government and municipality intervention in a non-competitive field usually causes the inability of management of urban mass transport companies to apply any progressive programs to reduce the costs or increase the effectiveness of existing operations.

METHODS

Objective of the study was to analyze the profitability of the individual public transport bus and trolleybus lines within the city of Zlín. Within the analysis it was necessary to accurately assign the cost and revenues to the individual operated lines. The company operating the land urban mass transport by means of busses and trolleybuses within the territory of Zlín (population 100 000) was chosen for carrying out this case study. The reason why this company was chosen is the fact that the company started dealing with more accurate cost allocation based on the ABC techniques.

The company operates 13 trolleybus lines, 11 bus lines, and cooperates with the national provider of the passenger rail transport. Besides the major transport services, the company also provides other additional services: an advertising agency and repair services for trolleybuses. The company owns 65 trolleybuses and 45 busses.

The following table presents the basic information about the company performance in years 2008 – 2010. The financial data are transformed from CZK currency in fixed exchange rate of 25 CZK per EURO. Income from the transportation service is calculated as the sum of all types of fare including the time coupons. The number of passengers was calculated as the sum of individual fares sold and estimated volume of 4 rides a day per time coupons. Data from the fiscal year 2010 had been used in the profitability measurement.

Tab. 1– Characteristics of Zlín urban transport company.

	2008	2009	2010
Total Income	€ 10 129 249	€ 10 827 942	€ 11 169 016
Transport services income	€ 4 633 981	€ 4 394 259	€ 4 361 783
Municipal subsidies	€ 3 723 200	€ 3 865 139	€ 3 860 102
Other subsidies	€ 185 359	€ 175 770	€ 174 471
Total Costs	€ 10 683 275	€ 10 699 588	€ 11 247 914
Profit	-€ 554 026	€ 128 354	-€ 78 817
Number of passangers	37 334 050	35 934 000	35 314 000

Source: Company financial statements

As the table shows, the trend in number of passengers and income from transportation services is declining. This confirms the De Boer´s [3] proposition about the declining trends in transport demand in most industrial economies. Hajek and Siwek [9] also researched the passenger behavior in the Zlín region and conclude the growing passenger preference for individual means of transport. Table 1 also illustrates quite a large portion of municipal subsidies for the company. The fare revenues cover only 45% of the cost of transportation services. This portion is quite standard in conditions of the Czech Republic in other similar public transport operators. Values differ from 46% in Ústí nad Labem to 29% in České Budějovice [17]. This situation matches the situation in developed economies. Pucher et al. [15] features that the passengers fare covered only 42% of transit operating costs in the U.S. in the 1980´s compared to 99% in 1965 and 86% in 1970.

Drury´s elementary methodology has been used for the calculation of the cost using Activity-Based Costing approach, with additional consulting of other sources [7].

1. Identifying the major activities taking place in an organization
2. Assigning costs to cost pools/cost centers for each activity

3. Determining the cost driver for every activity
4. Assigning the costs of activities to products according to their individual demands on activities

The calculation of the operation costs of vehicles per kilometer was not sufficient for considering the individual costs objects, defined as individual lines. For those purposes the costs and revenues of individual bus and trolleybus lines had to be estimated. The costs of the lines could be quantified based on the kilometer length of the line and the operation frequency. The revenue estimation was much more complicated because the used system of fare disallows the identification of individual passenger and route which he takes. One of the existing information inputs of the project was the observation research of passenger quantities in individual lines, which was conducted in 2008. In this research, the number of passengers in individual lines was determined. The research output was then used for allocation of revenues for individual lines.

RESULTS

The first step of cost calculation via ABC approach was to define the appropriate structure of activities. Four major processes were defined within the organization: mass transport services, advertising services, external and supplemental services and the support process. All processes were than disarticulated into several activities. Table 2 display the activities defined within the model. The numerical codes were also assigned to individual activities in order to facilitate the work with activities. The objective of this step was to keep the lowest possible number of activities in order to simplify the work with the data. Finally 11 primary and 4 secondary activities had been defined within the model. Such structure of the ABC model is relatively simple. Some of the activities (201, 301, 302) were defined in the way that matches the future cost object for the purpose to simplify the allocation of the activity costs to cost objects.

Tab. 2– Processes and activities defined within the model. Source: authors

Process: 100 - Mass transport operation	
101	Administration and support of the mass transit
102	Tickets sale and distribution
103	Daily service and cleaning of vehicles
104	Operation of vehicles
105	Ticket inspection
191	Traffic network maintenance
192	Repair of vehicles
Process: 200 - Advertising and promotional services	
201	Advertising and promotional services
Process: 300 - External and supplemental services	
301	External repairs
302	Charter services
303	Other external services
Process 900 – Secondary activities	
901	Management and infrastructure
902	Building maintenance
903	Accounting and finance
904	IS/IT

Source: Authors

The second step within the cost calculation process was to assign the costs to defined activities. According to the relatively simple structure of activities, the assignment of costs to those activities was in some cases relatively easy, because the whole cost centers could be assigned to the activities. Table 3 demonstrates the total sum of costs which were assigned to individual activities.

Tab. 3 – List of activities and assigned primary activity costs. Source: authors

Process	Activitiy		Activity cost
100	**Mass transport services**		**€ 9 445 095**
	101	Administration and support of the MT	€ 413 676
	102	Tickets sale and distribution	€ 288 334
	103	Daily service and cleaning of vehicles	€ 613 451
	104	Operation of vehicles	€ 5 548 458
	105	Ticket inspection	€ 484 825
	191	Traffic network maintananace	€ 483 027
	192	Repair of vehicles	€ 1 613 323
200	**Advertising services**		**€ 112 648**
	201	Advertising and promotional services	€ 112 648
300	**External and supplemental services**		**€ 809 001**
	301	External repairs	€ 575 254
	302	Charter services	€ 23 987
	303	Other external services	€ 209 761
900	**Support activities**		**€ 877 723**
	901	Management and infrastructure	€ 307 659
	902	Building maintenance	€ 345 594
	903	Accounting and finance	€ 159 019
	904	IS/IT	€ 65 451

Source: Authors

In following step the cost driver for every activity had to be determined. In most cases the intensity drivers (direct allocation) were used for the allocation of activity costs to individual cost objects. Table 4 indicates the cost drivers used for the allocation of activity costs to cost objects. No specific relations and cost allocations were defined within the mass transport services (process 100). Even if the more accurate cost drivers could be identified, finally, the simple cost driver – the number of total kilometers of all vehicles was selected as the general cost driver for most of the activities. Only activities where the different cost drivers were defined are traffic network maintenance, which is performed only in connection with trolleybus transport, and the ticket inspection, which was measured individually. For the traffic network maintenance, the total number of trolleybus kilometers was chosen as the cost driver. After the definition of the cost drivers the output measure of the individual activities had to be determined. Output measure quantifies the number of cost drivers consumed in specific time period. After the determination of output measures, the primary rates of the activities could be calculated as the total activity costs divided by determined output measures.

Tab. 4 – List of activity cost drivers, output measures and primary rates of activities. Source: Authors

Activitiy	Total activity costs	Cost driver	Output measure	Primary rate
101	€ 413 676	number of total km of all vehicles	4814970	€ 0,086
102	€ 288 334	number of total km of all vehicles	4814970	€ 0,060
103	€ 613 451	number of total km of all vehicles	4814970	€ 0,127
104	€ 5 548 458	number of total km of all vehicles	4814970	€ 1,152
105	€ 484 825	direct alloacation	N/A	
191	€ 483 027	number of total km of trolley-buses	3131373	€ 0,154
192	€ 1 613 323	number of total km of all vehicles	4814970	€ 0,335
201	€ 112 648	direct allocation	N/A	
301	€ 575 254	number of hours	30250	€ 19,017
302	€ 23 987	number of km	11250	€ 2,132
303	€ 209 761	direct alloacation	N/A	
901	€ 307 659	primary activity costs	259 168 603	€ 0,001
902	€ 345 594	square meters	19 810,98	€ 17,445
903	€ 159 019	account entries	7608	€ 20,901
904	€ 65 451	number of computers	70,00	€ 935,013

Source: Authors

The following step of the ABC system implementation was to allocate the costs of secondary activities to defined primary activities. This step is a usual part of all ABC systems, while the secondary activities cannot be directly traced to the cost objects. They can only be assigned to the primary activities, which consume their outputs [15]. Defined cost drivers were used for the allocation of those secondary activity costs. Table 5 shows the recalculated primary activity costs after the allocation of secondary activities. The combined rate is calculated as the sum of primary rates and secondary rates. The secondary rate represents the consumption of secondary activity costs by unit of primary activity.

Tab. 5 – Total activity costs after allocation of secondary activity costs. Source: authors

Activitiy	Total activity costs	Output measure	Secondary rate
101	€ 468 165	4814970	€ 0,097
102	€ 330 263	4814970	€ 0,069
103	€ 702 381	4814970	€ 0,146
104	€ 5 784 352	4814970	€ 1,201
105	€ 506 927	N/A	
191	€ 550 412	3131373	€ 0,176
192	€ 1 857 383	4814970	€ 0,386
201	€ 126 139	N/A	
301	€ 639 388	30250	€ 21,137
302	€ 38 005	11250	€ 3,378
303	€ 241 052	N/A	

Source: Authors

After the performing of all necessary steps the calculation of the profitability of individual operated lines could be performed.. The first output of the model was the cost calculations of the individual cost objects, in this case the mileage costs per kilometer travelled by vehicle. These costs could be easily quantified as the sum of combined rates of activities, which are used for the performance of urban mass transport. This means activities 101, 102, 103, 104 and 192 for buses and activities 101, 102, 103, 104, 191 and 192 for trolley busses. The sum of costs per km is then € 1.9 for busses and € 2.07 for trolley busses. In comparison, the km cost for charter services is € 3.38.

The calculation of the operation costs of vehicles per kilometer was not sufficient for considering the individual costs objects, defined as individual lines. The costs of the lines could be quantified based on the kilometer length of the line and the operation frequency. The revenue estimation was based on the field analysis of passenger quantities in individual lines, which was conducted in 2008. In this study, the number of passengers in individual lines was determined based on this performed analysis. The research output was then used for allocation of revenues for individual lines.

Tab. 6 - Bus and trolleybus lines profitability. Source: authors

	line	% passengers	recalculated revenues	% km	Line cost	Profit	Protitability	cost coverage
trolleybus	1	0,78%	€ 69 851	1,03%	€ 105 078	-€ 35 227	-50,43%	66,48%
trolleybus	2	17,22%	€ 1 539 329	15,44%	€ 1 574 937	-€ 35 608	-2,31%	97,74%
trolleybus	3	2,60%	€ 232 560	2,22%	€ 226 088	€ 6 471	2,78%	102,86%
trolleybus	4	5,96%	€ 533 301	5,27%	€ 537 690	-€ 4 388	-0,82%	99,18%
trolleybus	6	15,90%	€ 1 421 519	13,50%	€ 1 376 524	€ 44 994	3,17%	103,27%
trolleybus	8	9,91%	€ 886 362	7,76%	€ 791 678	€ 94 684	10,68%	111,96%
trolleybus	9	7,74%	€ 692 114	6,33%	€ 645 357	€ 46 757	6,76%	107,25%
trolleybus	10	4,56%	€ 408 070	5,33%	€ 544 055	-€ 135 986	-33,32%	75,01%
trolleybus	11	4,11%	€ 367 346	4,60%	€ 469 143	-€ 101 797	-27,71%	78,30%
trolleybus	12	1,21%	€ 108 163	1,55%	€ 158 415	-€ 50 252	-46,46%	68,28%
trolleybus	13	2,79%	€ 249 350	2,05%	€ 209 420	€ 39 930	16,01%	119,07%
trolleybus	14	1,47%	€ 131 076	1,52%	€ 155 083	-€ 24 007	-18,32%	84,52%
bus	31	3,42%	€ 305 936	4,48%	€ 456 710	-€ 150 773	-49,28%	66,99%
bus	32	2,58%	€ 230 241	4,04%	€ 412 493	-€ 182 253	-79,16%	55,82%
bus	33	5,08%	€ 454 545	5,87%	€ 598 615	-€ 144 070	-31,70%	75,93%
bus	34	1,57%	€ 140 445	1,63%	€ 166 590	-€ 26 145	-18,62%	84,31%
bus	35	0,89%	€ 79 963	1,29%	€ 131 083	-€ 51 120	-63,93%	61,00%
bus	36	1,49%	€ 133 302	2,87%	€ 293 229	-€ 159 927	-119,97%	45,46%
bus	51	0,24%	€ 21 057	0,69%	€ 70 475	-€ 49 417	-234,68%	29,88%
bus	53	0,34%	€ 30 612	0,53%	€ 54 421	-€ 23 809	-77,78%	56,25%
bus	55	7,59%	€ 678 292	7,71%	€ 786 373	-€ 108 081	-15,93%	86,26%
bus	58	0,78%	€ 69 666	0,80%	€ 81 175	-€ 11 509	-16,52%	85,82%
bus	70	1,77%	€ 158 163	3,48%	€ 355 249	-€ 197 086	-124,61%	44,52%
	total	100,00%	**€ 8 941 264**	100,00%	**€ 10 199 883**			

Source: Authors

Table 6 illustrates the calculation of profit and profitability of individual bus and trolleybus lines. Column “revenues/costs” shows the percentage of the cost covered by the revenues. As we can see, only 5 lines out of 23 are able to cover its costs by the revenues. Municipal subsidies are included in the line revenues.

DISCUSSION AND CONCLUSION

Performing the profitability analysis of the urban mass transport lines using Activity-Based approach bring number of specifics in comparison with traditional analysis in manufacturing industry. The major difference consists in the specific structure of the cost objects, i.e. the individual operated lines in our case which is different from traditional cost objects such as individual products in case of manufacturing organizations. Despite the many problems that go with the application process, the ABC model is able to offer different view on the cost of activities and products inside the company. The ABC analysis, which we presented in this study, is relatively simple and does not apply to all ABC features, but could be accepted as the model example of further research in the field.

Utilization of the ABC in urban mass transport operator brought a lot of specifics. According to the municipal subsidies, the company couldn't be managed as the organization which is oriented to the profit creation. Company receives the municipal subsidies in order to operate the specific routes. Profit generated by the individual operated routes, which have been calculated in the study, then could not be used for the elimination of the unprofitable routes. ABC in this situation could show the way how to reduce the loss generated by the less profitable routes or determine the impact of the different routes structure.

Study also showed the level of profitability of individual processes of the company. This information is not new, because the existing cost center structure of the company, used before the ABC application allows the profit measurement. On the other hand ABC brings more accurate way of support activity costs allocation. The many authors see the application of Activity-based costing method in service organization as the more usable, than in manufacturing industry. As mentioned above, the service organizations along with the urban mass transport providers face the many problems via application of effective costing system. Every additional piece of information which is provided by costing system could improve the quality of decision making and may lead into increase of performance and profitability of such organization.

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COST BEHAVIOR AND COST MANAGEMENT RESEARCH IN INDUSTRIAL ENTERPRISES IN CZECH REPUBLIC WITH EMPHASIS ON COST VARIABILITY

Petr Novák[68], *Boris Popesko*[69]

Abstract – This paper presents results of the quantitative research focused on cost behavior, cost variability and cost management systems.The main goal is to analyze and to introduce the principal findings resulting from the research of the level of cost management as well as for understanding various types of cost behavior in manufacturing enterprises in the Czech Republic.The first part of the paper analyses present theories regarding approaches to cost management with the emphasis on overhead cost management, general and asymmetric cost behavior in industrial enterprises.In the next part, procedure as well as methodology of research is presented. Hypotheses that are the base for the analysis of particular areas within the cost management are also presented in this part.The third part presents research results themselves that were also verified by a statistical check-up of dependence relations. Rather significant drawbacks and reserves of manufacturing enterprises in their overhead cost management mainly were found out. These results are then discussed in the final part of the paper in response to the analysis of relational indicators in the industrial enterprises in the short term with explanation of the cost remanence in the manufacturing process of industrial enterprise. Results of cost remanence should be given to maximum attention to the company and chiefly in the managerial control of the company and it is necessary to identify ways how to eliminate or minimize growth-inducing activity of variable costs.

Keywords – cost behavior, cost variability, cost system, asymmetric cost behavior, overhead cost management

INTRODUCTION AND THEORETICAL BACKGROUND

Area of the cost management is one of the most important areas of company performance and company financial management. We can constantly monitor increasing importance of cost management quality that is caused by significant changes in business climate. Companies need the more detailed and accurate information about the profitability of their products, customers or markets due to growing competition on globalized markets. It carries higher need for understanding of the costs spend by different activities and other different areas where the costs play the important role. These changes in the business environment are associated also with the changes of structure and organization of company activities and structure of products. Then the ability to analyze company costs is one of the most important premises of the effective cost management and it is also one of the most important area of company performance. The most important feature of the cost analysis is cost classification when costs are classified into defined categories according to the particular characteristics. Another key area of cost management aimed mainly to predictions of future costs is then also a detailed analysis of the cost behavior.

Knowing how costs change as activity output changes is an essential part of planning, controlling, and decision making [13]. Ways to proceed with the assessment of costs and their analysis are numerous. In traditional models of cost behavior which appears in literature, costs are described as fixed or variable with respect to changes in volume production. In this model, variable costs change proportionately with changes in the volume of production [10], [13], [16], [25], implying that the magnitude of a change in costs depends only on the extent of a change in the level of production, not on the direction of the change. But some allege costs rise more with increases in activity volume than they fall with decreases [1], [6], [9], [17], [23]. In fact, not knowing and understanding cost behavior can lead to poor and even disastrous decisions. And this is the

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reason why we constantly talk about the variability of costs and how they translate into costing systems and hence the price of the product.

The main goal of this paper is to present results of the pre-test of the quantitative research done within the research project called “Variability of cost groups and its projection in the costing system in manufacturing enterprises”. **The partial goal** is to analyse current situation regarding cost management in practice within manufacturing enterprises in the Czech Republic. **The attention is paid** to particular results of the questionnaire survey with the emphasis on overhead cost management in manufacturing enterprises as well as perception of potential asymmetric cost behavior. The analysis of management approaches regarding overhead costs mainly, and their dependence on particular factors will be made.

Financial and management accounting in different countries usually offers different approaches to cost classification. Financial accounting uses the cost classification on financial statements [11]. This classification assorts natural types of costs based on a type of the consumed input. E.g. Drury states the main division into direct and indirect costs [10]. Among the direct costs then classified primarily direct materials and direct labor as represent those which could be easily and accurately identified with a particular cost object. Indirect costs then cannot be identified specifically and exclusively with a given cost object. [10], [12].

Another division is according to the cost behavior to the variable costs, fixed costs, semi-variable or semi-fixed costs. e.g. [10], [13], [15]-[16], [22], [25]-[26] etc. In connection with this issue Hansen adds, that then cost assignment is one of the key processes of the cost accounting system [13]. And just the correct identification of variability in each cost groups due to production is the key to the exact allocation. It is necessary to realize that costs need to be split to variable (links to load capacity) and fixed (independent to load capacity). How Popesko [19] says, in practice it is really necessary to distinguish these sets of costs. We can distinguish for example costs united with dose and its level, which are going to be change in addiction at quantity of doses, but stays fixed in link to individually produced units or products. Next possibility is to distinguish costs related to group of products or services. These costs are independent of made products quantity of certain type, but they have tend to grow in case of product type number produced by company grows. We could continue in this enumeration of variability, for example through costs, theirs formation is induced by specific customers and individual attitude to them (e.g. in marketing, support of customers etc.).

Many authors have stressed the need for exploring the cost behavior, depending on various factors in this current turbulent period of economic fluctuations and instability of production. For example Weiss [24] has examined the effect of sticky cost behavior in estimating analysts’ earnings forecast and how the earnings forecast can affect the market responses in any surprise earnings announcements. Similar research performed also Banker and Byzalov [5] when examined the sticky cost behavior by using a global Compustat data from 20 countries, to see whether the sticky cost is a global phenomenon or it is more pronounced in the US only. They have tested 5 hypotheses to analyze the cost behavior of firms along with managers’ optimism and pessimism about the future economic outcomes.

From earlier performed (and published) researches then based on Shust and Weiss [20] when examined the sticky costs behavior between reported operating expenses in the annual report versus the operating expenses paid in cash by analyzing three models given by Banker and Byzalov [5] (According to Anderson, Banker and Janakiraman specification (ABJ) [2], the liner ABJ model given by Balakrishnan et al. and Weiss firm specific nature of stickiness [4], [24]). They argue that, financial reporting choices of operating costs induces stickiness, more than the costs paid in cash, which is noted as economic costs.

Cost stickiness becomes a phenomenon of present time. Yasukata and Kajiwara [21] found out from their researches, that, the difference in cost stickiness even larger when managers are more optimistic about the future sales even when sales decline, hence keeping the slack resources for future uses. When analyzing the individual stickiness between selling, general and administrative (hereafter, SG&A) costs and cost of goods sold (hereafter, COGS), they find that, SG&A costs are stickier than the COGS costs. In this case, managers are reluctant to cut the administrative costs or any downsizing costs of selling personnel with an expectation that they need to higher again the selling personnel when sales restore.

In connection with this issue Chen etc. [7]-[8] found out, that SG&A costs increased by 0.80 % if sales increased by 1%, whereas SG&A costs decreased by 0.74% per 1% decrease in sales where the manger is less confident and further decrease by 0.61% where the manager is overconfident. Thus, the result is showing that, overconfident manager is less willing to cute resources when sales reduce due to his perceives believe that sales will increase in the near future. They differentiated the sticky cost behavior beyond the managerial agency theory and economic behavior of the cost accounting. Authors argue that, in an agency theory, stickiness cost behavior arises due to opportunity seeking behavior of the managers. However, overconfident manger is not looking for any personal benefits, however he is driven by his self-stream about the positive future outcome, and that is why he is keeping the unutilized resources to increase the value of the firm in future.

All these (and many other) studies clearly demonstrate the need for such exploration, comparison and verification of this issue also in terms of manufacturing firms in the Czech Republic.

METHODOLOGY

In accordance with the goals of this paper, the partial research results are also presented. This quantitative research was done as a pre-test of the complex quantitative research focused on the issue of cost management in manufacturing enterprises. This is done from their variability cost perspective as well as taking into account costs in particular cost and calculating systems within the enterprises.

The questionnaire was divided into 4 basic areas that fulfil the goals and hypotheses of this research project with one additional part. These are following:

- General information about the enterprise – the emphasis on the size of it, ownership and type of production
- General information about the costs – structure of the costs according to their classification, the attention paid to the costs (frequency of their monitoring and evaluation, what types of costs are monitored in more detail, etc.)
- Costs and calculations (the emphasis on overhead costs) – what types of calculations are made, how the overhead costs are reflected in calculation formulas, how the overhead costs are matched with an expense item, and so on.
- The area of cost variability – whether the enterprises have knowledge and consider the fact that costs do not have to be dependent on production capacity only, how they work with overhead costs in relation to various factors (number of customers, production batches, orders, etc.), the approach to semi-fix or semi-variable cost management
- Additional information – information environment, methods regarding cost processing, and so on.

For this quantitative research, the firm´s range of exploration was bounded in the manufacturing industry CZ – NACE from 10.10 to 33.20. There were addressed 200 randomly chosen firms. It managed to find out 57 respondents of these firms, which is a 30 % return rate. The results obtained from the questionnaires were evaluated by relative frequency and the hypotheses were tested using χ2 Tests (Goodness of Fit Tests and Contingency Tables) for determination dependence between categorical variables. The null hypothesis is that the actual distribution can in fact be represented by the theoretical distribution, and that the discrepancies between them are due to chance.

We compute test statistic [14]

$$\chi^2 = \sum_{i=1}^{k} \frac{(n_i - n\pi_{0,i})^2}{n\pi_{0,i}} \tag{1}$$

where n_i are observed sample frequencies and $n\pi_{0,i}$ are theoretical (expected) frequencies in the i-th group. χ2 has (if n is large enough) a χ2 distribution with (k − 1) degrees of freedom (df).

Decision rule: we reject the null hypothesis if

$$\chi 2 \geq \chi 21 - \alpha \text{ (k} - 1) \qquad (2)$$

otherwise we do not reject it. The measure of dependence is the Pearson´s contingency coefficient:

$$P = \sqrt{\frac{\chi^2}{\chi^2 + n}}; \quad P \in \langle 0;1) \qquad (3)$$

The level of infallibility was defined on 0.05, which means that the hypothesis of independence of two variables can be rejected if the calculated p-value will be lower than this level defined. In such case, it is possible to consider the statistical dependence of two variables. Despite the total number of respondents, which is not too high and the results can be rather distorted for this reason, it is possible to make certain conclusion regarding this pre-test. This pre-test based on questionnaires also verified the relevance of questions in connection with the companies studied. Having the test corrected shall enable us to do a standard research when 150 respondents are expected to take part in. This sample should be sufficient enough to generalize particular findings.

Based on the project goals, the following **hypotheses** were stated regarding this part of result evaluation:

- *H1: There is a statistically significant dependence between the company size and the attention that is paid to manage its fixed costs.* In this hypothesis, the author assumes that with the growing size of the companies will be paid more attention to fixed (overhead) costs because of their higher cost volume and more difficult activity and cost structure.
- *H2: There is a statistically significant dependence between the company size and considering the cost variability evaluation according to other quantity than production capacity.* In this hypothesis, it is again assumed that larger companies will use more sophisticated tools to cost management and will consider more factors than just the cost dependency on the standard factor **-** volume of production.
- *H3: Medium and large enterprises concentrate more on the development of overhead costs than small enterprises.* This hypothesis builds on the previous two.
- *H4: In fact, there are certain groups of costs that are increasing when the production capacity is getting higher. However, when the capacity is getting lower, these are to stay on the same level. Such costs do not decrease again. This does not depend on the company size, type of production or the ownership structure.* Using this hypothesis, the author wants to **verify whether the companies recognize the existence of asymmetric costs, which are called as sticky Costs.** It could occurs mainly in cost groups as (e.g.):

    - *machine cost – emergency repair* in connection with use of tangible long-lived assets,
    - *costs of transport* in connection with supply of production process (cost of logistics),
    - *costs of warehouse rent* in connection with providing of storage space,
    - *costs of external transport* in connection with the process of products distribution etc.

RESULTS

In this part, some results of the research will be introduced. First, regarding the goals and hypotheses, it was essential to evaluate enterprises from the following perspectives – their size, ownership structure and type of production.

Table 1 illustrates the structure of respondents regarding their size. It was carried out on the basis of Commission Regulation (ES) no. 800/2008 and the most important criterion was the number of employees. It is evident that the highest number (about 77 % of companies) belong to the segment of small and medium enterprises (SME) with
1 – 249 employees. About 37 % of the companies can be then classified as small enterprises with 10 – 49

employees. There was not one respondent of the micro-enterprise segment. About ca. one quarter of companies could be classified as large enterprises with over than 250 employees.

Table 1. Structure of companies by size (number of employees)

Number of employees	Freq.	%
10 - 49	21	37%
50 - 249	23	40%
250 - 499	5	9%
500 +	8	14%

The aspect of company ownership was also studied as there are other various dependences that can occur. When the companies are owned by a domestic or foreign proprietor may seem as important aspect. Regarding this one, about 75 % of respondents were owned by a domestic proprietor, 19 % of companies were owned by a foreign proprietor, and there was a joint ownership of both domestic as well as foreign proprietors in case of 5 % of companies.

As an important seems to be also type of production for the purpose of further conclusions and research. It is possible to search for connection between cost behavior and particular types of products. The table below shows this feature.

Table 2. Type of production

Type of production	Freq.	Weighted average percentage of production
Piece production	32	25%
Small batch production	31	21%
Large batch production	23	25%
Project production	20	17%
Mass production	11	14%

Note: Number of cases in which at least 1% of the respective type of production was indicated.

The respondents were to choose more possibilities when also mentioning the percentage of these types of production. Therefore, the evaluation had to be based on weighted average. Table II shows that numbers of particular types of production are rather balanced. We can state that no type of production considerably predominates.

For the purpose of cost management, it is necessary to find out a structure of costs from the perspective of their classification. The table below shows the portion of overhead and fixed costs

Table 3. Cost portion (on total cost)

	Portion on total cost
Unit cost	62%
Overhead cost	38%
Variable cost	65%
Fixed cost	35%

Table 3. illustrates that average portion of overhead costs is about 38 % whereas regarding fixed costs it is only 35 %. There we can also identify a small disproportion between overhead and fixed cost portions. This could be caused by the fact that it is possible to include a part of overhead costs within production into variable costs. It is optimistic that firms understand the differences in costs and they are able to distinguish between different cost classifications. From other questions and answers to these, it is evident that companies do not pay special attention to overhead costs. The respondents mentioned (almost 55 % of cases) that they pay as much attention to overhead cost management as to variable cost management. 28 % of respondents mentioned that they focus on variable (unit) costs mainly. Only 7 % of respondents specified that they concentrate directly on fixed cost management. Then, 22 % of respondents specified that they tend to focus on cost division in detail after having them divided into particular categories. This means that they also pay attention to overhead cost management. To sum up, **only about 30 % of respondents focus on overhead cost management in detail.**

To have an overall view on the issue of cost management, it is interesting to mention that about 10 % of respondents do not use calculations for their cost management. In other cases, the companies (more than half of the cases – 54 %) make use of full absorption costing. To compare these findings with previous studies, it is also interesting to mention the use of a modern method called Activity-based costing, which was used in 7 % of the cases only. This confirms its low usage, which also emerged in previous studies that were already published by the author. [18] As the proof of these findings, we can state that there is the least possible cost management based on other cost drivers than production capacity**.** This was confirmed also by other respondents´ answers when only 20 % of these mentioned that they are aware of the fact that cost variability can also be considered in relation to other quantities than in relation to production capacity only. On the contrary, 75 % respondents stated that they are aware of the above mentioned but they do not make usage of such knowledge for the cost management itself. 5 % of respondents mentioned that they have never heard of this issue. This confirmed also other findings when majority of the companies (up to 60 %) mentioned that they do not distinguish semi-fixed or semi-variable costs. About 27 % of respondents have never heard of these issues. This means that only 13 % of respondents distinguish the categories of semi-fixed and semi-variable costs. This was again confirmed by the answers to the last question from this category when 72 % of respondents do not see the possibility of having other groups within the company that are increasing in relation to a growing production capacity. However, when the production capacity is getting lower these will stay on the same level and do not decrease again.

Based on the facts mentioned above, a more thorough research was carried out in order to find out potential connections among various areas of companies. Firstly, we assume that there is a strong dependence between overhead cost management and the company size. Logically, a larger company is to have a more complex system of costs and will have to pay more attention to overhead cost management mainly as in this area, there are possibilities how to save costs almost in any company.

Table 4. Dependence between the firm size and the attention paid to the management of particular cost groups

Attention is paid especially to the:	variable cost management	fixed cost management	both equally
Small enterprises	33%	19%	38%
Medium and large enterprises	21%	25%	54%
$\chi 2$	2,119		
p-value	0,55		

Based on the calculated feature of $\chi 2$ (p-value = 0.55), it is evident that the hypothesis of independence is not possible to be rejected. This means that the research carried out **did not confirm statistically important dependence** between the company size and the attention paid to management of particular cost groups. It cannot be assumed that in connection with a higher company size there is a greater emphasis on the attention paid to, for example fixed (overhead) costs contrary to variable costs. Nevertheless, this does not mean that the companies do not pay any attention at all to overhead cost management. This fact was also confirmed by other hypothesis (*H2*), which has to be rejected as well for the reason of being tested on statistical dependence with the result of having p-value on the level of 0.71, which is a higher value than the critical one of 0.05. The hypothesis of two variables independence cannot be falsified and therefore, the statistically significant dependence between the company size and the cost variability assessment done by other cost drivers than production capacity **was not confirmed.**

Although there was no proof of dependence between the company size and paying a special attention to certain cost groups, majority of companies (up to 85 %) monitor structure and development of overhead costs. The statistical dependence between the company size and detailed study of overhead costs was confirmed (*H3*). In this case, p-value was lower than 0.05 (0.016), which enable us to reject the null hypothesis regarding the independence of these two variables. It is possible to state that medium and large enterprises statistically monitor in detail their overhead cost structure more often than small enterprises.

The final hypothesis made (*H4*) describes the fact regarding asymmetric cost behavior. These are costs that are increasing when the production capacity is getting higher. However, when the production is getting lower these are to stay on the same level and do not decrease again. This does not depend on the company size, type of production or the ownership structure. This hypothesis **was found valid** due to three partial conclusions of statistical check-ups. The first conclusion made was based on study regarding dependence between the firm size and understanding the fact of having asymmetric (sticky) costs. In this case, relative frequencies did not show significant differences between small and larger enterprises. Subsequently, the statistical test did not confirm the differences as p-value on the level of 0.726691 did not enable to reject the null hypothesis regarding the independence of two variables.

Likewise it is possible to evaluate dependence between perception of asymmetric cost behavior and type of production. Even relative frequencies show that for example companies with a project type of production or a small-quantity production see the disproportionality of some of the costs more clearly than other companies perceive them. Still, these differences were not found to be statistically significant. The p-value of 0.649411 does not enable to reject the null hypothesis regarding the independence of two variables (see table 5).

Tab 5. Perception of the existence of cost groups that increase with the increasing volume of production, but in case of reduced production will remain at the same level according to production character

	YES	NO
Piece production	29%	71%
Small batch production	45%	55%
Large batch production	20%	80%
Project production	40%	60%
Mass production	25%	75%
χ^2	2,4734	
p-hodnota	0,649411	

This was also confirmed by the third conclusion regarding the study of dependence on property structure. The most significant relative differences were visible between the companies owned by a domestic proprietor and the companies of a joint ownership. The statistical testing confirmed that there is no dependence between the company ownership and perception of the costs (p-value of 0.559).

DISCUSSION AND CONCLUSION

This survey together with the previous ones (researches that were executed by the research team of Novák and Popesko in the years 2004 – 2009) carried out show that in many manufacturing enterprises, **the share of overhead (fixed) costs increased** up to about 40 % of total costs (38% in the year 2014, 39.5 % in the year 2009, 40.7 % in the year 2007[70]). The positive aspect of the findings is that companies are aware of the importance and significance of cost management as well as detailed monitoring and overhead cost management. This was stated by 85 % of the companies studied. Still, we cannot declare that companies pay a greater attention to analyses and overhead cost management than to variable cost management.

Then, it is necessary to state that there is no sign of application of detailed cost analyses that would monitor the cost behavior within the companies from other perspectives than production capacity only. This is confirmed by survey thanks to which we can declare that up to 75 % of respondents concentrate on studying the relation to a quantitative factor, i.e. production capacity or total of sales. To find out the reasons for the above mentioned, the research project is to focus on carrying out a qualitative research. However, one reason can be mentioned at this very moment. The research has proved that there is only a minimum awareness regarding asymmetric cost behavior. Almost three quarters of respondents (senior executives of the companies studied were addressed) are not aware of the fact regarding asymmetric cost behavior or the influence of other factors than production capacity only. Concerning this fact, no connection was proved in relation to the company size or a type of production, which again draws attention to drawbacks in the area of cost management within many companies.

In general, out of 4 hypotheses, there were 2 of them rejected and 2 of them confirmed. We consider mainly the result of hypothesis H1 rather surprising. In this case, it will be essential to do further research regarding this hypothesis, and this should be done on a larger sample of respondents. These findings will also be verified in the future by a qualitative research within companies selected.

In conclusion, although many authors have discussed the issue of cost management, there is still a great need of reactions and attitudes towards changing economic situation. It is important to provide companies with possibilities regarding problem solving in the area of planning and cost prediction thanks to which they can reach higher economic efficiency. As shown by the research, there are still reserves regarding cost management in companies, and majority of companies still follow the practice of historically rooted models of cost management. Since there is a growth in overhead cost portions, it is vital to pay a greater attention to these, to make detailed analyses, and search for various possibilities of savings. It is essential that monitoring as well as overhead cost evaluation are then reflected in calculation methods, which are to offer a better view on allocation of these costs on the basis of relevant relational quantities.

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FINDING THE LOCATIONS OF LOGISTIC DEPOTS FOR DISASTER RELIEF OPERATIONS USING GIS: THE CASE STUDY OF ERZINCAN, TURKEY

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Abstract− Disasters result in significant impacts on communities, including the loss of many lives and properties, injuries, diseases, disabilities, psychosocial problems and other health impacts and economic damages. Earthquakes are the most desperate disasters in human history. One of the emergent areas in emergency logistics management is facility (relief item depots) location problem, since the response time to affected area affects the survival rate and timely availability of relief items, dramatically. To deal with facility location problem realistically, many real-life aspects must be considered and implemented in the proposed solution approach. In this study, we address the facility location problem in disaster relief activities. We take into account the condition of the road network by assessing a traffic speed for each road and bridge in the network according to their width and structure. We present a Geographic Information System (GIS) based framework that solves how to choose the optimal locations for relief item depots to reach the demand points with minimum total travel time. A case study in Erzincan province of Turkey where the most devastating earthquake in Turkey's history occurred is utilized and several scenarios are generated to analyze solutions found in different scenarios under different circumstances. ArcGIS package is used to solve the problem and create effective plans for locating the relief depots for distributing any kind of aid after earthquakes.

Keywords− ArcGIS, Emergency Humanitarian Logistics Management, Facility Location, Relief Distribution, Traffic Speed.

INTRODUCTION

A disaster is defined as "an occurrence disrupting the normal conditions of existence and causing a level of suffering that exceeds the capacity of adjustment of the affected community" by the World Health Organization (WHO, 2002) [1]. The aim of the disaster management is achieving rapid and durable recovery. The Disaster–Development continuum covers preparation, response/relief, rehabilitation, reconstruction and mitigation/prevention phases. Preparedness consists of a set of activities implemented before the impact of a disaster in order to ensure the organized mobilization of personnel, funds, equipment and supplies within a safe environment for effective relief, whereas response phase consists of activities implemented after the impact of a disaster in order to assess the needs, reduce the suffering, limit the spread and the consequences of the disaster and open the way to rehabilitation [1].

This paper presents relief item depots (RID) location problem which is crucial after an earthquake in terms of minimizing the fatality enabling immediate distribution of emergency supplies. We developed a Geographic Information System (GIS) based framework that selects RIDs locations such that all demand points in the affected areas are served within a specified minimum total travel time. The method takes into account the condition of the road network by assessing a traffic speed for each road and bridge in the network according to their width and structure. We define the effects of an earthquake on the travel conditions of road segments in the network. A case study is performed on Erzincan province in Turkey where the most devastating earthquake in Turkey's history occurred and several scenarios are generated to analyze solutions found in different scenarios under different circumstances. Here, we review studies related to facility location and studies specifically deal with variable travel time depending on road conditions in emergency logistics management.

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Caunhye et al. [2] classify emergency logistics studies in the literature into two main categories: facility location, relief distribution and casualty transportation, and present a brief discussion on the contents of facility location studies based on the model types, decisions, objectives, and constraints. Anaya-Arenas et al. [3] give a recent review of relief distribution networks focusing on the logistics aspects of the problem.

Very few studies in literature take into consideration of the condition of the road network. Eiselt et al. [4], Eiselt et al. [5] and Melachrinoudis and Helander [6] are the first studies that make only a single edge failure or single facility location assumption on a tree network where road segments fail independently. Günneç and Salman [7] examine dependency among link failures of a given transportation network in case of a disaster and propose a novel dependency model. Salman and Yücel [8] study the problem of selecting emergency response facilities in pre-disaster stage where a survival probability is assigned to each road segment of the network according to the risk level of the region under an expected disaster scenario. The objective is to maximize the expected demand coverage within a specified distance overall possible network realizations.

The travel time on each road segment of the logistics network cannot be considered as a constant due to the condition of the road network. Yuan and Wang [9] presents two mathematical models for path selection in emergency logistics management taking into account that the travel speed on each arc will be affected by disaster extension and the total number of arcs included in the path which is called path complexity. The travel speed on each arc is modeled as a continuous decrease function with respect to time. Zhang et al. [10] proposed a novel bio-inspired method to solve the route selection problem for emergency logistics management considering the travel speed will change under disaster extension and the type of the disaster.

In the literature, there are studies that implement Information Technology Applications to effectively solve real-life problems. Chang et al. [11] developed two stochastic programming models to determine rescue center locations for flood emergency logistics problem in conjunction with Geographic Information Systems (GIS) software. Saadatseresht et al. [12] present a multi-objective evolutionary algorithm (MOEA) and GIS for solving a multi-spatial evacuation planning problem. Widener and Horner [13] use GIS in conjunction with spatial optimization models in post-hurricane settings to decide the size and location of facilities for distributing relief services. Chen, Peña-Mora and Ouyang [14] present a GIS based framework that facilitates equipment allocation in response to disasters. The framework is composed of three subsystems to facilitate information gathering and decision making for equipment distribution.

The paper is organized as follows: In Section 2, the problem characteristics and the solution methodology are given. In Section 3, we provide the application of our approach to Erzincan case and give the details of the generated scenarios and the results and analysis of scenarios. Finally, concluding remarks are outlined and future research directions are highlighted in Section 4.

PROBLEM DEFINITION

In this paper, we focus on facility location problem in emergency logistics management under an earthquake disaster case. We used ArcGIS package to find the locations of facilities (logistic depots). In the earthquake response literature, three types of objectives have been generally considered: minimization of transportation cost, minimization of unsatisfied demands and minimization of unserved injured people [15]. However, since the response time to affected area is one of the most critical actions to minimize the loss of life and maximize the efficiency of the relief operations, total minimum travel time is our main criteria while finding the locations of logistics depots. We focus on locating enough depots among candidate regions which can serve to a demand point in shortest time so that the timely availability of relief items is ensured, and the survival rate in affected areas are increased.

Considering an earthquake scenario, many real-life aspects must be taken into account and realistically implemented in the proposed solution methodology. For that reason, we take into consideration the condition of the road network. We assess a traffic speed for each kind of roads and bridges in the network according to their width and structure. As a result, the total travel time on road network vary due to the speed capacity of different road types.

We first considered 4 different scenarios with respect to magnitudes of earthquake. For first scenario it is accepted that there is an earthquake in Erzincan province with a magnitude of 6.0. For second scenario it is 6.5, for third scenario 7.0 and for fourth scenario 7.5. Then we choose the worst scenario with most devastating earthquake with a magnitude of 7.5 the vulnerability of each zone is affected by the magnitude of the earthquake. In generating a scenario, a ratio between the exponential functions of the magnitudes of the earthquakes is defined and it is used to calculate the effect on travel time values of road networks.

For the case study, first, we generate the actual road distances of Erzincan using ArcGIS package. We consult AFAD in Erzincan to locate the logistic depot (only one logistic depot is currently active in Erzincan for relief items for a possible disaster) on our network. We calculated the travel time from this depot to all towns and city center of Erzincan. We think that this depot will not be enough to reach victims of earthquake in proper time. Then we work on locating one, two and three more depots to optimal provinces of Erzincan in order to reach demand points in time.

We solved a large scale problem having 17.736 road segments generating 4 different scenarios with respect to magnitudes of earthquakes for different demand points in Erzincan province of Turkey. The details of our case study and the description and analysis of earthquake scenarios are given in Section 3.

CASE STUDY

Earthquake is the most feared type of disaster in Turkey because of the high frequency of seismic activities. A large scale fault line called North Anatolian Fault (NAF) is formed more than 1,000 km long from east to west in the northern territory of Turkey and historically, many strong earthquakes have occurred along this fault line. Erzincan is in the first degree earthquake zone and located on NAF line.

The Erzincan 1939 earthquake was the most devastating earthquake in Turkey’s history with a magnitude 7.9 which ranks 15.th among the most severe earthquakes of 20. century. There were around 32968 dead and 116720 destroyed buildings. Table 1 represents severe earthquakes in Erzincan above a magnitude of 5.5 and their respective damages.

Table 1. Earthquakes in Erzincan since 1900 with a Magnitude over 5.5

Date	Hour	Place	Magnitude	Nu. of Death	Nu. of Damaged Buildings
21.11.1939	10:48	Tercan (ERZİNCAN)	5.9	43	-
27.12.1939	01:57	ERZİNCAN	7.9	32968	116720
12.11.1941	12:04	ERZİNCAN	5.9	15	-
13.03.1992	19:08	ERZİNCAN	6.8	653	8057
22.09.2011	06:22	Cengerli-Refahiye (ERZİNCAN)	5.6		

As it can be understood from Table 1, Erzincan suffered from 5 severe earthquakes in the last century. Many lives are lost, and many people left without their homes. The earthquakes in Erzincan and around after 1800 with a magnitude over 5.5 can be seen in Fig. 1. The most devastating earthquakes were between Erzincan and Erzurum.

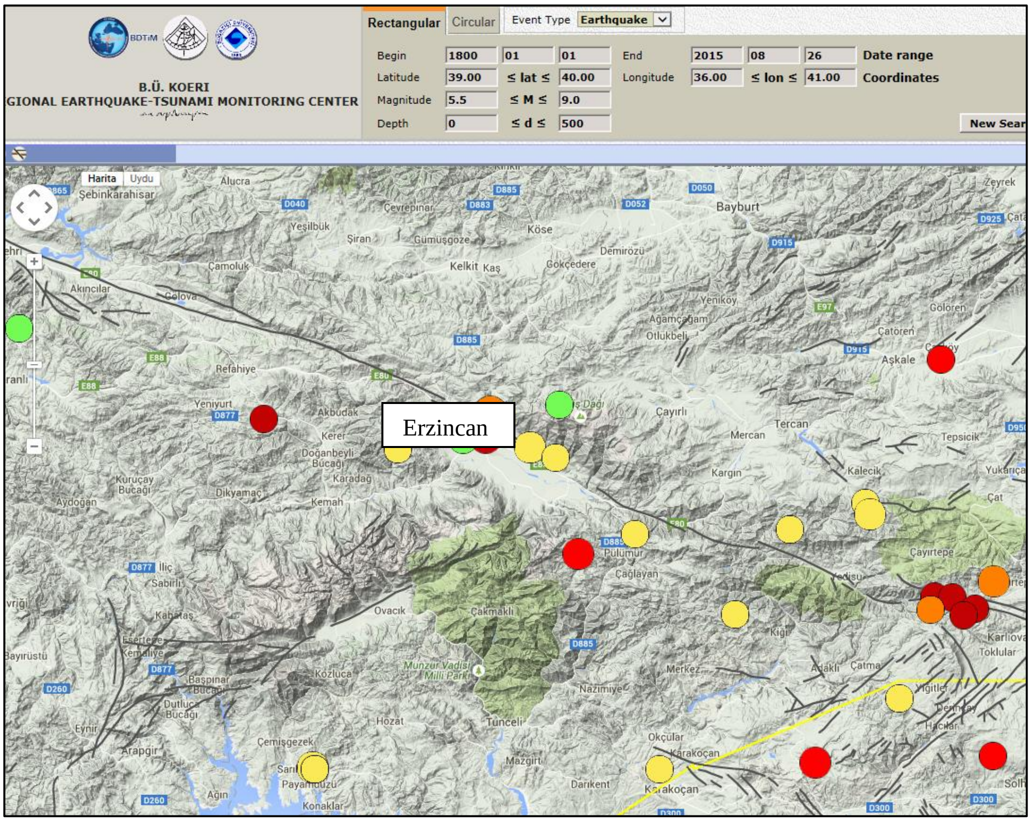

Figure 1. The earthquakes around Erzincan and around after 1800 with a Magnitude over 5.5

The road network of Erzincan covers a range of wide principal roads to narrow streets. The density of narrow streets is high especially in city center which makes up the transportation system that is very important since they are the most vulnerable to potential blocking due to building collapses. Furthermore, since the collapse of a bridge at the time of an earthquake can stop the flow of all vehicles, including emergency vehicles such as ambulances, fire engines, etc. Thus, we include all the narrow streets and bridges in Erzincan map in our study. It results in a huge road network with 17736 arcs. These arcs are used to select the best route among depot and demand points with minimum total travel time in two steps.

First, we generate the actual road distances of Erzincan using ArcGIS package. Defining the width and road specification, a traffic speed is determined for each road in the network. By this way, the total minimum travel time among the nodes are defined without considering the disaster situation.

Traffic speeds are set as shown in Table 2 according to the road specifications and/or widths:

Table 2. Traffic Speed According to Road and Bridge Type

No.	TYPE OF ROAD OR BRIDGE	Speed km/h
1	Road under construction	50
2	Road that has at least three traffic lane	110
3	Asphalt Road that has more than 9 m platform and more than 6 meters width	90
4	Asphalt Road that has 7-9 m platform and more than 5 meters width	80
5	Asphalt Road that has less than 7 m platform and less than 5 meters width	75
6	Gravel. Macadam Road that has more than 9 m platform	70
7	Gravel. Macadam Road that has 7-9 m platform	65
8	Gravel. Macadam Road that has less than 7 m platform	60
9	Road inside city	50
10	Road reaches a main road and a truck can pass easily during all seasons	40

11	Road reaches a main road and a truck can pass easily during open weather	30
12	Bridge on the Road that has at least three traffic lane	70
13	Wooden Bridge	20
14	Suspension Bridge	50
15	Iron Bridge	30
16	Concrete Bridge	40
17	Tunnel	50

In the second step, the effect of the magnitudes of earthquakes to travel time is considered.

In this study, it is expected that the magnitudes of earthquakes will extend the travel time exponentially. Table 4 shows the effect of the magnitudes of earthquakes on travel time. It is accepted that the earthquakes with a magnitude over 5 will cause extension on travel time. So, we first calculated exponential values of magnitudes of earthquakes which can be seen in Table 3. Then we divided the calculated exponential values of magnitudes 6, 6.5, 7.0, and 7.5 (403.429, 665.142, 1096.633 and 1808.042 respectively) with the exponential value of 5.0 (148.413) and we found the effect of magnitude of earthquakes which can be seen in third column of Table 3. Finally, we extend the travel time on each segment with the values found in third column of Table 3.

In other words, for the first scenario, we first calculate the travel time on road segment with respect to distance and travel speed before the earthquake and then we multiply the calculated travel time on that road segment with 2.718 in order to find the effect of the expected earthquake. We did the same calculation for other scenarios.

Table 3. Effect of Earthquake Magnitudes on Travel Time

Magnitude	Exponential of Magnitude	Effect on Time
5,00	148,413	1,000
6,00	403,429	2,718
6,50	665,142	4,482
7,00	1096,633	7,389
7,50	1808,042	12,182

Figure 2 shows the location of Erzincan with blue colored pentagon and existing logistic depot with yellow colored square. Before starting to calculate the travel time after an earthquake from existing depot to supposed demand points, we calculated the boundaries of regions in 3 hours distance from the existing depot which can be seen on the right part of Figure 2. The pink circles show the towns of Erzincan. It is obvious from Figure 2 that without any earthquake the relief items can be send to all possible demand points in 3 hours.

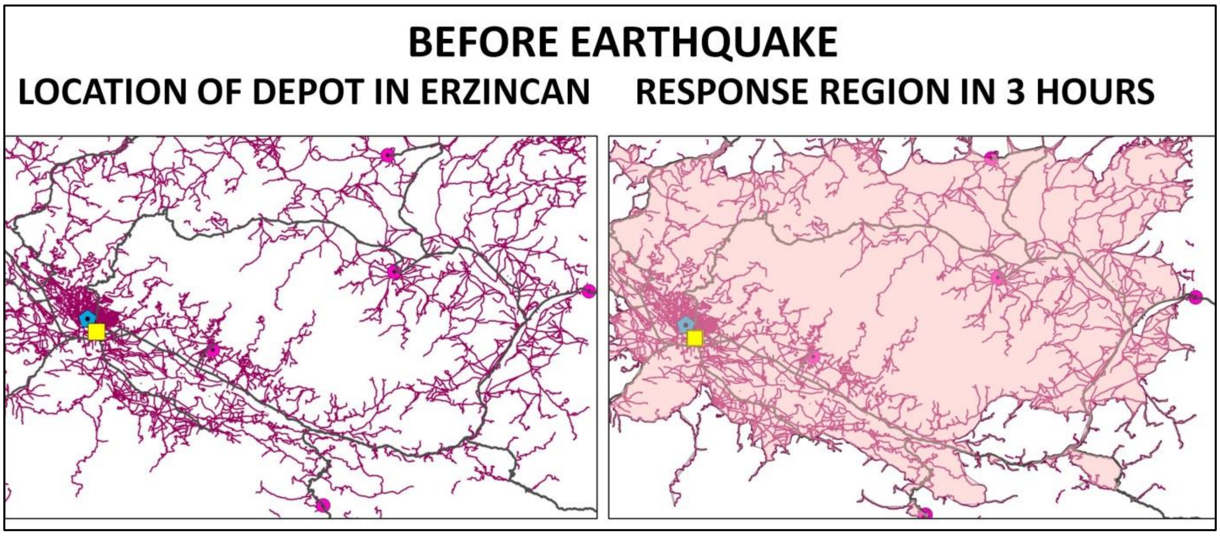

Figure 2. Location of Logistic Depot in Erzincan and Response Region in 3 Hours from The Depot

As the second step, we calculated the response region in 3 hours for 4 different scenarios shown in Figure 3. When we focus on the worst scenario in which there is an earthquake with a magnitude of 7.5, the region that can be reached in 3 hours becomes smaller. Therefore, it becomes difficult to reach the people (who need help after an earthquake with magnitude of 7.5) from the existing depot in proper time.

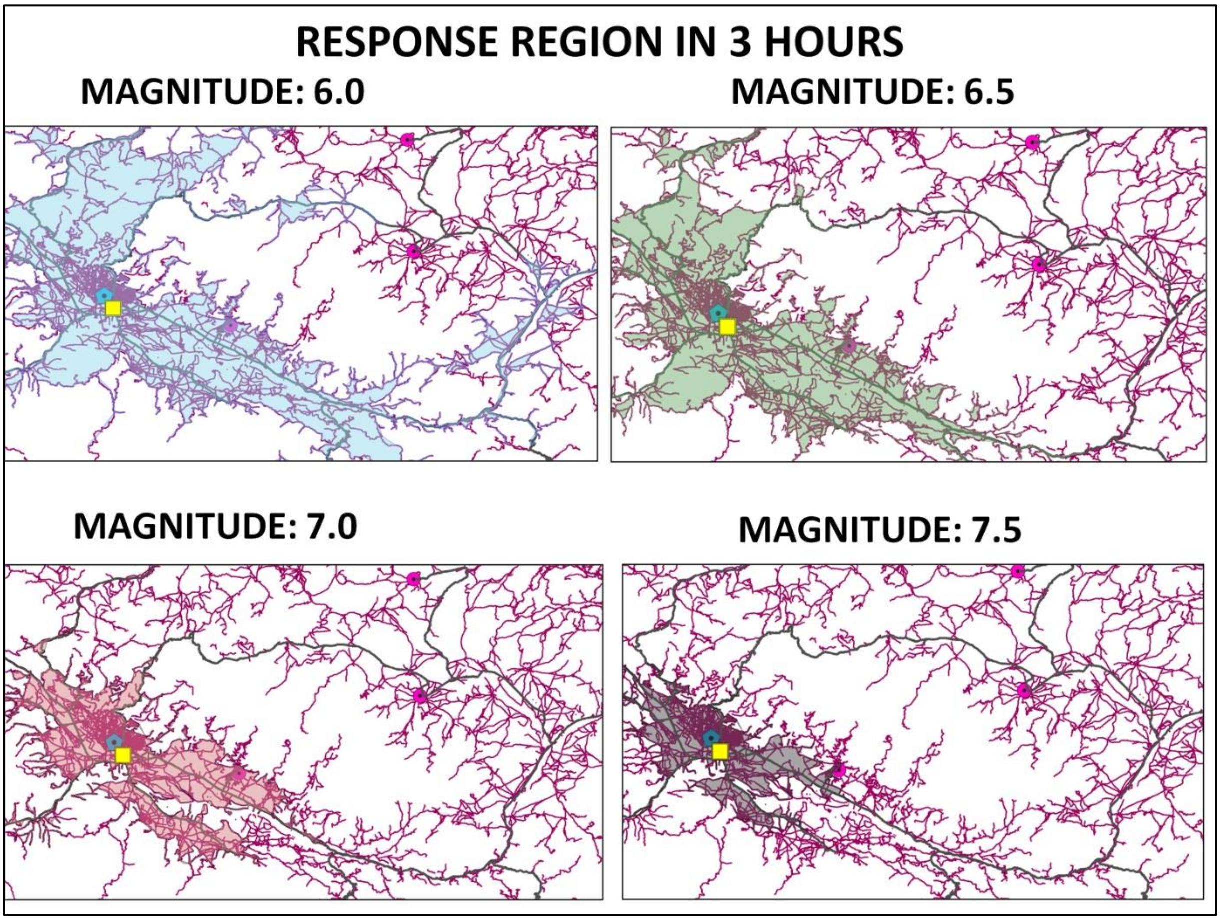

Figure 3. Response Region in 3 Hours for Four Different Scenarios

The fact that existing depot will not be enough to reach people suffering from the earthquake in fourth scenario, we study on finding out the optimal number of depots and their optimal locations in Erzincan province. The details of work that we focus on for the worst scenario can be seen in Figure 4. If the authorities decide that the proper time to reach suffering people will be 16 hours, the existing depot will be enough to reach people living in city center and towns of Erzincan.

If the authority decides that 3 hours is sufficient to reach people, than AFAD or Erzincan Municipality should locate 3 more depots which can be seen in right part of Figure 4. The square shapes in blue, pink and red colors show the locations of new proposed depots and the region that can be covered in 3 hours from these depots are shown in pink, gray and blue colors respectively.

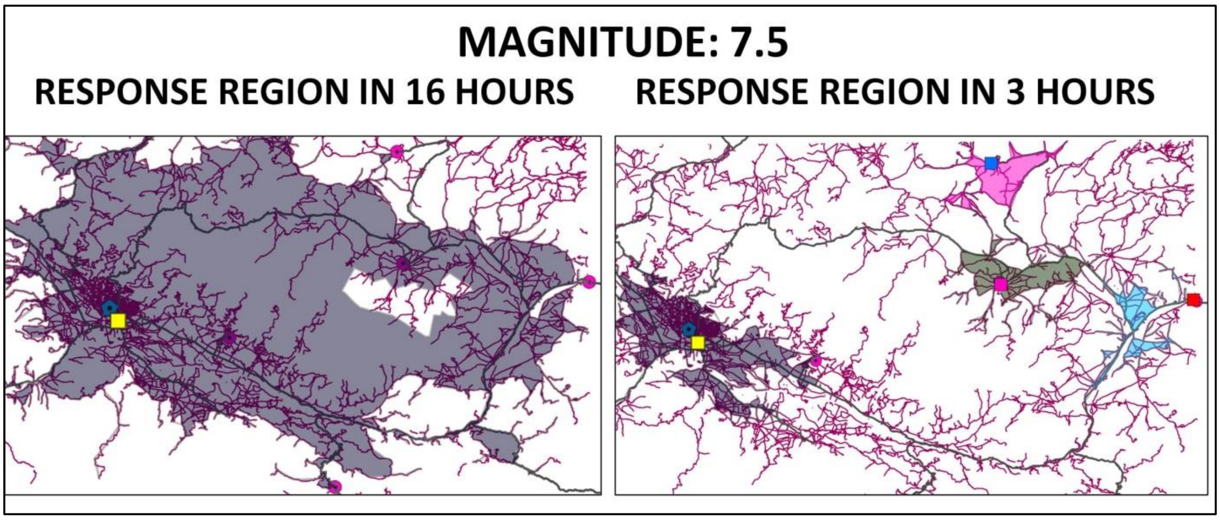

Figure 4. Response region in 16 and 3 hours distance from existing and proposed depots for fourth Scenario.

We continued to find optimal locations for the logistic depots if the authority decides the proper time as 6 or 10 hours. If the government or municipality decides that 6 hour will be sufficient to reach people, AFAD should add 2 more depots (blue and red square shapes in Figure 5) to existing depot (yellow square shape in Figure 5). We accepted that the optimal places for new depots should be in city center or in town centers to with respect to security. So, we tried all possible alternatives to locate 2 more depots by using ArcGIS package. The optimal location that we found for two additional depots can be seen at the up-left part of Figure 5.

For 10 hours response time to reach the suffering people from earthquake, only one more depot will be enough to cover all Erzincan provinces. We found 3 optimal alternative locations for additional one depot.

In our study, we proposed alternative locations for additional depots with different accepted response time to reach people suffering from the earthquake. The authorities are the decision makers for relief operations after disasters. They will decide what to do.

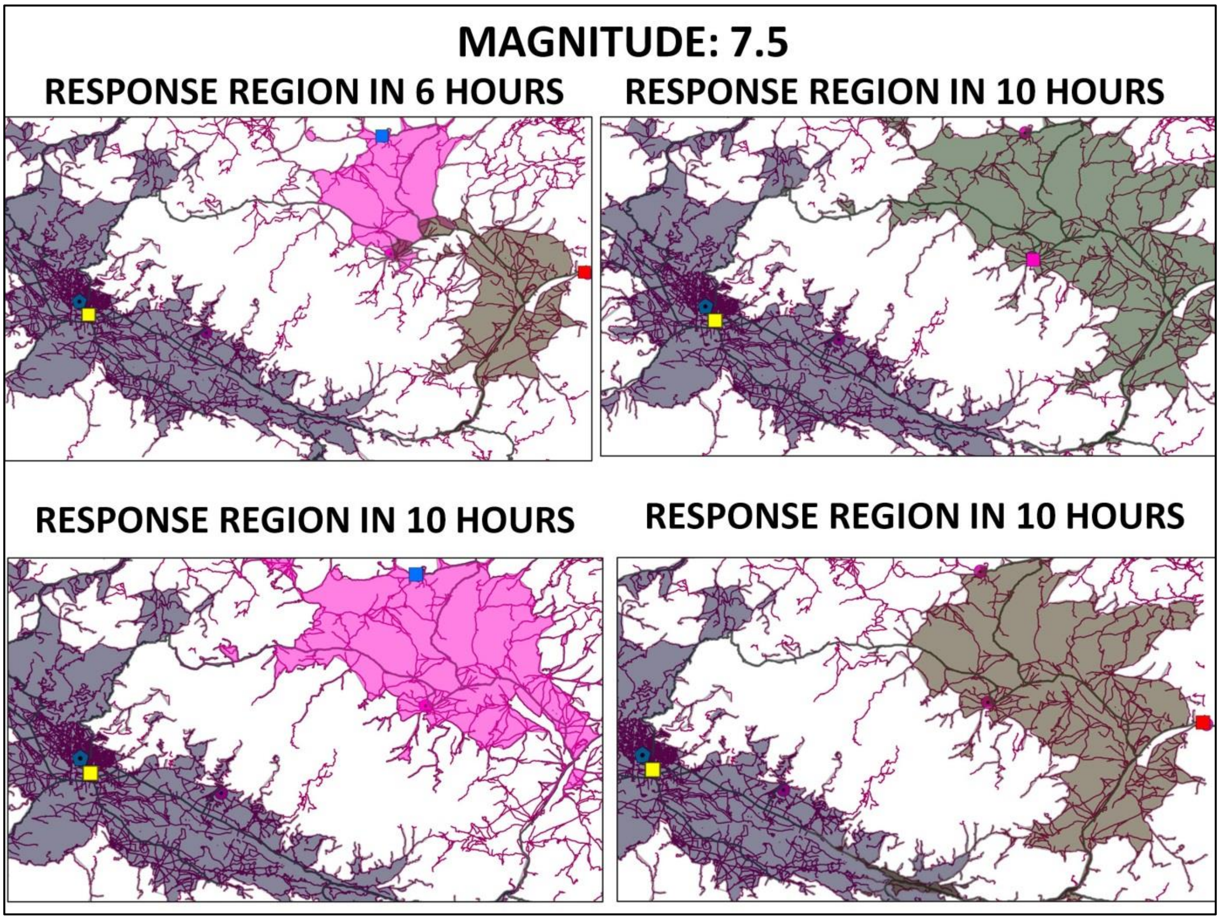

Figure 5. Response region in 10 and 6 hours distance from existing and proposed depots for fourth Scenario.

CONCLUSION AND FUTURE WORKS

We proposed optimal locations for new logistic depots for disaster response in order to access demand points in shortest response time. First, we assess traffic speed to infrastructure i.e. roads and bridges to identify the best path with total minimum travel time in network before an expected earthquake. However, we consider that the total travel time on a path will differ according to the magnitudes of the earthquakes.

We focus on locating enough depots among candidate regions which can serve to a demand point in shortest time so that the timely availability of relief items is ensured, and the survival rate in affected areas are increased.

A case study is performed on Erzincan province in Turkey where the most devastating earthquake in Turkey's history occurred. We have constructed a real large-scale network with 17736 road segments. By generating 4 different scenarios, the effect of road type and the magnitude of the earthquakes on location of new logistic depots are investigated.

It is concluded that the magnitudes of the earthquakes effects the total minimum travel time dramatically and as the magnitude of earthquake increases, the probability to reach demand points in proper time will decrease. So, the authorities should focus on locating additional depots in Erzincan to be prepared to possible earthquakes. We conduct our study via ArcGIS techniques. In contrast to developing mathematical models, it allows us to dynamically adapt the changes in network conditions into our solution approach and find a realistic solution for a large amount of data in a very reasonable time.

In future, it would be worthwhile to consider completely unusable roads in disaster response in creating effective plans. It is very crucial to reach the people affected from the earthquake in an acceptable time. If we study the case in one city we propose additional logistic depots. However, if we work on all country, rather than locating additional depots to all cities, mobile logistic depots can be optimal solutions for these kind of problems.

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DEFINING AND WEIGHTING THE CRITERIA WHICH CAUSES DELAYS IN TRAVEL TIME OF THE VEHICLES CARRYING DISASTER RELIEF ITEMS AFTER AN EARTHQUAKE

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Abstract - It is impossible to prevent disasters in the world but it is possible to take some precautions to decrease the effects of disasters. Earthquakes are most disruptive disasters among all since its economic and social loses are worst. There are many studies including thesis and articles related to emergency logistics, routing the vehicles after disasters, locating the relief facilities before an earthquake, finding the optimal locations of disaster response teams. It is hardly possible to find studies about defining the criteria which causes delays in travel time of relief vehicles. It will be sensible to take into consideration these criteria while finding optimal routes for disaster response vehicles after an earthquake.
In this study, our aim is to define the criteria which affect the travel time of disaster response vehicles to reach the demand points after an earthquake by causing delays in travel time and then we used multi-criteria decision methods to find the weights of these criteria. While finding optimal routes for the relief vehicles after a possible earthquake, considering the damage of earthquake on highways, motorways, bridges, viaducts and tunnels is very important. There are other criteria such as traffic density and traffic jam on roads, debris removal on the roads, speed limits. While defining the criteria we survey the literature and we also consult experts. After finding the criteria and their relation with each other we prepared a questionnaire for the experts to give scores for the criteria and we used multi criteria decision methods to evaluate the questionnaire and find the weights of the criteria.

Keywords - Disaster Relief operations, Disaster Logistics, Multi-Criteria Decision Making.

INTRODUCTION

Disaster is defined in different ways throughout the literature. International Federation of Red Cross and Red Crescent Societies(IFRC) defined disaster as “A sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community’s or society’s ability to cope using its own resources” [1]. Since the beginning of the millennium, almost 2.7 billion people have been affected, 1.1 million killed and a damage of 1.3 trillion dollars has been reported worldwide due only to natural disasters [2].

There are two main types of disasters: “natural hazards” and “technological or man – made hazards”. Natural hazards are naturally occurred phenomena which can be caused by slow or rapid onsets. Geophysical activities (earthquakes, landslides, tsunamis and volcanic activities), hydrological activities (avalanches and floods), climatological activities (extreme temperatures, drought and wildfires), meteorological activities (cyclones and storms/wave surges) and biological activities (disease epidemics and insect/animal plagues) can be classified as natural hazards.

Technological or man – made hazards are events that are caused by humans and they usually occur in or near urban zones. Complex emergencies/conflicts, famine, displaced populations, industrial accidents and transport accidents lies in this category [3]. Hazards (disasters) can also be divided into 5 main types which can be seen in Table 1.

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Table 1. Various Types of Hazards

Type	Hazards	
Geological Hazards	1. Earthquake 2. Tsunami 3. Volcanic eruption	4. Landslide 5. Dam burst 6. Mine Fire
Water & Climatic Hazards	1. Tropical Cyclone 2. Tornado and Hurricane 3. Floods 4. Drought 5. Hailstorm	6. Cloudburst 7. Landslide 8. Heat & Cold wave 9. Snow Avalanche 10.Sea erosion
Environmental Hazards Biological	1. Environmental pollutions 2. Deforestation 1. Human / Animal Epidemics 2. Pest attacks	3. Desertification 4. Pest Infection 3. Food poisoning 4. Weapons of Mass Destruction
Chemical, Industrial and Nuclear Accidents	1. Chemical disasters 2. Industrial disasters	3. Oil spills/Fires 4. Nuclear
Accident related	1. Boat / Road / Train accidents / air crash Rural / Urban fires Bomb /serial bomb disasters blasts 2. Forest fires	3. Building collapse 4. Electric Accidents 5. Festival related 6. Mine flooding

Source: CBSE (2006)

People all over the world deeply suffer from earthquakes. This fact forces the authorities to put forth a management system which is named as Disaster Risk Management. Disaster Risk Management includes sum of all activities, programmes and measures which can be taken up before, during and after a disaster with the purpose to avoid a disaster, reduce its impact or recover from its losses. The three key stages of activities that are taken up within disaster risk management are as follows [4]:

Before A Disaster (Pre-Disaster);

Pre-disaster activities those which are taken to reduce human and property losses caused by a potential hazard. For example carrying out awareness campaigns, strengthening the existing weak structures, preparation of the disaster management plans at household and community level, etc. Such risk reduction measures taken under this stage are termed as mitigation and preparedness activities.

During A Disaster (Disaster Occurrence);

These include initiatives taken to ensure that the needs and provisions of victims are met and suffering is minimized. Activities taken under this stage are called emergency response activities.

After A Disaster (Post-Disaster);

There are initiatives taken in response to a disaster with a purpose to achieve early recovery and rehabilitation of affected communities, immediately after a disaster strikes. These are called as response and recovery activities [4].

Natural disasters occur in many different countries around the world. This kind of disasters has a big damage on country’s economies and hence it also causes negative psychological and social impact on humans. Especially in highly inhabited areas, thousands of people may be affected or killed. Earthquakes come first among all disasters with respect to its damage to population, environment and economy. People living all over the world are affected from earthquakes and sometimes from tsunamis after the earthquakes.

Turkey suffers from earthquakes especially with the magnitude over 6.0 in every ten years. Especially after the earthquakes in 1999 (Kocaeli and Düzce), both government and non-governmental organizations increased their efforts on mitigation of the effects of earthquakes. New organization with the name of AFAD is established in 2001 by Turkish Government to be more prepared to disasters. AFAD placed 22 logistics depot in different cities of Turkey. Four more depots are planned to be located to other cities. It is very important to take precautions for disaster. To react quickly after disasters and reach the people suffering from disasters is also as important as taking precautions to disasters. This necessity forces the authorities, emergency response teams and relief carrying units to find optimal routes for their vehicles with respect to time attribute.

In this study we focus on finding the criteria which effects time of reaching the demand points after an earthquake. First, we searched literature and consult experts to find related criteria which effects travel time. Second, we summarized the problem definition. Third, we describe AHP methodology and finally we find the weights of the criteria in conclusion part.

PROBLEM DEFINITION

There are thousands of people who need help after earthquakes. Life of many people depends on time and if the rescue teams reach the earthquake regions as soon as possible, life of many people waiting under demolished building can be saved.

In most of the articles, route planning is considered as finding the shortest paths from emergency response teams or logistics depots to demand points. Shortest paths are found with respect to road lengths. But in emergency routing, for example finding a route for firefighting; the core problem lies in how to get to the accident scene from some place as soon as possible under complex emergency circumstance [5]. After disasters, time must be considered as the first criteria for finding optimal paths to demand points. Shashikiran et. al., in their study [6], described Kruskal‟s algorithm to find shortest paths between a respond point and demand point based on traffic rate or distance. Dynamic Vehicle Navigation System is described which generates shortest path based on traffic updated given by traffic in-charge, however it fails to reflect other important criteria such as road width, road type, mass density, proportion of damage on roads after the disaster etc. In recent studies, GIS web services and AJAX (Asynchronous JavaScript and XML) approach are used to design disaster management system so that spatial data can be loaded efficiently into the client browser and loading time can be minimized [7]. Abdul Fattah Chandio et. al., presented the modular structure of route assisting system for path planning [8]. Recently developed GIS-based advanced traveler Information System (ATIS) has a point-and-click graphical user interface which is more user friendly [9].

The intervention as soon as possible is vital importance in disasters. After any disaster happened, providing aid in that area, helping people and reaching the accident scene in minimum time is most important issue. To find out a path between any two points either shortest path which has minimum distance or optimum path which has minimum travel time is to be selected, but in disaster situations, optimum path will be preferred over shortest path because latter will not guarantee to take minimum time due to lots of factors which causing delays in travel time [10]. Suitable rescue path selection is very important to rescue lives and which delay the loss of disasters, and has been a key issue in the field of disaster response management [11].

As a problem which should be studied, all the criteria which have an effect on travel time must be considered. Of course it will not be enough just to describe the criteria. The weights of the criteria should also be calculated in order to find realistic solutions for finding optimal routes with respect to travel time. While finding optimal routes for the relief vehicles after a possible earthquake, considering the damage of earthquake on highways, motorways, bridges, viaducts and tunnels is very important. In this study, our aim is to define the criteria which affect the travel time of disaster response vehicles to reach the demand points after an earthquake by causing delays in travel time. We also intend to find weights of each criterion. It will be sensible to take into consideration these criteria while finding optimal routes for disaster response vehicles after an earthquake.

CRITERIA IDENTIFICATION

For selecting the evaluation criteria the general rule is that they should be recognized with respect to the problem situation. No universal techniques are available for considering a set of criteria although the desirable properties of objectives can yield guidelines for selecting a set of evaluation criteria. For a particular problem, the set of evaluation criteria may be developed through an examination of the relevant literature, analytical study and opinions [5].

In this study, two methodologies are used to find the criteria which effects travel time of reaching demand points after earthquakes. First we search literature for the related articles. It is hardly possible to find articles related to the criteria which effect travel tme. Yang S., and Li C. [5], proposed 7 criteria in their article for emergency routing for firefighting vehicles. These criteria are;

- Road Length (RL),
- Road Width (RW),
- Road Type (RT),
- Velocity Limit (VL),
- Traffic Volume (TV),
- Mass Density (MD) or Traffic Jam(TJ),
- Junction Delay (JD).

We think that the above criteria which are important for emergency routing for firefighting can also be accepted as the criteria which effects travel time for relief distribution after an earthquake. Since we study to describe the criteria to find optimal routes after an earthquake, for sure the criteria which cause delays on travel time after an earthquake must also be considered. Therefore, as a second methodology, we consult experts to describe criteria which mostly effects travel time of emergency response teams after an earthquake to reach demand points. After talking with experts in Republic of Turkey General Directorate of Highways, AFAD and Disaster Coordination Center (AKOM) we add two more criteria as;

- Density of buildings,
- Damage proportion on roads (DPR) after earthquake.

After finding the criteria and their relation with each other we prepared a questionnaire for the experts to give scores for the criteria and we used multi criteria decision methods (AHP) to evaluate the questionnaire and find the weights of the criteria.

There are several methods which exist for MCDM [12]. We cannot categorize the techniques as better or worse techniques, but some techniques better suit to particular decision problems than others do. The advantage of these methods is that they can account for both financial and non-financial impacts. Among these methods, the most popular ones are, analytic hierarchy process (AHP)[13], Analytic Network Process (ANP) and TOPSIS etc. The most popular methodology to find the weights of the criteria is AHP. The authors did not only use these methodologies to find the weights of criteria but also to sort, select or score the alternatives. In our study, we only used AHP methodology to determine the weight of the criteria.

AHP METHODOLOGY

The Analytic Hierarchy Process (AHP), is one of Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty (1980) [14]. In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurement such as price, weight etc., or from subjective opinion such as satisfaction feelings and preference. AHP allow some small inconsistency in judgment because human is not always consistent. The ratio scales are derived from the principal Eigen vectors and the consistency index is derived from the principal Eigen value.

The procedure for using the AHP can be summarized as [15]:

Model The Problem As A Hierarchy Containing The Decision Goal, The Alternatives For Reaching It, And The Criteria For Evaluating The Alternatives;

AHP processing starts with modeling the problem as hierarchy in which overall goal of processing is considered as root and criterion are modeled as branches from that root. Similarly, all impedance factors towards obtaining minimum travel time are considered here in the form of criterions and hierarchy is created as shown in the Figure 1.

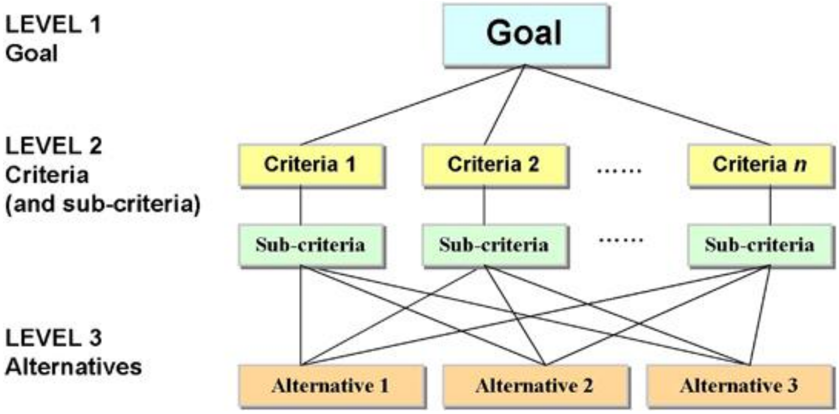

Figure 1: AHP Hierarchy [16]

Establish Priorities Among The Elements of The Hierarchy by Making A Series of Judgments Based On Pair Wise Comparisons of The Elements;

In AHP method, for obtaining priority vector of all criterions, Pair wise comparison is performed. Pair wise comparison is done in order to compare the importance of one criterion on another (Refer Table 2.). Scales are defined to quantitatively evaluate the importance of one criterion over another.

Table 2. Scales in pair wise comparisons

Intensity of Importance	Verbal Judgment of Preference
1	Equally Importance
3	Moderate Importance
5	Strong Importance
7	Extreme Importance
9	Extremely More Importance
2,4,6,8	Intermediate values between Adjacent Scale Values

If the elements of the pair wise comparison matrix are shown with cij, which indicates the importance of i^{th} criterion over j^{th}, then c_{ji} could be calculated as $1/c_{ij}$. Giving importance ratios for each pair of alternatives, a matrix of pair wise comparison ratios is obtained.

Synthesize These Judgments To Yield A Set of Overall Priorities For The Hierarchy;

Priorities of each factor is calculated by first calculating normalized comparison matrix by geometric mean method [14]-[17] given as,

$$r_i = \prod_{j=1}^{n} (a_{ij})^{1/n} \tag{1}$$

Then priorities are calculated as

$$w_i = \frac{r_i}{\sum_j r_j} \tag{2}$$

Where a_{ij} (i,j=1…n) are the comparison values in the pair wise comparison matrix and n is number of alternatives.

Check the Consistency of the Judgments;

Consistence comparison matrix holds the condition $a_{ij} * a_{jk} = a_{ik}$ where a_{ij} is the ij^{th} element of the matrix [11]. Consistency Ratio is a measure to check consistency of comparison matrix which is calculated as follows,

$$C.R. = \frac{C.I.}{R.I.} \tag{3}$$

$$C.I. = \frac{\lambda_{max} - n}{n-1} \tag{4}$$

In this λ_{max} maximum eigen value of comparison matrix, n is number of criterion and R.I is Random Index (Refer Table 3).

If C.R. < 0.1 then consistency is acceptable otherwise comparison matrix should be modified again until it reaches consistency criterion.

Table 3. Random Index for n = 1…9

n	1	2	3	4	5	6	7	8	9
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Priority vector of n criterion indicates the priority of each criterion toward final goal that is obtaining optimum and dynamic routing.

FINDING THE WEIGHTS OF CRITERIA

In this study, our aim is to define the all criteria which affect to reach the demand points after an earthquake by causing delay on travel time. It has very crucial importance to select an optimum and dynamic route between respond and demand points. It is certainly that a route which selected by considering all criteria has critical importance in effective emergency logistics management.

In this context, we consult experts to describe criteria which mostly effects travel time of emergency response teams after an earthquake to reach demand points. The hierarchy of our study can be seen in Figure 2. Our aim is to describe the weights of the criteria to find optimum and dynamic routes for relief carrying vehicles after an earthquake.

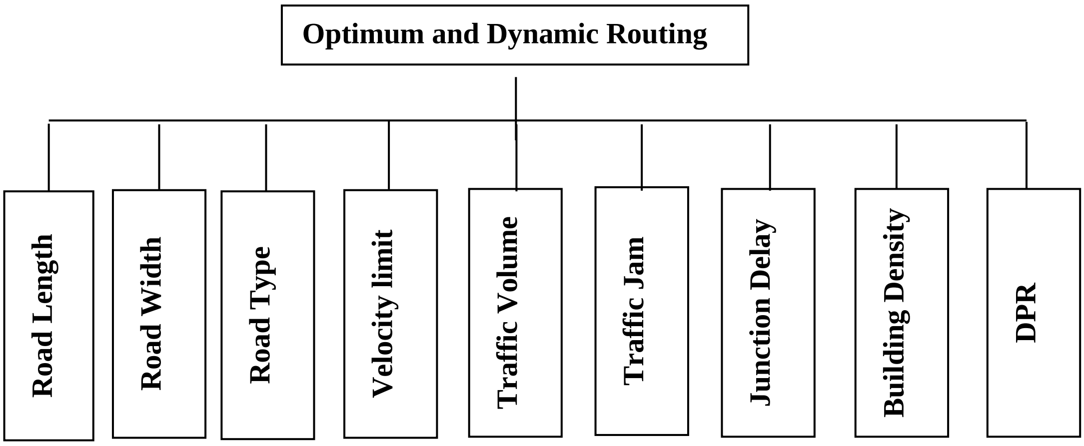

Figure 2. The Hierarchy of Optimum And Dynamic Routing

We consult experts to give scores (by using the values shown in Table 2) for the criteria and pair wise comparison is done in order to compare the importance of one criterion on another (Refer Table 4). Giving importance ratios for each pair of alternatives, a matrix of pair wise comparison ratios is obtained.

The determined criteria and pair wise comparison matrix is presented in the Table 4.

Table 4. Pair Wise Comparison Matrix

	RL	RW	RT	VL	TV	TJ	JD	BD	DPR
Road Length	1,00	8,00	9,00	6,00	7,00	5,00	4,00	3,00	2,00
Road Width	0,13	1,00	2,00	0,33	0,50	0,25	0,20	0,17	0,14
Road Type	0,11	0,50	1,00	0,25	0,33	0,20	0,17	0,14	0,13
Velocity Limit	0,17	3,00	4,00	1,00	2,00	0,50	0,33	0,25	0,20
Traffic Volume	0,14	2,00	3,00	0,50	1,00	0,33	0,25	0,20	0,17
Traffic Jam	0,20	4,00	5,00	2,00	3,00	1,00	0,50	0,33	0,25
Junction Delay	0,25	5,00	6,00	3,00	4,00	2,00	1,00	0,50	0,33
Building Density	0,33	6,00	7,00	4,00	5,00	3,00	2,00	1,00	0,50
DPR	0,50	7,00	8,00	5,00	6,00	4,00	3,00	2,00	1,00

Firstly, priorities of each factor is calculated by geometric mean method given as equality (1) then priorities (w_i) are calculated by equation (2). Calculated priority values of each factor is presented Table 5.

Table 5. Priority Values

RL	RW	RT	VL	TV	TJ	JD	BD	DPR
0,308	0,025	0,018	0,051	0,035	0,074	0,108	0,157	0,223

Consistency Ratio (CR) is measured by using the equations 3 and 4 to check consistency of comparison matrix which can be seen in Table 6.

Table 6. Consistency Ratio Value

Criteria	ri	W		
RL	4,147	0,308		
RW	0,332	0,025	**λ**	9,400
RT	0,241	0,018		
VL	0,685	0,051		
TV	0,473	0,035	**CI**	0,050
TJ	1,000	0,074		
JD	1,459	0,108		
BD	2,113	0,157	**CR**	0,035
DPR	3,008	0,223		

As shown in Table 5, the most important factor which effects travel time of emergency response teams after an earthquake to reach demand points is length of road with 0,308 value. It is followed by damage proportion of road, building density, junction delay, traffic jam, velocity limit, traffic volume, width of road and type of road, respectively. Type of road and width of road have lower effect on travel time. Therefore they are having lower contribution in finding an optimum and dynamic route.

Although AHP has a consistent systematic in itself, realism of the results depends on the consistency in pair wise comparison which made by the decision makers among all criteria. Thus we performed consistency analysis to check consistency of comparison matrix (Table 6). Consistency Ratio (CR) was calculated as 0.035 by equation (3) and (4). Since 0.035 less than 0.10, the consistency is acceptable.

CONCLUSION AND FUTURE WORKS

In this study, our aim is to define and weight the criteria which affect the travel time of disaster response vehicles to reach the demand points after an earthquake by causing delays in travel time. After an earthquake finding a path which takes minimum travel times is critical. There are many factors which influences travel time in real time. While finding optimal routes for the relief vehicles after a possible earthquake, considering effects of all factors in contribution to optimum and dynamic travel time path is very important. While defining the criteria we survey the literature and we also consult experts. After finding the criteria and their relation with each other we prepared a questionnaire for the experts to give scores for the criteria and we used multi criteria decision methods to evaluate the questionnaire and find the weights of the criteria. We used Analytical Hierarchical Processing to find factor priorities and to decide which factor play great role in yielding optimal path.

In our study we just described the criteria and find the weights of them. By using our criteria weights, future works will focus on finding optimum and dynamic path between respond and demand points, considering effects of all factors to use in any emergency situations as a possible earthquake.

These criteria can also be referred by the future works to find optimal routes for other kind of disasters.

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THE STRONG RELATIONSHIP BETWEEN LOGICTICS MANAGEMENT AND DISASTER RESPONSE

Ahmet Murat KÖSEOĞLU[77], *Türkan Müge ÖZBEKLER*[78]

Abstract – Disasters interrupt the regular life of people and overcome community's compliance ability. Disasters cause a high mortality rate, loss of property and injuries. Disaster management covers the phases before, during and after disaster. The main drive of disaster response is to minimize the impact of disaster on affected people and get better the conditions caused by disaster as soon as possible. Disaster management aims to prevent and reduce the physical and economic losses in any country. Another aim is to decrease people's suffering and speed up the reconstruction process. The foundation of a successful aid operation depends on timely, balanced and fast delivery of aid materials and equipment. Considering all disaster management activities, the great and also the most difficult part is logistics. Food, water and health services are the most vital systems of disaster region and need to be provided by logistics. Disaster logistics provide the bridge between aid materials and the areas of disasters. Disaster logistics ensure the efficient flow of aid to disaster areas. Logistics activities constitute the most important part of the humanitarian aid operations and disaster management. In this study, the strong relationship between disaster logistics and disaster response has been examined.

Keywords –Disaster Management, Disaster Response, Logistics Management

INTRODUCTION

Any extraordinary event which causes damage on the environment or for the people in the aspects of economical, social, cultural and psychologically can easily ruin the regular life order. It is widely announced that the intensity and impact of disasters are rising year by year and the number of people affected from disasters are growing. Despite the developed technologic and scientific improvements, disasters continue to cause negative results over communities.

The disasters' possible effects that lead to mankind's sufferings are targeted to decrease by national and international humanitarian aid operations. The content of a successful aid operation is closely related with timely, coordinated and fast delivery as an instant response of aid materials and equipment. Thanks to disaster management activities cause possible actions can be implemented before, during or after of any potential risk to return the normally functioning order as quickly as possible. With necessary disaster preparedness, disaster management and disaster response, it is possible to prevent disasters' destruction to some extent and overcome the disasters' negative effects with minimum losses through accurate measures and planning.

During the preparation period of disaster management, according to the highly possible impacts of disaster, actions are estimated and planned before its occurrence. When the disaster takes a place, these plans are operated to minimize the results over the community. After disaster, efforts for re-improvement process and reducing long term negative effects through aspects of physical, psychological and economic losses are handled [9]. In this framework, logistics operations constitute the most vital part of disaster management. Such processes include phases of preparedness for pre- disaster, during disaster, and after disaster through providing urgent needs such as food, water and health services to disaster victims in the right place, within the right quantity, and at the right time. Logistics practices can be defined as the directive of system execution. The main mechanism of this system is related with the staff and environment. In origin, logistic systems are projected by humans, after these planned systems rule the people. To ensure the logistics system operation effectiveness, accurate estimations and smooth planning processes are required [4].

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Disaster Logistics is a critical element of disaster response plans to manage the flow of required goods and services as humanitarian aid operations to disaster areas as soon as possible. Logistics activities actualize the targets of disaster response which includes minimizing the effects of disaster on society and getting better after destruction caused by disaster.

In this study, the concept of disaster event in points of definition and varieties will be defined to clarify the operating case for logistics at first. Then the frame of disaster response in scope of relationship with logistic management will be emphasized. Importance of disaster logistics planning will be underlined in aspects of its scope and stages. Finally, the strong relationship between disaster logistics and disaster response will be presented.

DEFINITION OF DISASTER

Daily life and social activities for members of society suffers directly from disasters. Disasters can cause various losses in many aspects such as physical, social, economic and cultural. Because of its numerous negative effects, communities cannot handle the results of natural or man- made disasters easily [19, 27].

As a result of disasters' effects, affected societies' capability of reaction and adaptation to disasters cannot be sufficient to cope with them. Because of their destructive power, disasters lead high number of life and property loss. In consequence of natural or man-made disasters, % 95 life losses are experienced in undeveloped and developing countries. [20]

Every uncommon event such as hurricane, tsunami, flood or earthquake cannot be counted as a disaster. When it affects community in vulnerable way which causes lack of using their own resources to overcome, then referred as a disaster. As an example, whilst tsunami showed up at Gölcük on 1999 Marmara Earthquake didn't adverted as a disaster, but 2004 Indian Ocean Tsunami, which led to reach lifeless bodies over 230 thousand people in the end of event, evaluated as a disaster [19].

According to the report presented by CRED (Centre for Research on the Epidemiology of Disasters), for an event to be counted as a disaster, at least one of the following conditions should be existed [7].

- At least 10 or more death rate
- At least 100 or more injuries/ displacements
- The situation of emergency announcement by affected country's government
- Feeling necessity for calling of international aid by affected country's government.

TYPES OF DISASTER

Disasters consist of different types of incidents according to their characteristic and form of occurrence. Because of diversity among occurred disasters, humanitarian aid operations require to operate in different methods and approaches. Disaster types can be seen as follow [1];

- Natural disasters which are based on rapid move such as earthquakes, tornados, storms,
- Man-made disasters which are based on rapid move such as terror attacks, industrial accidents,
- Natural disasters which are based on slow move such as starvation, famine, epidemics,
- Man-made disasters which are based on slow move such as economic crises, refugee crises.

Among all types of disasters, most dangerous ones are related with rapid move natural disasters. This kind of disaster necessitates the quickest and most flexible response because of its destructive nature in a very short-time. On the other hand, disasters which spread out in slow movement need to long periods of aid and improvement projects. For instance, earthquakes are not presumable and actualized in rapid onset, so they suddenly cause many life loss and infrastructure damage. Otherwise, scarcity and starvation harm to humanity in long run with spreading over wide areas without damaging infrastructure [21].Owing to this variability, every aid operation requires following different paths regarding planning and implementation according to the disaster's nature at hand.

DISASTER RESPONSE

Throughout the history especially for Turkey and the neighborhood areas faced with many destructive disasters. Recently, destroying 1999 Marmara Earthquake occurred and proved society that Turkey needs amendment in executed disaster management operations. To cope with failures of disaster response, the only way is operating efficient disaster management plans. With the aim of disaster response which includes providing assistance to maintain life, disaster management provides the effective disaster response as soon as possible. Disaster management can be defined as cooperative effort towards better management of disaster with the aim of reducing the caused damage. Shortly, disaster management covers synchronized coordination and planning of all phases of disasters such as preparedness, response and first aid, restructuring processes and all measures in damage reduction [19].

Evaluation of resources at hand, creating possible disaster scenarios, work planning and requirements list are the main subjects of disaster management [20]. The purpose of disaster management involves; reducing or preventing losses in the aspects of human, physical and economic, supporting affected society from the ways of building up infrastructure and after shocking, improvements in human’s psychological situation [21].

Properly organized disaster management process considers the possible effects of disaster before it comes up. While preparedness phase is designed with using possible scenario plans and evaluations, in after response phase, restructuring step starts to minimize the long term negative effects over community. So, logistic practices which require coordination of steps to be taken indicate the most crucial parts of disaster management.

In the concept of disaster management, security, communication, psychological support, sheltering, transportation, food and health assistances are the basics of the disaster response plans. These modules should be arranged cooperatively and communicatively to operate effective and efficient disaster management. The priorities of these modules alter according to the characteristics of the disaster at hand [19].

When achieving disaster management plans, information systems undertake important role. The processes of disaster management which are consist of damage reduction, preparedness, response and reconstruction is executed by advanced disaster management systems. Thanks to these systems, both field and administrative staff obtain benefits [18].

After occurrence of disaster, emergency health services are vital for staying alive. Taking care of disaster victims in safe zones, emergency response to the injured people and ensuring psychological support to community are critical actions after shock of the disaster. As taking actions, the right distribution of medical staff to disaster zone in a right time can be important point to reduce deaths and psychological traumas. Also, whatever the conditions hard to reach disaster area, military forces could find a way to provide health services and logistic support [13]. Because of the high number of injured population in collection centers, Medical personnel should be aware of infectious diseases after the disaster [8].

LOGISTICS MANAGEMENT

Logistics can be defined as a the process of satisfying customer needs and wants; gathering necessary materials, technologies, and information to optimize goods or service-producing through meeting requests from network in a timely manner [10]. Logistics management process consists of planning, implementing and controlling of procedures for efficient and effective actualization of targets with the purpose of fulfilling customer requirements. This process covers inbound, outbound, internal and external movements in network [11]. Logistics management provides opportunities for better capacity utilization, inventory reduction and closer integration with members of network at planning level. The underlying idea behind logistic management is co-ordinating the materials flow from source to user as an integrated system rather than flow as series of independent activities [14].

The main idea of disaster logistics follows same direction with content of logistics management. While disaster logistics comprise functions such as preparedness, supply, transportation, tracking, warehousing, inventory control and customs, providing flow and storage of all necessary supplies and information effectively from origin to disaster area is the mission of disaster logistics [23].

Saving lives after natural or man-made disasters forms purpose of humanitarian aid operations which largely consist of logistics practices. Efficient humanitarian aid operations connected with lead time of aid materials and services at right amounts, on right time and in right circumstances for the areas in requirement. In emergency situation, transportation of medicals, communication stuff, food, shelters, and administrative personnel to disaster area play crucial role. [26]

Infrastructural incapacity, political barriers, lack of cooperation within organizations and lack of information can damage the process of humanitarian operations [17]. After the occurrence of disaster, destructive results cause logistic operation restrictions such as insufficient capacity of the seaports and airports, poor conditions of roads, unsafe storage places and communication system damages. All of these limitations give rise to reduce the effectiveness of logistic activities [22].

While the participation to humanitarian aid highly relies upon voluntariness both in financial and manpower frames, this kind of aid is not related with commercial transaction. According to type and effect of disaster, final delivery point can diverse from injured people to damaged infrastructure [6]. In operating effective humanitarian aid operations, non- governmental organizations give priority to get donations and find donors for the aid at urgency moments. But donors usually make their donations for short term urgencies. Long term investments on logistics systems do not receive much attention [16].

Despite the disaster’s nature and its difficulties, all logistic activities have to practice rapidly in disaster area. Time is the most important point to evaluate operation’s efficiency. Also, designing proper coordination among the different organisations and participants is highly important in the phase of designing logistics system during preparation period with the aim of increase in logistics operation efficiency [2].

It is generally known that eighty percent of disaster operations consist of critical logistic activities roughly [23]. For this reason, logistics can be seen as the most important and costly part of disaster management. In a result of this, it could be clearly implied that successful disaster management highly depends on well-planned and successful executed disaster logistic activities [25].

METHOD

In this study, qualitative approach is used.. As the research method, literature review is picked. Declarations, real time disaster management informations, news, aid organizations’ activity reports are gathered as resources. Issues about disaster logistics are identified by researching recent disaster events.

FINDINGS

When disaster occurs, there is no extra time for completing unfinished disaster management plans or making new ones [24]. People’s needs which can be assisted by humanitarian aid operations require properly planned and coordinated logistic management plans and designing disaster logistic activities. Detailed planning for logistic activities to actualize successful disaster management can be divided into four phases; which are strategic planning phase, preparedness phase, pre-disaster phase and post-disaster phase [3]. To conduct a disaster with minimum trouble, the main topics are needed to be determined during the strategic planning phase. The most important topics include comprehensive coordination of information flow and close connection with international, local, regional organizations. Also in the strategic planning phase, recent informations for using during disaster can be very beneficial to find out. These kind of recent information may be related with climate, population density, highway infrastructure, transportation, fleet air and sea port capacity, storage facilities, communication systems, and location of main fuel stations about the operation area [5].

During the disaster preparedness phase, logistical support is not only evaluated according to the strategic plan but also according to the different scenarios [15]. All logistics plans should definitely be in the same line with other disaster management plans. The logistics plan has to be flexible, predictable and keep alternative practices in it. Considering the level of investment on transport and communication before the disaster, usually defines the effectiveness of logistic activities during disaster [5].

Logistics activities are %80 of disaster management which is the crucial and costly part of disaster management. %65 Part of this %80 is consisting materials and equipment procurement cost. Remaining %15 is transportation and storage expenses. Therefore planning and implementation of logistics activities should be considered carefully [4, 12, and 13].

Humanitarian aid organisations play a big role as the bridge between victims and donors of disaster by providing coordinated humanitarian supply chain [24]. Logistics activities should be integrated with the humanitarian supply chain operations. These operations involve linkages of all logistic activities such as administration of the aid programs, donation process, and budget management [15]. Most humanitarian organizations do their operations into two parts; field operations and support activities. While transportation and distribution of aid materials such as water, food, medicine, and shelter generate field operations, efforts about technology, finance, communication and human resources can be defined as supporting activities. All of these logistic activities place vital role in disaster management [2].

CONCLUSION

Once any disruptive disaster occurs, the life order of humans and environment is affected deeply in negative way. After occurrence of disaster, alongside all the human injury, there is also huge physical damage in infrastructure and environment. While disasters which are resulted from natural or man-made factors cannot be stopped, by using systematic logistic management vision, the effects of diaster can be reduced or prevented gradually.

The most important thing in disaster response is reacting quick and effective with taking necessary measures and providing sufficient aid at right time, in right place and with accurate plans. Through efficient disaster preparedness, it could be realistic to overcome disasters' destructive effects to some extent with minimum losses. The aim of disaster logistic activities involves creating effective disaster response with implementation of forecasting, risk-management, excellent planning, effective management of plans, and ability to adapt them into different conditions which can change with the nature of disaster characteristics.

In the framework of disaster management, security, communication, psychological support, sheltering, transportation, food and health assistances are the basic logistics activities of the disaster response plans. To operate effective disaster response, practices such as supporting affected society from the all aspects like building up infrastructure, helping for improvements in human's psychological situation for minimizing all negative results over long term should be managed successfully. This situation proves that logistic activities cannot be separated from disaster response. For this reason being successful in disaster management mainly depends on excellent performance of logistics operations on the disaster area.

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DISASTER LOGISTICS PREPAREDNESS INDEX FOR CITIES IN FIRST DEGREE SEISMIC ZONE OF TURKEY

Mehmet TANYAS[79]*, Ismail KARAYUN*[80]

Abstract - The scope of delivery of relief materials at the right quantity, right time and right cost, to people affected either by man-made or natural disasters requires making short-term and long-term disaster plans. Such plans are classified as pre-disaster, during disaster and post-disaster plans; and it is crucial to implement various disaster strategies by considering the "uncertainty" criteria. In humanitarian logistics all these plans can be materialized by prosper management to deliver and store relief materials in order to rescue communities affected by disasters. This study aims to reveal the disaster preparedness level of each city in the first-degree seismic zone of Turkey under the frame of a stream of predetermined criteria with respect to a large scale earthquake scenario. The mentioned criteria are analyzed in accordance with AHP (Analytical Hierarchy Process) method by getting expert opinions and weighed to indicate the importance level of each criteria. The preparedness index of each city shall be presented and classified considering certain factors including above mentioned weighed index criteria, population, disaster risks and geographical features.

Keywords- Disaster Logistics, Humanitarian Logistics, Index, Analytic Hierarchy Process

1. INTRODUCTION

The concept of disaster logistics is an area with increasing significance whereas the measures developed by states and even individuals against various disaster types have importance in terms of disaster management. All actions to be taken before, during and after the disaster are identified in disaster management plans and updated with the context of the effects ot the disaster. In case of a disaster under disaster logistics; it is crucial to deliver the required materials to the right place, at the right time and in the required amount. In this regard, issues including condition of the logistics storehouses where the materials required in regions affected by the disaster shall be supplied, the disaster management plan comprising the actions to be taken before and after the disaster, the field hospital where the injured shall be cured, and main and alternative roads between all logistics units address important details within disaster logistics.

This study aims first to clarify disaster logistics and humanitarian logistics concepts; and then to analyze disaster logistics preparedness levels of cities located in the first-degree seismic zone of Turkey under the frame of a stream of predetermined criteria. Knowing how prepared a city is against a disaster under the scope of disaster logistics, considering disastrous level of cities under predetermined criteria, shall determine the logistics preparedness level of the mentioned city against unexpected disasters. The cities shall be alined pursuant to disaster logistics preparedness index to be created for each city, and interpretations shall be made between disastrous level and disaster logistics preparedness level of a city.

2. DISASTER LOGISTICS DEFINITON

Disaster management has a vital role when facing disaster by natural or man-made. When it is looked at applications and preacautions about disasters in countries, it is clear that most of them are not ready to face with a real disaster. Logistical and infrastructural investments are highly important and it seems as the major part of disaster management. Some applications can be operated before disaster and it is named as pre-disaster but most of them are operated after disaster so named as post-disaster. To understand the level of damage and

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organizing food, water and other necessities at right time and right quantity for people needs a well-developed humanitarian supply chains.

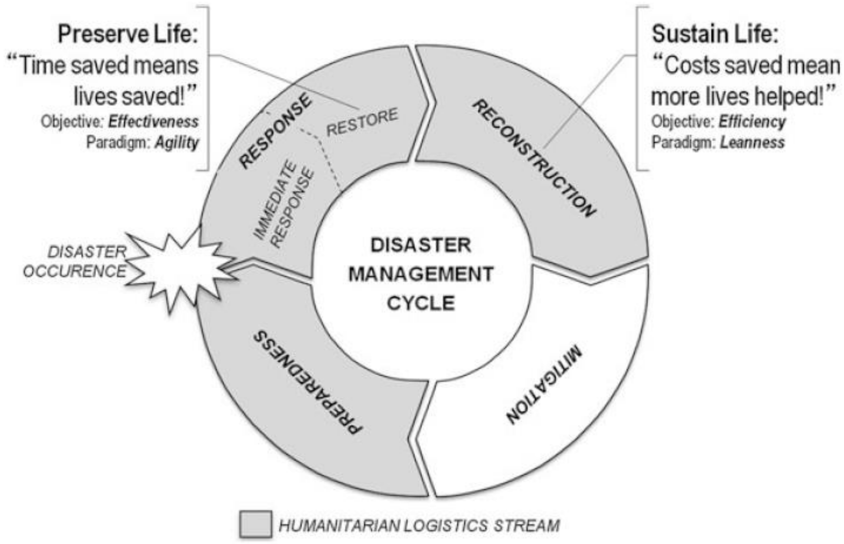

Figure 1: Humanitarian Logistics Stream
Source: Cossolino et.al[1].

Disaster management is often described as a process with several stages, borrowing from the risk management literature, talks about the planning, mitigation, detection, response and recovery phases of disaster management [4]. Within the context of disaster logistics, there are four important stages as it is seen above. According to Hadiguna et.al [2] *Preparedness* refers to "activities enhance the ability to respond immediately after an incident including the response procedure development, design and installations of warning systems, evacuation planning and also training for emergency operations". Also *Response* is an activity which occurs during or immediately after disaster to meet the immediate needs of disaster victims including mobilization and positioning of emergency supplies, equipment and personnel, undertaking time-sensitive operations such as search, rescue and evacuation as well as providing emergency medical care, food and housing programs. To be successful in response phase it depends on information reliability. Because according to Perry [5], Information plays a crucial role in disaster management. It is clear that the speed with which the critical information is collected, analyzed and distributed by participating agencies will facilitate an effective response and hence more lives can be saved *Recovery* refers to repair of buildings, bridges and other facilities effected by disasters. The last phase named as *mitigation* refers to activities which make people more conscious about disasters and to lessen disaster effects by such as trainings for people to explain how reduce disaster risks. So it is clear that preparedness and mitigation phases are mentioned as pre-disaster activities even recovery and response are mentioned as they are post-disaster activities.

In disaster management, according to Sheu [7], quick response has vital role to operate disaster process efficiently. It is to the urgent need of relief in affected areas right after disasters is a critical issue for emergency logistics, which has aroused growing concerns and research interests recently due to the occurrence of several notorious disasters either natural or man-made. But in order to support quick response to effected areas is not an easy activity because of demand uncertainty and severity of effected areas differently by disasters. Therefore, to cope with disasters and manage the most effective way to help people and maket hem survival, there is to need emergency logistics management instead of business logistics activities.

3. DISASTER LOGISTICS PREPAREDNESS INDEX: AN APPLICATION

3.1. OBJECTIVE AND SCOPE

Under the scope of disaster logistics, it is extremely important for human survival to execute the logistics functions in regions affected by disaster, whatever the nature of the disaster may be. Apart from issues including transportation, storage, stock management of relief materials to people in these regions; providing health care, designing all logistics processes pursuant to disaster management plans, and availability of roads and required facilities to those people reinforces preparedness of the mentioned region for disaster logistics.

A lot of major earthquakes have occurred in Turkey until now. Given the fact that Turkey has witnessed loss of lots of lives and significant material damages due to earthquakes in terms of disasters; it is essential to take exceptional measures against this disaster type. Today, in addition to urban transformation attempts initiated especially in big cities regarding this issue; it is necessary to technically determine the preparedness levels of cities for disaster logistics.

The objective of the study is to exhibit disaster management competence of regions selected according to criteria obtained from primary and secondary data sources. Only earthquake is taken into consideration in terms of disasters in our study, whereas other disaster types are excluded.

3.2. DATA COLLECTION, ANALYSIS AND FINDINGS

In data collection phase, a classification is made especially according to seismicity of cities. To make a classification, especially first-degree seismic zones were defined with reference to Seismic Zone Map of Turkey published by R.T. Prime Ministry Disaster and Emergency Management Presidency [6].

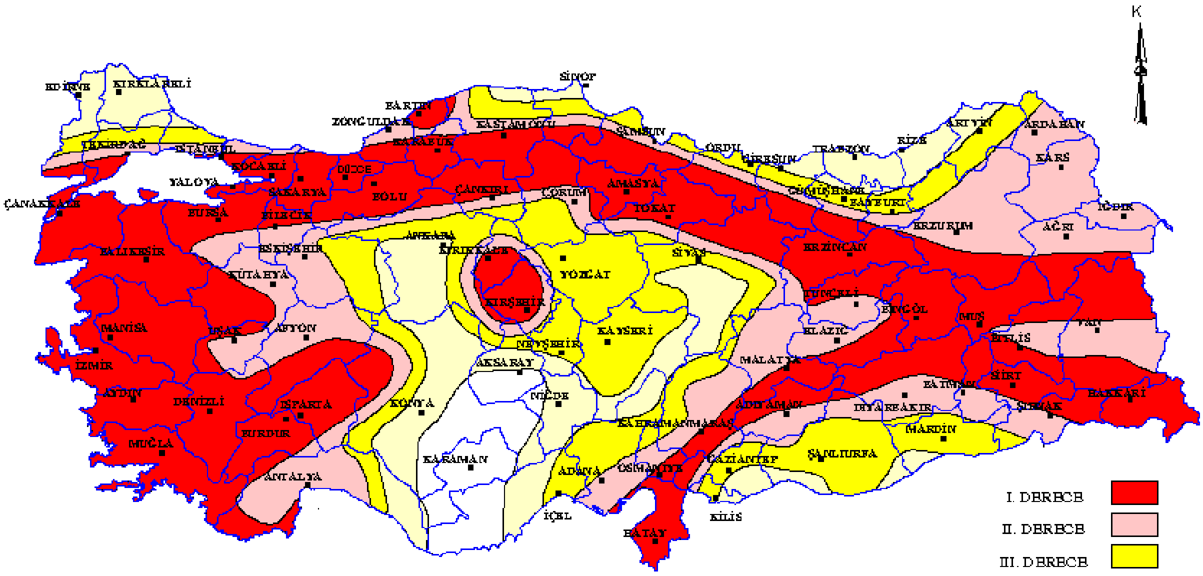

Figure 2. Seismic Zone Map of Turkey

Source: Prime Ministry Disaster And Emergency Management Presidency Official Web Site, (http://www.deprem.gov.tr), [Reach: 10.07.2015].

In light of the data obtained from R.T. Prime Ministry Disaster and Emergency Management Presidency, seismicity level of Turkey can be demonstrated in various colors according to risk factors as given in the above figure. First-degree seismic zone covers 34 cities. Yet, preparedness of 8 cities has been analyzed for disaster logistics under the scope of this study, online disaster information system of which can be accessed.

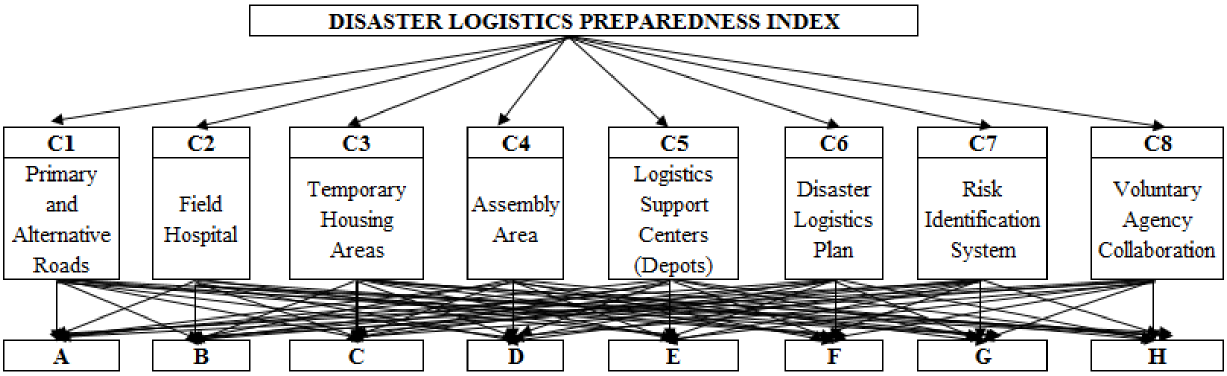

Figure 3. AHP Hierarchy – Disaster Logistics Preparedness Index Criteria's

8 cities named in the first-degree seismic zone in Seismic Zone Map of Turkey are included in this study; yet their names are not disclosed but indicated in letter as A, B, C, D, E, F, G and H). The criteria defined in the scope of *Disaster Logistics Preparedness Index* are; *Primary and Alternative Roads (C1), Field Hospital (C2), Temporary Housing Areas (C3), Assembly Area (C4), Logistics Support Centers (Depots) (C5), Disaster Logistics Plan (C6), Risk Identification System (C7) and Voluntary Agency Collaboration (C8)* criteria. Experts are consulted to define criteria weights and criteria weights are calculated by AHP (Analytical Hierarchy Process) method. AHP method is a decision making and estimation tool which provides percentage distributions of decision points in terms of factors influencing decision making; and it is used for identification of decision hierarchy [10]. Preparedness of cities against given criteria is assessed by attributing scores to the criteria in accordance with the acquired criteria weights; and disaster preparedness and disaster resilience of cities are calculated to make comparisons.

Table 1: AHP Assessment Criteria

Score	Definition	Statement
1	Equal Importance	Two activities make equal contribution to the objective of the study.
3	More Importance	One activity is preferred over the other with experience and judgment
5	Strong Importance	Preferring One activity is preferred over the other with strong experience and judgment
7	Very Strong Importance	One activity is strongly preferred and its dominance can be observed in the implementation
9	Full Importance	Evidences for preferring one activity over the other have major credibility
2,4,6,8	Average Values	Values falling between two successive judgments to be used when agreement is required

The criteria must be assessed by experts for implementation of AHP method. Expert opinions are defined as given in the above table according to 9 Point Likert Scale. All sums in relation with the method are calculated using MS Excel. Geometric means are calculated for each criteria according to expert opinions obtained using these values and criteria weights are identified.

Table 2: Weighted Disaster Prepredness Index Criteria Matrix

WEIGHTED CRITERIA'S MATRIX									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**Wi**
C1	0,09	0,16	0,14	0,11	0,12	0,11	0,07	0,07	**0,11**
C2	0,06	0,11	0,12	0,09	0,11	0,11	0,16	0,13	**0,11**
C3	0,06	0,08	0,09	0,06	0,09	0,10	0,09	0,09	**0,08**
C4	0,04	0,06	0,06	0,05	0,05	0,05	0,03	0,05	**0,05**
C5	0,11	0,14	0,13	0,14	0,14	0,17	0,11	0,16	**0,14**
C6	0,37	0,31	0,27	0,28	0,26	0,30	0,36	0,32	**0,31**

C7	0,20	0,10	0,14	0,23	0,19	0,12	0,14	0,14	**0,16**
C8	0,07	0,04	0,05	0,05	0,04	0,05	0,05	0,05	**0,05**

In accordance with the information obtained from Weighted Disaster Preparedness Criteria Matrix; the most important criteria is the Disaster Logistics Plan (C6) with 31%, the second most important criteria is the Risk Identification System (C7) with 16% and the third and most important criteria is the Logistics Support Centers (Depots) (C5) with 11%. In the analysis performed using AHP method, reliability of calculations and accurateness of analysis depend on the Consistency Measure value. Here, consistency of factor comparisons are defined and if the resulting value is smaller than 0,10 the comparisons made by the decision maker are correct (Yaralıoğlu, 2010). When determining the consistency value, Consistency Indicator (CI) and Random Indicator (RI) values are required. As a result of the calculations CI value is identified as 0,03 and RI value is identified as 1,41, whereas Consistency Value is calculated as 0,02 (the CI/RI ratio). The fact that 0,02<0,10 proves that the factor comparisons are correct and there is not any inconsistency.

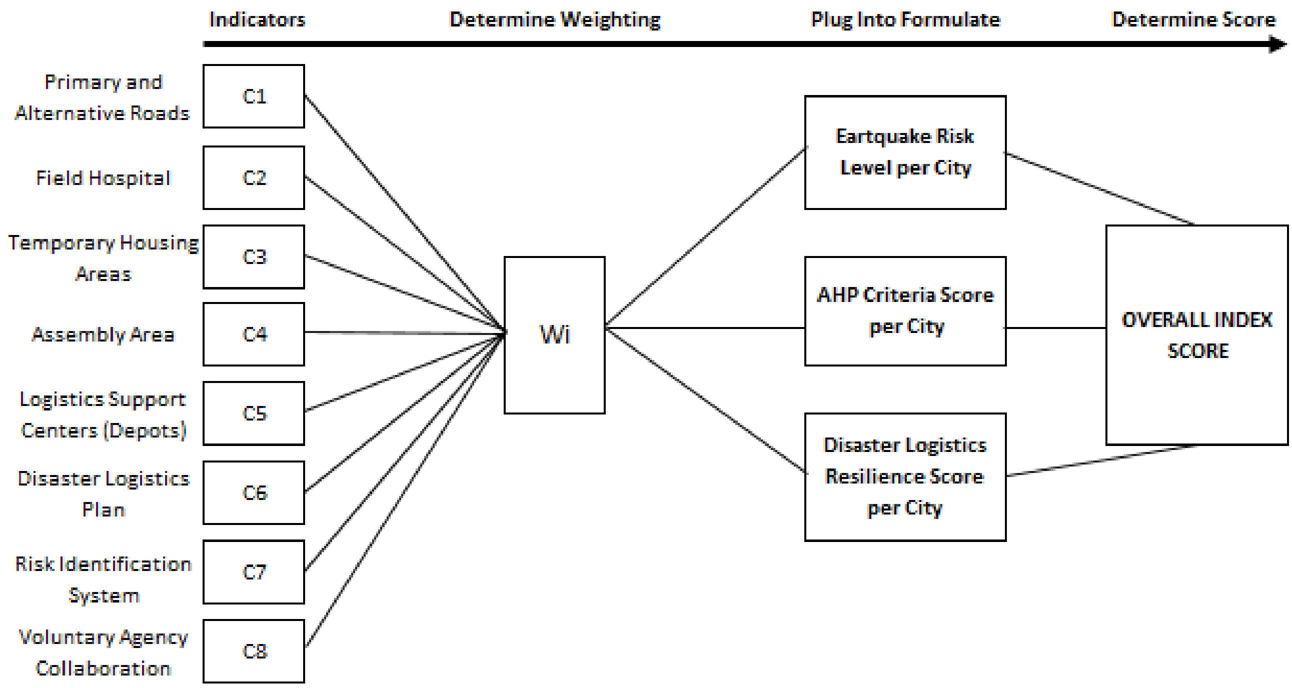

Figure 4: Disaster Indexing Measurement Model Diagram, ***apopted from Simon*** **[8].**

After identifying and naming the criteria required for calculation of disaster logistics preparedness index, some certain values must also be calculated to determine the disaster logistics preparedness index based on cities including seismic risk level per city, total criteria value obtained as a result of the AHP method, and disaster logistics resilience score.

Table 3. Determination of Disaster Logistics Resilience Score

		Cities							
	Calculation Method	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Population	Derived from Turkish Statistical Institute (2014)	14.377.018	4.113.072	932.706	1.722.795	511.790	978.700	2.787.539	1.089.038
Seismic Risk Level per City	Σ(District Population*Eartquake Risk Level per District) / Total City Population	1,69	1,00	1,00	1.03	1,00	1,00	1.02	1,47
AHP Criteria	Criteria *Wi* Value*(1-city has criteria, 0-	1,00	0,79	0,95	0,86	0,84	0,79	0,65	0,31

Value	null)								
Disaster Logistics Resilience Score	AHP Criteria Score/Earthquake Risk Level	0,59	0,79	0,95	0,84	0,84	0,79	0,64	0,21

When calculating *disaster logistics preparedness index* for cities, population appears as an important value. On the other hand, when calculating seismic risk level for each city, some districts remain in the first seismic zone whereas others remain in the second or third seismic zones. In order to avoid effects of this variation on calculations, disaster logistics resilience score of the city is identified and certain assessments are performed based on districts. When carrying out assessments for districts, seismic risk level of each district is obtained from Seismic Risk Table of İstanbul Chamber of Civil Engineers [3] and 2014 district demographics are obtained from Turkish Statistical Institute [9]. Population of each district and seismic risk level is multiplied and added to determine “Seismic Risk Level of the City”. AHP Criteria Value of the city is determined considering whether or not the criteria, weights of which are defined according to AHP method, are within the city (1-yes, 0-no). When AHP Criteria Value of the city is divided by Seismic Risk Level of the city, Disaster Logistics Resilience Score is obtained. Looking at the results, C city has the greatest Disaster Logistics Resilience Score followed by D and E cities in the second place with the same scores; and followed by B and F in the third place again with the same scores.

To calculate disaster logistics preparedness index of each city, categories for each criteria are determined and scored instead of analyzing index values within the city by Yes-No analysis by giving values (0, 1). When we look at possessive levels of cities with regard to these criteria in accordance with online accessible disaster information systems A city is in the first place with 9,30, G city is in the second place with 7.18, and C city in the third place with 7.08 as shown in the above given table. When seismic risk level values and disaster logistics preparedness index of cities are compared; A city is expected to have the greatest Disaster Logistics Preparedness Index in line with its greatest seismic risk level; A city not surprisingly has the greatest preparedness index value with 9.30. However, though H city has the greatest seismic risk level after A city, its Disaster Logistics Preparedness Index as 2.75 takes it to the eight place instead of the second.
The same is valid for D city; meaning D city is in the third place in terms of seismic risk level with 1.03 and in the fifth place in terms of Disaster Logistics Preparedness Index Value. Seismic risk levels and disaster logistics preparedness index values of cities are not always in direct relation due to reasons including development levels of cities, population, perception of disaster in cities, economic structure of cities.

Table 4. Disaster Logistics Preparedness Index Results

					FIRST DEGREE SEISMIC ZONE - CITIES							
Code	**Wi**	**Criteria**	**Evaluation**	**Score**	**A**	**G**	**C**	**B**	**D**	**F**	**E**	**H**
C6	**0,31**	**Disaster Logistics Plan**	%100 of City and Districts	10	10	7,5	7,5	10	10	7,5	5	5
			%75 of City and Districts	7,5								
			%50 of City and Districts	5								
			%25 of City and Districts	2,5								
			None	0								
C7	**0,16**	**Risk Identification System**	Enough	10	10	10	5	0	5	5	0	0
			Relatively	5								
			None	0								
C5	**0,14**	**Logistics Support Centers (Depots)**	Enough	10	10	5	10	5	0	5	0	0
			Relatively	5								
			None	0								
C2	**0,11**	**Field Hospital**	Enough	10	5	5	5	5	5	0	5	0
			Relatively	5								

			None	0								
C1	**0,11**	**Primary and Alternative Roads**	Enough	10	10	10	10	10	5	5	5	5
			Relatively	5								
			None	0								
C3	**0,08**	**Temporary Housing Areas**	Enough	10	10	5	5	10	5	10	0	5
			Relatively	5								
			None	0								
C8	**0,05**	**Voluntary Agency Collaboration**	Enough	10	5	0	0	0	0	0	0	0
			Relatively	5								
			None	0								
C4	**0,05**	**Assembly Area**	Enough	10	10	10	10	10	10	5	5	5
			Relatively	5								
			None	0								
			Disaster Logistics Preparedness Index		***9,30***	***7,18***	***7,08***	***6,75***	***5,90***	***5,43***	***2,90***	***2,75***
				Seismic Risk Level per City	1,69	1,02	1,00	1,00	1,03	1,00	1,00	1,47
				AHP Criteria Value	1,00	0,65	0,95	0,79	0,86	0,79	0,84	0,31
				Disaster Logistics Resilience Score	0,59	0,64	0,95	0,79	0,84	0,79	0,84	0,21

4. CONCLUSIONS AND RECOMMENDATIONS

When calculating disaster logistics preparedness indexes of cities; demographic values of districts and seismic risk values of districts also have significance in addition to total population of cities. Because when we look at seismic zone maps, we see that though a city might be places in the first seismic zone, certain regions of the same city might be placed in second and even third seismic zones. In order to get rid of this problem and to portray the city as a whole; calculations are made considering demographic values and seismic levels of each district, scores are appointed for the criteria obtained under the scope of AHP, and cities are alined according to their Disaster Logistics Resilience Values. Then, an effort was made to determine efficiency of cities in terms of logistics infrastructures which have significance on disaster logistics of cities with disaster logistics preparedness index. The data included in the disaster logistics preparedness index table are determined in accordance with the information obtained from online accessible disaster information systems. Criteria identification and scoring system will be developed in future studies.

As a recommendation of the study, the mentioned index study should not only be performed in 8 cities but also in 34 cities in the first degree seismic zone. Besides, this study which has been carried out for earthquakes, should also be carried out for all other disasters for first degree risk zones. Thus, a detailed analysis might be carried out for disasters in terms of regions with greatest risk factors. These steps shall be followed in further stages of this study.

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HUMANITARIAN LOGISTICS: A BIBLIOMETRIC ANALYSIS (2000-2015)

Ismail KARAYUN[81], *Mehmet TANYAS*[82]

Abstract- The humanitarian logistics is newly-emerging topic in logistics that aims to plan and control inventories of goods in efficient way and deliver to communities affected by natural and other disasters. The success of disaster response is highly depends on prosper planning of relief inventories with regarding key logistics goals as right place, right time and right quantity in order to avoid excess using inefficient ways. Considering the importance of humanitarian logistics, in this paper it is aimed to reveal bibliometric analysis on papers related to humanitarian logistics published between 2000 and 2015. This study aims to develop a literature review on the subject of the Humanitarian logistics and presents a comprehensive analysis of the studies in this field in order to execute main topics, trends, most-cited articles to have new perspective for further researches.

Keywords - Bibliometrics, Disaster Logistics, Humanitarian Logistics, Relief

1. INTRODUCTION

Researches on humanitarian logistics gained a rapid increase especially after 2000s. Disasters occurring in various forms yet in increasing numbers in our day made it a necessity for a lot of public and private agencies and institutes, particularly United Nations, to carry out studies intended for disaster management. Measurement studies to reduce impacts of disasters have gained speed all over the world especially with plans based on collaboration of public and private sectors in terms of disaster management. In academic sense, studies as to what should be done to create a successful disaster management system rapidly increased following substantial damage causing disasters, namely the tsunami which occurred in the Indian Ocean in 2004 and Hurricane Katrina which occurred in 2005. Within the scope of humanitarian logistics, which still has a lot of untouched areas to make researches, there are a good number of studies carried out especially on distribution scheduling, storage, and stock management of supplies.

This study aims first to define humanitarian logistics concept and to provide information on the importance of humanitarian logistics. In the second part of the study, completion of the bibliometric analysis and the steps to be watched during realization of these studies shall be mentioned. In the last part of the study, a general table shall be comprised including a classification of studies derived from keyword groups under the scope of humanitarian logistics mentioned in the database of the *Web of Science* between 2000-2015 based on year, publication, subject and numbers of citations.

2. DEFINITION OF HUMANITARIAN LOGISTICS

Both natural and man-made disasters, which have occurred in the past few decades have alerted the world community to the importance need to be able to build an efficient and agile humanitarian supply chain [5]. Humanitarian logistics is focused on delivering the right goods and services to the right people at the right time and at the right price and transportation is a key aspect of humanitarian logistics and is a considerable cost to humanitarian [2]. In order to be prosper in humanitarian supply chain management Yang et.al.[5] suggest that the speed of response for major humanitarian programmes depends on the ability of logisticians to procure, transport and receive supplies at the site of a humanitarian effort, such as the humanitarian logistics centres (HLCs) which are the most important sites where both freight and information flows are congregated, relayed or distributed. In accordance with this explanation, as indicated by Tatham et.al.[3] to make good co-operations and inter-sectoral partnerships and link humanitarian organisations (i.e. aid agencies and humanitarian Non-Governmental Organizastions) to governments, local communities, business (suppliers and

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logistics service providers) as well as the military; all these together forming the humanitarian aid supply network also has a vital role to success.

Veras et.al.[4] also mentioned about short-term and long-term activities in humanitarian logistics and generalized these terms as short-term activities place at post-disaster humanitarian logistics (PD-HL) but long-term activities can be mentioned at pre-disaster (Regular Humanitarian Logistics) phase. In long-term activities mostly relate with infrastructure and investments in order to make good disaster planning and use basic functions of logistics efficiently. In contrast, short-term activities cover distributing food water and all necessities for people and saving lives. Veras et.al.[4] identified seven key characteristics that differentiate commercial logistics, regular humanitarian logistics, and PD-HL: objective pursued, origination of the commodity flows, knowledge of demand, decision-making structure, periodicity/volume of logistic activities, state of social fabric and networks, and state of the supporting systems. In order to make clear about differences between commercial logistics and humanitarian logistics, commercial logistics deals with certain limits about demand and supply. But this situation is not acceptable for humanitarian logistics because lack of knowledge about intensity and types of disasters. Therefore, humanitarian logistics operations are based on more developed forecasting techniques and disaster experiences.

3. GENERAL STRUCTURE OF BIBLIOMETRICS

In bibliometric studies, academic studies carried out for certain subjects are analyzed to reveal a detailed framework of research axis, new trends, used methods and models on the given subject. According to Zary et. al [6]; *"Bibliometrics is a quantitative technique of statistical measurement of the rates of production and dispersion of scientific knowledge. In this context, we can claim that bibliometrics studies analyze academic studies quantitatively and statistically other than qualitatively to reveal structures of academic studies more explicitly with more tangible data".* On the other hand, Daim et.al [1] define Bibliometrics as it helps to explore, organize and analyze large amounts of historical data helping researchers to identify "hidden patterns" that may help researchers in the decision making process.

As the procedure of bibliometrics analysis Zary et.al [6] suggested this figure to explain more clear about steps to make bibliometrics analysis:

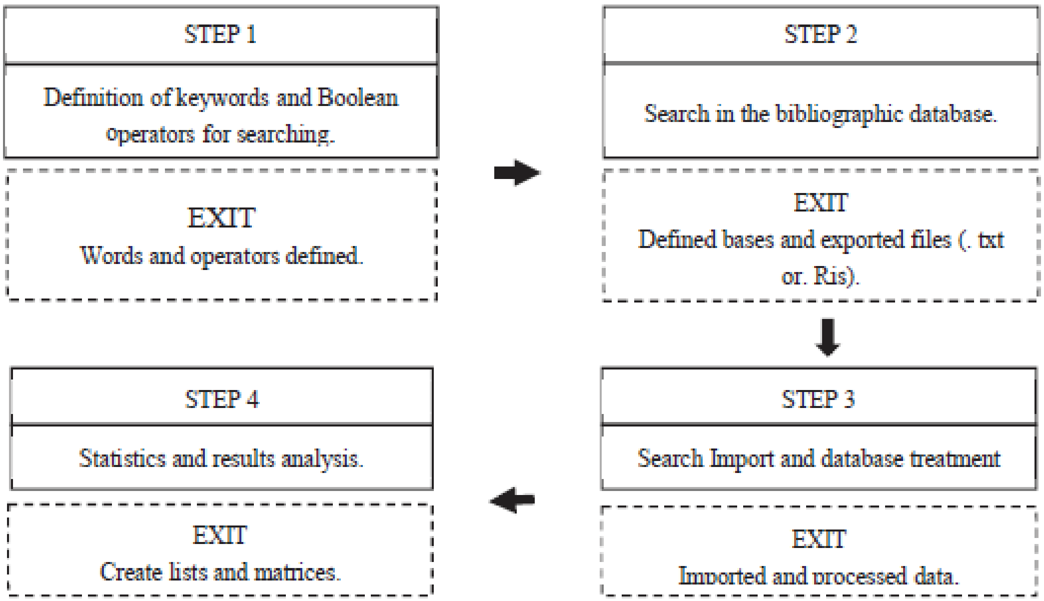

Figure 1: Proposed Bibliometric Analysis Structure

Initially, at step 1 to define appropriate key words to make bibliometric analysis by regarding intended subject has vital role to make the search results feasible. Among the academic databases, consist millions of articles about different research fields, choosing the most suitable database will make analysis process easier.

Recently *Web of Science, Science Direct* and *Scopus* are the most visited databases to make research in any field based on Social Sciences, Art & Humanities, Science & Technology etc.at research domains. After selecting the most appropriate academic database, importing search results by refining as document type, language, country, publish year, author, research area, journal etc. is third step before analysing search results. With doing this, researchers can limit the search results to make feasible bibliometric analysis. At last step depends to researcher's demand such as analysing articles by decided criteria to generate matrixes in order to expose relations between articles.

4. AIM AND SCOPE OF RESEARCH

Articles relevant to humanitarian logistics published in the database of Web of Science between 2000 and 2015 are searched and analyzed under the scope of this study. Databases of Science Direct and Scopus are excluded. *Web of Science Advanced Research* section is used to search articles and word groups including *"humanitarian^logistics", "humanitarian^supply chain", "disaster^logistics"* and *"disaster^supply chain"* which are significant in terms of humanitarian logistics are used with the help of given codes.

5. DATA COLLECTION, ANALYSIS AND FINDINGS

Total 284 records are obtained as a result of the research carried out with the help of keyword group identified in the Web of Science database.

Table 1: Numbers of Articles in Web of Science Academic Database

Database	Time Span	Search By	Document Type	Research For	Records
Web of Science	*2000-2015*	*Topic*	*Article*	**TS=(humanitarian* AND logistics*)** Refined by: RESEARCH DOMAINS: (SOCIAL SCIENCES) AND DOCUMENT TYPES: (ARTICLE) AND RESEARCH AREAS: (BUSINESS ECONOMICS OR OPERATIONS RESEARCH MANAGEMENT SCIENCE OR TRANSPORTATION OR SOCIAL SCIENCES OTHER TOPICS) AND LANGUAGES: (ENGLISH) Timespan: 2000-2015.	**63**
				TS=(humanitarian* AND supply chain*) Refined by: RESEARCH DOMAINS=(SOCIAL SCIENCES) AND RESEARCH AREAS=(BUSINESS ECONOMICS OR TRANSPORTATION OR OPERATIONS RESEARCH MANAGEMENT SCIENCE OR SOCIAL SCIENCES OTHER TOPICS) AND DOCUMENT TYPES=(ARTICLE) AND LANGUAGES=(ENGLISH)	**43**
				TS=(disaster* AND logistics*) Refined by: RESEARCH DOMAINS: (SOCIAL SCIENCES) AND RESEARCH AREAS: (BUSINESS ECONOMICS OR OPERATIONS RESEARCH MANAGEMENT SCIENCE OR SOCIAL SCIENCES OTHER TOPICS OR TRANSPORTATION) AND DOCUMENT TYPES: (ARTICLE) AND LANGUAGES: (ENGLISH) AND DOCUMENT TYPES: (ARTICLE) Timespan: 2000-2015. Search language=Auto	**94**
				TS=(disaster* AND supply chain*) Refined by: RESEARCH DOMAINS: (SOCIAL SCIENCES) AND RESEARCH AREAS: (BUSINESS ECONOMICS OR OPERATIONS RESEARCH MANAGEMENT SCIENCE OR SOCIAL SCIENCES OTHER TOPICS OR MATHEMATICAL METHODS IN SOCIAL SCIENCES OR TRANSPORTATION) AND DOCUMENT TYPES: (ARTICLE) AND LANGUAGES: (ENGLISH) Timespan: 2000-2015. Search language=Auto	**84**
					284

As we mentioned above, we analyzed researches carried out between 2000 and 2015 during the research phase. On addition to this, we preferred to make searches in terms of *"topic"* instead of "title"; because when it is searched in terms of "title", the system directly ignores the article if the keyword is not included in the title of the article. However, when it is searched in terms of "topic", the system analyzes the article even if the given keyword groups are not included in the title, but included in the abstract, keyword or the article as a whole. Especially, considering the fact that some articles bear strange titles, carrying out searches in terms of "topic" eliminates this risk. *"Article"* is selected as the document type and studies are limited to *"Social Sciences"* research area. Within the scope of the search results, another limit is that only *"English"* articles are included in the study.

The 284 studies which came into view within the scope of four main word groups *(humanitarian^logistics, humanitarian^supply chain, disaster^logistics, disaster^supply chain)* does not give us the net total number of articles. Because, one article can fall into more than one search groups (duplicate article). In order to prevent this, all articles which appear as a result of search word groups are presented in a table, a publication based classification is made and thus "duplicate article" problem is resolved. As a result of this classification, number of articles is reduced from 284 to 154, and all publications are determined to fall spread among 56 publications.

Table 2: Dispersion of Journals Humanitarian Logistics Articles Involved

NO	JOURNAL	NO.OF ARTICLES
1	INTERNATIONAL JOURNAL OF PHYSICAL DISTRIBUTION & LOGISTICS MANAGEMENT	21
2	TRANSPORTATION RESEARCH PART E-LOGISTICS AND TRANSPORTATION REVIEW	21
3	DISASTER PREVENTION AND MANAGEMENT	9
4	EUROPEAN JOURNAL OF OPERATIONAL RESEARCH	9
5	TRANSPORTATION RESEARCH PART B-METHODOLOGICAL	8
6	JOURNAL OF THE OPERATIONAL RESEARCH SOCIETY	6
7	OMEGA-INTERNATIONAL JOURNAL OF MANAGEMENT SCIENCE	5
8	SUPPLY CHAIN MANAGEMENT-AN INTERNATIONAL JOURNAL	5
9	INTERNATIONAL TRANSACTIONS IN OPERATIONAL RESEARCH	4
10	JOURNAL OF BUSINESS LOGISTICS	4
11	TRANSPORTATION RESEARCH PART A-POLICY AND PRACTICE	4
12	DECISION SCIENCES	3
13	INTERNATIONAL JOURNAL OF LOGISTICS-RESEARCH AND APPLICATIONS	3
14	JOURNAL OF OPERATIONS MANAGEMENT	3
15	HARVARD BUSINESS REVIEW	2
16	JOURNAL OF PURCHASING AND SUPPLY MANAGEMENT	2
17	JOURNAL OF SUPPLY CHAIN MANAGEMENT	2
18	THE ASİAN JOURNAL OF SHİPPİNG AND LOGİSTİCS	2
19	TRANSPORTATION JOURNAL	2
20	BUSINESS HORIZONS	2
21	INTERNATIONAL JOURNAL OF STRATEGIC PROPERTY MANAGEMENT	2
22	CANADIAN JOURNAL OF ADMINISTRATIVE SCIENCES-REVUE CANADIENNE DES SCIENCES DE L ADMINISTRATION	1
23	INTERFACES	1
24	PAPERS IN REGIONAL SCIENCE	1
25	TOURISM MANAGEMENT	1
26	INTERNATIONAL JOURNAL OF OPERATIONS & PRODUCTION MANAGEMENT	1
27	ACCIDENT ANALYSIS AND PREVENTION	1
28	ASIAN ECONOMIC PAPERS	1
29	BULLETIN OF INDONESIAN ECONOMIC STUDIES	1
30	FORBES	1
31	IMA JOURNAL OF MANAGEMENT MATHEMATICS	1
32	INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT	1
33	JOURNAL OF CONTINGENCIES AND CRISIS MANAGEMENT	1
34	SPACE POLICY	1
35	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	1
36	THE JOURNAL OF EURASİAN STUDİES	1
37	TRANSPORT POLICY	1
38	AFRICAN JOURNAL OF BUSINESS MANAGEMENT	1
39	ANNALS OF REGIONAL SCIENCE	1
40	ASIAN JOURNAL OF SOCIAL SCIENCE	1
41	CALIFORNIA MANAGEMENT REVIEW	1
42	ECONOMIC JOURNAL	1
43	ECONOMIC SYSTEMS RESEARCH	1
44	INFORMATION TECHNOLOGY & MANAGEMENT	1

45	INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	1
46	INTERNATIONAL JOURNAL OF SHIPPING AND TRANSPORT LOGISTICS	1
47	JOURNAL OF GLOBAL SCHOLARS OF MARKETİNG SCİENCE	1
48	JOURNAL OF REGIONAL SCIENCE	1
49	JOURNAL OF RISK RESEARCH	1
50	MANAGEMENT SCIENCE	1
51	MIT SLOAN MANAGEMENT REVIEW	1
52	RISK ANALYSIS	1
53	SOCIAL INDICATORS RESEARCH	1
54	SYSTEMIC PRACTICE AND ACTION RESEARCH	1
55	SYSTEMS RESEARCH AND BEHAVIORAL SCIENCE	1
56	THE INTERNATIONAL COMMERCE & LAW REVIEW	1
		154

As a result of the classification based on publications we can claim that the articles which appear under the scope of word groups related to humanitarian logistics are mostly published in *"International Journal of Physical Distribution & Logistics Management"* and *"Transportation Research Part E-Logistics And Transportation Review"* magazines with an equal publication number of 21. *"Disaster Prevention and Management"* and *"European Journal of Operational Research"* take the second place with 9 articles, and *"Transportation Research Part B-Methodological"* takes the third place with 8 articles.

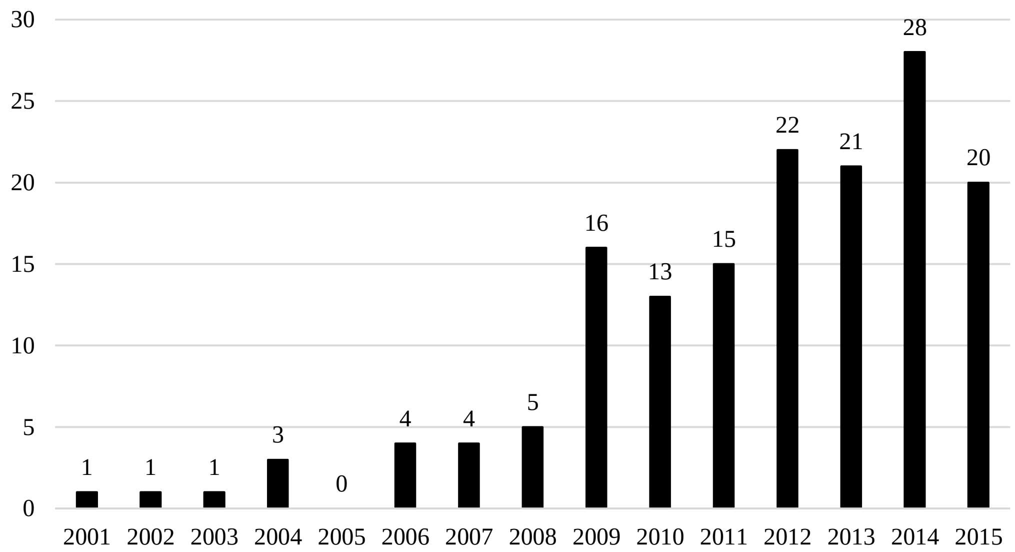

Figure 2: Dispersion of Articles Published by Year Between 2000-2015

Considering distribution of articles based on years, it is observed that number of studies on humanitarian logistics has increased especially after Hurricane Katrina which occurred in 2005 and that the maximum number of articles is in 2014. The articles which are published until today are taken into consideration since year 2015 has not ended. Yet, the number of publications in 2014 was 28 whereas number of publications in the first 7 months of 2015 is 20 which is an indicator of the fact that the number of publications by the end of 2015 will be more than the number of publications published in 2014.

Table 3: Citation Results

	humanitarian^logistics	**humanitarian^supply chain**	**disaster^logistics**	**disaster^supply chain**
Results found	63	43	94	84
Sum of the Times Cited	666	590	1507	1353
Average Citations per Item	*10,57*	*13,72*	*16,03*	*16,11*
h-index	14	12	18	17

When reference reports related to articles in Web of Science database, which appear as a result of searches made for reach word group, are analyzed we can claim that most citations are made to articles mentioned below disaster^supply chain word group with an average value of 16.11. Another conclusion to be obtained from here is that Humanitarian Logistics is a newly-emerging concept, and that previous studies are mostly based on *"disaster"*.

Table 4: The Most Cited Articles Derived from First Most Cited 20 Articles From Key Search Groups

NO	Title of Articles	Authors	Year	Times Cited	*Humanitarian^Logistics*	*Humanitarian^Supply Chain*	*Disaster^ Logistics*	*Disaster^Supply Chain*
1	Blackett Memorial Lecture - Humanitarian aid logistics: supply chain management in high gear	Van Wassenhove, LN	2006	*116*	**X**	**X**	**X**	**X**
2	Facility location in humanitarian relief	Balcik, B.; Beamon, B. M.	2008	*105*	**X**	**X**	**X**	**X**
3	Identifying challenges in humanitarian logistics	Kovacs, Gyongyi; Spens, Karen	2009	*34*	**X**	**X**	**X**	**X**
4	Robust optimization for emergency logistics planning: Risk mitigation in humanitarian relief supply chains	Ben-Tal, Aharon; Do Chung, Byung; Mandala, Supreet Reddy; Yao, Tao	2011	*33*	**X**	**X**	**X**	**X**
5	Critical success factors in the context of humanitarian aid supply chains	Pettit, Stephen; Beresford, Anthony	2009	*29*	**X**	**X**	**X**	**X**
6	From preparedness to partnerships: case study research on humanitarian logistics	Tomasini, Rolando M.; Van Wassenhove, Luk N.	2009	*22*	**X**	**X**	**X**	**X**
7	RESPONDING TO DISRUPTIONS IN THE SUPPLY NETWORK - FROM DORMANT TO ACTION	Kovacs, Gyongyi; Tatham, Peter	2009	*19*	**X**	**X**	**X**	**X**
8	Customer service in emergency relief chains	Oloruntoba, Richard; Gray, Richard	2009	*19*	**X**	**X**	**X**	**X**
9	Global service supply chains: An empirical study of current practices and challenges of a cruise line corporation	Veronneau, Simon; Roy, Jacques	2009	*20*	**X**	**X**	-	-
10	Humanitarian and Disaster Relief Supply Chains: A Matter of Life and Death	Day, Jamison M.; Melnyk, Steven A.; Larson, Paul D.; Davis, Edward W.; Whybark, D. Clay	2012	*12*	**X**	**X**	-	-
11	Horizontal cooperation in disaster relief logistics: benefits and impediments	Schulz, Sabine F.; Blecken, Alexander	2010	*12*	**X**	**X**	-	-
12	Supply chain network design for critical needs with outsourcing	Nagurney, Anna; Yu, Min; Qiang, Qiang	2011	*11*	**X**	**X**	-	-
13	A model to define and assess the agility of supply chains: building on humanitarian experience	Charles, Aurelie; Lauras, Matthieu; Van Wassenhove, Luk	2010	*11*	**X**	**X**	-	-
14	Using OR to adapt supply chain management best practices to humanitarian logistics	Van Wassenhove, Luk N.; Martinez, Alfonso J. Pedraza	2012	*10*	**X**	**X**	-	-
15	Models for relief routing: Equity, efficiency and efficacy	Huang, Michael; Smilowitz, Karen; Balcik, Burcu	2012	*25*	**X**	-	**X**	-

16	Pre-Positioning of Emergency Items for CARE International	Duran, Serhan; Gutierrez, Marco A.; Keskinocak, Pinar	2011	*24*	**X**	-	**X**	-
17	Disaster relief, inc.	Thomas, Anisya; Fritz, Lynn	2006	*17*	**X**	-	**X**	-
18	Dynamic relief-demand management for emergency logistics operations under large-scale disasters	Sheu, Jiuh-Biing	2010	*74*	-	-	**X**	**X**
19	An insurance risk management framework for disaster relief and supply chain disruption inventory planning	Lodree, E. J., Jr.; Taskin, S.	2008	*23*	-	-	**X**	**X**
20	On the unique features of post-disaster humanitarian logistics	Holguin-Veras, Jose; Jaller, Miguel; Van Wassenhove, Luk N.; Perez, Noel; Wachtendorf, Tricia	2012	*16*	**X**	-	-	-
21	On the appropriate objective function for post-disaster humanitarian logistics models	Holguin-Veras, Jose; Perez, Noel; Jaller, Miguel; Van Wassenhove, Luk N.; Aros-Vera, Felipe	2013	*14*	**X**	-	-	-
22	Locating disaster response facilities in Istanbul	Gormez, N.; Koksalan, M.; Salman, F. S.	2011	*10*	**X**	-	-	-
23	Humanitarian aid: an agile supply chain?	Oloruntoba, R; Gray, R	2006	*44*	-	**X**	-	-
24	Supply chain lessons from the catastrophic natural disaster in Japan	Park, YoungWon; Hong, Paul; Roh, James Jungbae	2013	*13*	-	**X**	-	-
25	Trends and developments in humanitarian logistics - a gap analysis	Kovacs, Gyongyi; Spens, Karen M.	2011	*10*	-	**X**	-	-
26	Coordination in humanitarian logistics through clusters	Jahre, Marianne; Jensen, Leif-Magnus	2010	*10*	-	**X**	-	-
27	What Skills Are Needed to be a Humanitarian Logistician?	Kovacs, Gyongyi; Tatham, Peter; Larson, Paul D.	2012	*8*	-	**X**	-	-
28	A Bayesian decision model with hurricane forecast updates for emergency supplies inventory management	Taskin, S.; Lodree, E. J., Jr.	2011	*6*	-	**X**	-	-
29	A dynamic logistics coordination model for evacuation and support in disaster response activities	Yi, Wei; Ozdamar, Linet	2007	*175*	-	-	**X**	-
30	An emergency logistics distribution approach for quick response to urgent relief demand in disasters	Sheu, Jiuh-Biing	2007	*159*	-	-	**X**	-
31	A scenario planning approach for the flood emergency logistics preparation problem under uncertainty	Chang, Mei-Shiang; Tseng, Ya-Ling; Chen, Jing-Wen	2007	*114*	-	-	**X**	-
32	An interactive approach for hierarchical analysis of helicopter logistics in disaster relief operations	Barbarosoglu, G; Ozdamar, L; Cevik, A	2002	*101*	-	-	**X**	-
33	Ant colony optimization for disaster relief operations	Yi, Wei; Kumar, Arun	2007	*95*	-	-	**X**	-
34	A hierarchical clustering and routing procedure for large scale disaster relief logistics planning	Ozdamar, Linet; Demir, Onur	2012	*23*	-	-	**X**	-
35	A multi-objective robust optimization model for logistics planning in the earthquake response phase	Najafi, Mehdi; Eshghi, Kourosh; Dullaert, Wout	2013	*18*	-	-	**X**	-
36	Managing risk to avoid supply-chain breakdown	Chopra, S; Sodhi, MS	2004	*294*	-	-	-	**X**
37	Global supply chain risk management strategies	Manuj, Ila; Mentzer, John T.	2008	*116*	-	-	-	**X**
38	How many suppliers are best? A decision-analysis approach	Berger, PD; Gerstenfeld, A; Zeng, AZ	2004	*84*	-	-	-	**X**
39	Measuring capacity flexibility of a transportation system	Morlok, EK; Chang, DJ	2004	*48*	-	-	-	**X**
40	Leveraging public-private partnerships to improve community resilience in times of disaster	Kim, Sang-Hyun; Cohen, Morris A.; Netessine, Serguei; Veeraraghavan, Senthil	2010	*23*	-	-	-	**X**
41	Contracting for Infrequent Restoration and Recovery of Mission-Critical Systems	Lodree, E. J., Jr.; Taskin, S.	2008	*23*	-	-	-	**X**
42	Financial performance of supply chains after disruptions: an event study	Papadakis, IS	2006	*20*	-	-	-	**X**
43	IMPACT OF DISASTERS ON FIRMS IN DIFFERENT SECTORS: IMPLICATIONS FOR SUPPLY CHAINS	Altay, Nezih; Ramirez, Andres	2010	*16*	-	-	-	**X**
44	Managing supply chains in times of crisis: a review of literature and insights	Natarajarathinam, Malini; Capar, Ismail; Narayanan, Arunachalam	2009	*15*	-	-	-	**X**

45	Why all the changes? An institutional theory approach to exploring the drivers of supply chain security (SCS)	Williams, Zachary; Lueg, Jason E.; Taylor, Ronald D.; Cook, Robert L.	2009	*14*	-	-	-	X

First 20 articles, which received the highest number of citations among articles which appear under the scope of all word groups, are taken to obtain the above given table. Considering the average citation values per article in terms of search word groups, we get closer to the average. There should be 80 articles according to search results, yet some articles are “Duplicate Articles”; therefore they appear under minimum two word groups giving us a total article number of 45.

Table 5: Researches Occupation, Research Areas and Keywords in Most Cited Articles

Researchers Occupation			Research Areas		Keywords	
No.of Researchers	**Country**	**%**	**WoS Research Areas**	**Records**	**Keywords**	**Records**
21	USA	34	Business &Economics	**45**	Emergency relief operations	1
7	Turkey	11	Operations Research & Management Science	**21**	humanitarian logistics	9
7	France	11	Engineering	**8**	supply chain management	13
5	England	8	Transportation	**9**	Humanitarian relief chains	1
4	Finland	6	Social Sciences-Other Topics	**1**	Emergency logistics	5
3	Taiwan	5	Environmental Sciences&Ecology	**2**	Aid Agencies	7
3	Australia	5			Disaster	16
3	Canada	5			Disaster Relief	2
2	Singapore	3				
1	Israel	2				
1	Netherlands	2				
1	Belgium	2				
1	Sweden	2				
1	Norway	2				
1	Iran	2				
1	Japan	2				
62						

When we analyze the state of authors of 45 articles USA takes the first place, Turkey and France take the second place, and United Kingdom takes the third place. Research area distribution of the studies reveal that highest number of studies are made on *Business&Economics*. *Operations Research & Management Science*, and *Transportation* follow this respectively. The most important keywords are “disaster”, “supply chain management” and “humanitarian logistics”.

6. CONCLUSIONS AND RECOMMENDATIONS

Total 284 articles obtained under the scope of four main search word groups from Web of Science database are classified based on publications; publications places under the same word group are reduced to one search group and 154 publications are obtained as a result. The mentioned studies are published in total 56 magazines and publications are placed under Social Sciences mostly under Business & Economics, Operation Research & Management and Transportation research areas. We can claim that studies are mostly operations research on areas including distribution planning, inventory management and traffic management. Besides, most studies are involved in composition of a disaster management system intended for collaboration of NGO’s, universities, public and private agencies.

When the articles obtained as a result of research studies are analyzed, it is observed that the articles are mostly on international scale, not many studies are carried out on national scale. The studies on Humanitarian Logistics exhibit a rapid increase especially since 2005. Yet, an analysis of the subject of the performed studies reveals that various studies must be performed on a wider range of subjects. The studies should not only cover quantitative subjects including distribution planning and stock management but also qualitative subjects including disaster management planning in collaboration of university-private sector and even army.

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EVALUATING THE ADVANTAGES OF SHORT SEA SHIPPING AND COMPARING TO THE OTHER MODES IN TURKEY

Murat YAPICI[83], *Erkut AKKARTAL*[84]

Abstract – *Transportation has been an inherent part of the trade since ancient times. As well-known, transportation modes have developed too much by technological innovations in the last decades. When the road, maritime, air and rail transportation modes were preferred with respect to speed, quality and cost criteria, nowadays, antipollutionist modes are begin to be preferred. If we want to compare with respect to CO_2 emissions, maritime transportation emits 15-21, road has 50 and air transportation emits 540 grams of CO_2 per ton in 1 km distance. That is why for both reducing the risk of accident and traffic jam in road transportation and, preferring an environmentalist and economical short distance maritime transportation are alternatively important solutions while transferring the load of road transportation to maritime. In this paper, in the bases of various distances, transportation modes were compared and evaluated with regard to emission values for short distance maritime transportation among existing ports. As a result, the need for maritime transportation was emphasized.*

Keywords *– Short distance Maritime transportation, Green Logistics, Emission, Air Pollution*

INTRODUCTION

International maritime transport is the most economical mode of transportation affected by changes in world trade. Short sea shipping is a type of marine transportation. In particular, it is an application supported by European countries. Short sea shipping has made great progress in the last twenty years. Short sea shipping is applied widely in Europe is carried out by North American countries. Its main purpose is to provide economical transportation by transferring road transport consistency to sea transport routing. Another aim is to provide an environmental benefit by reducing noise and air pollution. In recent years, the International Maritime Organization (IMO) 's MARPOL (Marine Pollution Convention) is aimed to reduce emissions by Annex six in marine transportation. In particular, reduction of the sulfur in the fuel ratio and the use of new alternative fuels were provided by increasing of the greenhouse effect and global warming.

THE AIM OF THE STUDY

Short sea shipping is currently supported by the governments. In the study short sea shipping, which is beneficial in both total cost and environment was evaluated in terms of air pollution. Generated maritime transportation emission was calculated by measuring the distances among Turkish ports. The aim of the study is to evaluate the preferability of short maritime transport in Turkey.

SHORT SEA SHIPPING

Short sea shipping is carried out in inland waterways, the main access roads, supply centers, a rivers and lakes. Short sea shipping is seen as alternative to transport by road. It provides powerful integration for intermodal and multimodal transportation. Short sea shipping is often confused with the cabotage transport. It is not just transport by using own flag in its territorial waters.

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European Union members are required to sea by the 90% of their imports and exports. Transport between the European Union countries with themselves is carried 45 percent by sea. Bureaucratic obstacles are reduced by European Union countries. This policy provides renew infrastructure of port and change port tariffs.

When examining the advantages of short sea shipping;
- Short sea shipping infrastructure investment costs are quite low.
- Ports in different ways, provided diversity created time lines. Regular shipping lines can be made.
- It is advantageous in terms of environmental sensitivity against emissions and noise pollution.
- There are not any capacity restrictions.
- With secure a navigational structure is the top level of safety and security.
- Creating economic price due to less cost.
- To provide the most appropriate course facilities.

TABLE 1. Cost advantage in accordance with the Transportation Modes (Euro/1000 ton. Km)

Cost Factor	Road	Railway	Inland Waterways	Maritime
Casualty	5.44	1.46	0	0
Noise	2.138	3.45	0	0
Contaminating Substance	7.85	3.8	3.0	2.0
Cost of Climate	0.79	0.5	-	-
Infrastructure	2.45	2.9	1.0	<1.0
Jam	5.45	0.235	-	-
Total	24.12		Max 5.0	4
Income of external costs (1000 km)		11.8	19	20
1 Euro marginal income obtained from the freight transfer to another mode of transport from road transport		85	52	50

Road, sea, rail transports and short sea shipping were investigated in Table 1. According the result of 1,000 km transportation; the maritime transportation accident rate is the minimum number of accident rate. Noise pollution consists at least carried by sea. It is seen that the maritime transport is advantageous to other transportation modes [1].

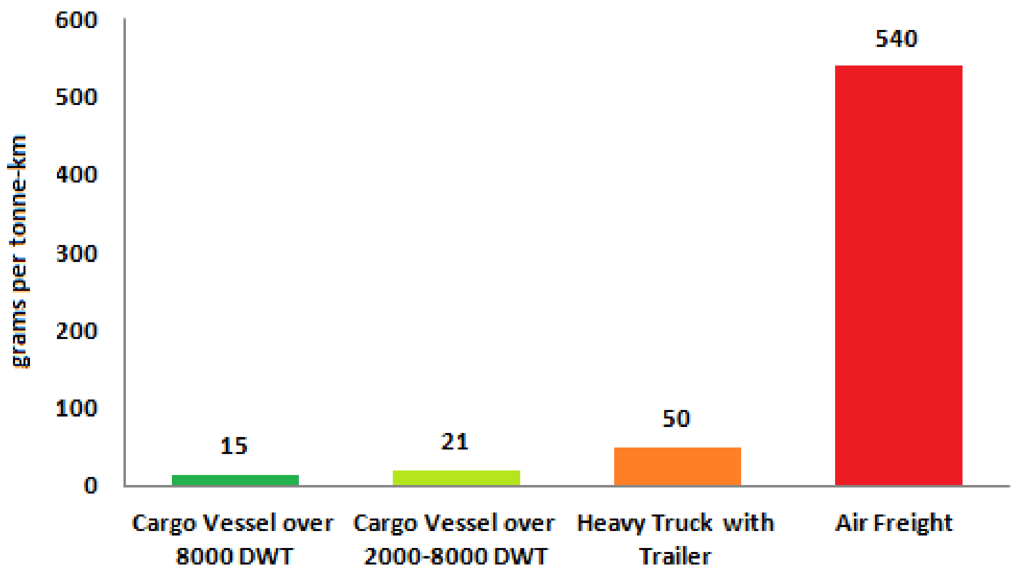

FIGURE 1. Comparison of Co_2 Emissions Between Modes of Transport (Grams per tone-km) (Source: NTM, Sweden)

8000 DWT, 2000-8000 DWT weight ships, heavy truck with trailer and air freight CO_2 emissions are shown in Figure 1. In this case it seems to be the most advantageous tonnage of 8000 dwt ships.

LITERATURE REVIEW

In the literature, the short sea shipping is discussed in terms of multimodal, intermodal transportation, emissions and liner trade. There are number of studies determining short sea shipping.

Casada, and Marlow, (2005) reported in his study, there were more reports, statistics and academic research about short sea shipping. These studies told that insufficient road to sea transport mode change. He has suggested establishing strategic partnerships to reach the optimum level of service [2].

Perakis and Denisis, (2008) examined the short sea shipping and stated that the United States have a high share of the two main transport mode as Ro-Ro and container shipping. He compared USA and Europe Short Sea Shipping implementations [3].

Xie, (2009) found in his study that the traffic of Chinese multimodal transportation as railway-sea mode selection problem. He suggested that renew infrastructure and new investments [4].

In Turkey, Atar, Aydoğdu, Okan, Şenol (2013) investigated short sea shipping advantages and combined transport by sampling Zonguldak-Trabzon and Adana-Antalya port line. According their results, Combined transport, minimizing the high costs and emissions in road transport, it is understood that the traffic congestion and traffic accidents resulting in death is the optimum solution for the reduction [6].

In this study, short sea shipping emissions inspections are made on different ports distances. Determining the required number of trees corresponding to CO_2 emissions of pollution have been made in determining the proposal.

METHODOLOGY

CO_2 emissions from sailing ship between two ports have been studied. 8000 dwt ship is selected for model. The ship has been accepted as the average speed of 8 knots. The total emissions of a sailing ship consist of main engine(s) of the generator(s) and boiler(s). In this study, only CO_2 emission was calculated.

Calculation method for ship emission;

$$\sum_{SE} = \sum_{ME} + \sum_{DE} + \sum_{BE} \quad (1)$$

$\sum_{SE}$ = Total Ship Emission (kg),

$\sum_{ME}$= Total Main Engine(s) Emission (kg),

$\sum_{DE}$ = Total Diesel Generator Engine(s) Emission (kg),

$\sum_{BE}$ = Total Boiler(s) Emission (kg),

This formula was covered for CO_2 emissions as follows.

$$\sum_{\text{Ship } CO_2 \text{ Emission}} = \sum_{CT} \times \sum_{D} \times C \qquad (2)$$

$\sum_{CT}$ = Total Cargo Tonnage (ton),

$\sum_{D}$= Total Distance Between Port(s)

C = Emission Coefficient (g per ton-miles)

Needed tree quantity for green footprint neutralizing

$$\sum_{QTN} = \frac{\sum \text{Ship CO2 Emission} \;\; / \; (\sum D \, / \;\; SS)}{\text{Coefficient for tree need}} \qquad (3)$$

$\sum_{QTN}$ = Needed tree quantity (pc)

$\sum_{\text{Ship CO2 Emission}}$ = Total Ship Emission (kg)

$\sum_{D}$= Total Distance Between Port(s)

SS = Ship Speed (knot)

FINDINGS

Measuring the distances between different Turkish ports comparison matrix is created. Figure 2 shows the information generated from the different 17 Turkish ports.

8000 DWT	Ambarlı	Bandırma	Bodrum	Çanakkale	Derince	Fethiye	Gemlik	Haydarpaşa	İskenderun	İzmir	İzmit	Karaköy	Marmaris	Mersin	Samsun	Sinop	Yarımca
Ambarlı		70	351	118	54	450	46	15	795	258	59	17	423	735	383	319	54
Bandırma	70		311	78	113	410	82	81	755	218	118	80	383	695	448	384	113
Bodrum	351	311		233	400	113	366	366	457	168	404	366	86	397	734	670	399
Çanakkale	118	78	233		167	332	133	133	677	140	171	133	305	617	501	437	166
Derince	54	113	400	167		499	70	50	844	307	5	51	472	784	419	355	1
Fethiye	450	410	113	332	499		465	465	370	278	503	465	50	313	833	769	498
Gemlik	46	82	366	133	70	465		50	810	273	75	50	438	750	418	354	70
Haydarpaşa	15	81	366	133	50	465	50		810	273	54	1	438	750	368	304	49
İskenderun	795	755	457	677	844	370	810	810		623	848	810	397	77	1178	1114	843
İzmir	258	218	168	140	307	278	273	273	623		311	273	251	563	641	577	306
İzmit	59	118	404	171	5	503	75	54	848	311		55	55	788	423	359	6
Karaköy	17	80	366	133	51	465	50	1	810	273	55		438	750	368	304	50
Marmaris	423	383	86	305	472	50	438	438	397	251	88	438		340	806	742	471
Mersin	735	695	397	617	784	313	750	750	77	563	788	750	340		1118	1054	783
Samsun	383	448	734	501	419	833	418	368	1178	641	423	368	806	1118		72	418
Sinop	319	384	670	437	355	769	354	304	1114	577	359	304	742	1054	72		354
Yarımca	54	113	399	166	1	498	70	49	843	306	6	50	471	783	418	354	

FIGURE 2. Matrix of Distance Between Ports [5]

8000 DWT	Ambarlı	Bandırma	Bodrum	Çanakkale	Derince	Fethiye	Gemlik	Haydarpaşa	İskenderun	İzmir	İzmit	Karaköy	Marmaris	Mersin	Samsun	Sinop	Yarımca
Ambarlı		566.95	2842.87	955.72	437.37	3644.71	372.57	121.49	6438.98	2089.63	477.86	137.69	3426.03	5953.02	3102.05	2583.69	437.37
Bandırma	566.95		2518.90	631.75	915.23	3320.73	664.15	656.05	6115.01	1765.66	955.72	647.95	3102.05	5629.05	3628.51	3110.15	915.23
Bodrum	2842.87	2518.90		1887.15	3239.74	915.23	2964.36	2964.36	3701.40	1360.69	3272.14	2964.36	696.54	3215.44	5944.92	5426.57	3231.64
Çanakkale	955.72	631.75	1887.15		1352.59	2688.98	1077.21	1077.21	5483.26	1133.91	1384.99	1077.21	2470.30	4997.30	4057.78	3539.42	1344.49
Derince	437.37	915.23	3239.74	1352.59		4041.58	566.95	404.97	6835.85	2486.50	40.50	413.07	3822.89	6349.89	3393.63	2875.27	8.10
Fethiye	3644.71	3320.73	915.23	2688.98	4041.58		3766.20	3766.20	2996.76	2251.62	4073.97	3766.20	404.97	2535.10	6746.76	6228.40	4033.48
Gemlik	372.57	664.15	2964.36	1077.21	566.95	3766.20		404.97	6560.48	2211.12	607.45	404.97	3547.52	6074.51	3385.53	2867.17	566.95
Haydarpaşa	121.49	656.05	2964.36	1077.21	404.97	3766.20	404.97		6560.48	2211.12	437.37	8.10	3547.52	6074.51	2980.56	2462.20	396.87
İskenderun	6438.98	6115.01	3701.40	5483.26	6835.85	2996.76	6560.48	6560.48		5045.90	6868.25	6560.48	3215.44	623.65	9541.04	9022.68	6827.75
İzmir	2089.63	1765.66	1360.69	1133.91	2486.50	2251.62	2211.12	2211.12	5045.90		2518.90	2211.12	2032.94	4559.94	5191.68	4673.33	2478.40
İzmit	477.86	955.72	3272.14	1384.99	40.50	4073.97	607.45	437.37	6868.25	2518.90		445.46	445.46	6382.29	3426.03	2907.67	48.60
Karaköy	137.69	647.95	2964.36	1077.21	413.07	3766.20	404.97	8.10	6560.48	2211.12	445.46		3547.52	6074.51	2980.56	2462.20	404.97
Marmaris	3426.03	3102.05	696.54	2470.30	3822.89	404.97	3547.52	3547.52	3215.44	2032.94	712.74	3547.52		2753.78	6528.08	6009.72	3814.79
Mersin	5953.02	5629.05	3215.44	4997.30	6349.89	2535.10	6074.51	6074.51	623.65	4559.94	6382.29	6074.51	2753.78		9055.08	8536.72	6341.79
Samsun	3102.05	3628.51	5944.92	4057.78	3393.63	6746.76	3385.53	2980.56	9541.04	5191.68	3426.03	2980.56	6528.08	9055.08		583.15	3385.53
Sinop	2583.69	3110.15	5426.57	3539.42	2875.27	6228.40	2867.17	2462.20	9022.68	4673.33	2907.67	2462.20	6009.72	8536.72	583.15		2867.17
Yarımca	437.37	915.23	3231.64	1344.49	8.10	4033.48	566.95	396.87	6827.75	2478.40	48.60	404.97	3814.79	6341.79	3385.53	2867.17	

FIGURE 3. Calculated CO_2 (g per tones) Emission Between Ports

Emissions were calculated by determined distance between ports as gram per each cargo ton .

CO_2 (kg)	Ambarlı	Bandırma	Bodrum	Çanakkale	Derince	Fethiye	Gemlik	Haydarpaşa	İskenderun	İzmir	İzmit	Karaköy	Marmaris	Mersin	Samsun	Sinop	Yarımca
Ambarlı		4535.64	22742.98	7645.79	3498.92	29157.67	2980.56	971.92	51511.88	16717.06	3822.89	1101.51	27408.21	47624.19	24816.41	20669.55	3498.92
Bandırma	4535.64		20151.19	5054.00	7321.81	26565.87	5313.17	5248.38	48920.09	14125.27	7645.79	5183.59	24816.41	45032.40	29028.08	24881.21	7321.81
Bodrum	22742.98	20151.19		15097.19	25917.93	7321.81	23714.90	23714.90	29611.23	10885.53	26177.11	23714.90	5572.35	25723.54	47559.40	43412.53	25853.13
Çanakkale	7645.79	5054.00	15097.19		10820.73	21511.88	8617.71	8617.71	43866.09	9071.27	11079.91	8617.71	19762.42	39978.40	32462.20	28315.33	10755.94
Derince	3498.92	7321.81	25917.93	10820.73		32332.61	4535.64	3239.74	54686.83	19892.01	323.97	3304.54	30583.15	50799.14	27149.03	23002.16	64.79
Fethiye	29157.67	26565.87	7321.81	21511.88	32332.61		30129.59	30129.59	23974.08	18012.96	32591.79	30129.59	3239.74	20280.78	53974.08	49827.21	32267.82
Gemlik	2980.56	5313.17	23714.90	8617.71	4535.64	30129.59		3239.74	52483.80	17688.98	4859.61	3239.74	28380.13	48596.11	27084.23	22937.37	4535.64
Haydarpaşa	971.92	5248.38	23714.90	8617.71	3239.74	30129.59	3239.74		52483.80	17688.98	3498.92	64.79	28380.13	48596.11	23844.49	19697.62	3174.95
İskenderun	51511.88	48920.09	29611.23	43866.09	54686.83	23974.08	52483.80	52483.80		40367.17	54946.00	52483.80	25723.54	4989.20	76328.29	72181.43	54622.03
İzmir	16717.06	14125.27	10885.53	9071.27	19892.01	18012.96	17688.98	17688.98	40367.17		20151.19	17688.98	16263.50	36479.48	41533.48	37386.61	19827.21
İzmit	3822.89	7645.79	26177.11	11079.91	323.97	32591.79	4859.61	3498.92	54946.00	20151.19		3563.71	3563.71	51058.32	27408.21	23261.34	388.77
Karaköy	1101.51	5183.59	23714.90	8617.71	3304.54	30129.59	3239.74	64.79	52483.80	17688.98	3563.71		28380.13	48596.11	23844.49	19697.62	3239.74
Marmaris	27408.21	24816.41	5572.35	19762.42	30583.15	3239.74	28380.13	28380.13	25723.54	16263.50	5701.94	28380.13		22030.24	52224.62	48077.75	30518.36
Mersin	47624.19	45032.40	25723.54	39978.40	50799.14	20280.78	48596.11	48596.11	4989.20	36479.48	51058.32	48596.11	22030.24		72440.60	68293.74	50734.34
Samsun	24816.41	29028.08	47559.40	32462.20	27149.03	53974.08	27084.23	23844.49	76328.29	41533.48	27408.21	23844.49	52224.62	72440.60		4665.23	27084.23
Sinop	20669.55	24881.21	43412.53	28315.33	23002.16	49827.21	22937.37	19697.62	72181.43	37386.61	23261.34	19697.62	48077.75	68293.74	4665.23		22937.37
Yarımca	3498.92	7321.81	25853.13	10755.94	64.79	32267.82	4535.64	3174.95	54622.03	19827.21	388.77	3239.74	30518.36	50734.34	27084.23	22937.37	

FIGURE 4. Calculated Total Carbon Footprint CO_2 (kg) Emission Between Ports

The total emission of the ship is considered to be full loaded is calculated according to this table. But if she isn't full with cargo or empty cargo holds she will be ineffective sail.

Need Tree	Ambarlı	Bandırma	Bodrum	Çanakkale	Derince	Fethiye	Gemlik	Haydarpaşa	İskenderun	İzmir	İzmit	Karaköy	Marmaris	Mersin	Samsun	Sinop	Yarımca
Ambarlı		6	28	9	4	36	4	1	64	21	5	1	34	59	31	26	4
Bandırma	6		25	6	9	33	7	7	61	18	9	6	31	56	36	31	9
Bodrum	28	25		19	32	9	29	29	37	14	33	29	7	32	59	54	32
Çanakkale	9	6	19		13	27	11	11	54	11	14	11	25	50	40	35	13
Derince	4	9	32	13		40	6	4	68	25	1	4	38	63	34	29	1
Fethiye	36	33	9	27	40		37	37	30	22	40	37	4	25	67	62	40
Gemlik	4	7	29	11	6	37		4	65	22	6	4	35	60	34	28	6
Haydarpaşa	1	7	29	11	4	37	4		65	22	4	1	35	60	30	24	4
İskenderun	64	61	37	54	68	30	65	65		50	68	65	32	6	95	90	68
İzmir	21	18	14	11	25	22	22	22	50		25	22	20	45	52	46	25
İzmit	5	9	33	14	1	40	6	4	68	25		4	4	63	34	29	1
Karaköy	1	6	29	11	4	37	4	1	65	22	4		35	60	30	24	4
Marmaris	34	31	7	25	38	4	35	35	32	20	7	35		27	65	60	38
Mersin	59	56	32	50	63	25	60	60	6	45	63	60	27		90	85	63
Samsun	31	36	59	40	34	67	34	30	95	52	34	30	65	90		6	34
Sinop	26	31	54	35	29	62	28	24	90	46	29	24	60	85	6		28
Yarımca	4	9	32	13	1	40	6	4	68	25	1	4	38	63	34	28	

FIGURE 5. Calculated Tree Quantity for Green Footprint Neutralizing Between Ports

After all calculations, the data obtained in atmosphere release carbon dioxide gas was calculated neutralize number of trees in nature.

CONCLUSION

Ship-source air pollution produce different emissions as well as CO_2, CO, NOx, SOx, PM, etc. These emissions can be evaluated in terms of comparing different types of transport modes in the future. Today, reduced sulfur content of marine fuels used in marine transport. Reducing carbon limits and new technologies will become an advantage in terms of short sea shipping. In this study, only distance measurements made between Turkish ports. In future coastal states can be compare between road transport and short sea shipping.

Short sea shipping is an important criterion for the selection of the new port area. By using shore electric power as Cold Ironing at port facilities will complement the short sea shipping. Traffic in the road transport will be reduced by the expansion of short sea shipping.

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LEVERAGE EFFECT OF FREIGHT TRANSPORTATION ON UNSUSTAINABLE URBAN AREAS

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Abstract-*Sustainability has three dimensions: ecological, economic, and social. Each dimension triggers the other dimension so it is important to handle these as whole under the name of sustainability. In this paper the effects of freight transportation as leverage on unsustainability level of urban areas are analyzed with a case study of Izmir city. The results of the study would be a beneficial tool for sustainability scholars and decision makers to take into account the freight transportation related issues described in this study.*

Keywords-Freight transportation, sustainability

INTRODUCTION

Today's cities cover only 2% of the earth's surface, yet they consume 75% of all resources and produce 75% of all waste [1]. The total population of the world is now in excess of 7 billion [2], more than halve of them already live in urban areas [3]. By 2025, the urban population is expected to represent more than two-thirds of the global population. As a result, more goods deliveries will be required which, in turn, will lead to an increase in demand for urban transportation. Cities face a number of transport and logistics related challenges, which threaten their desire to remain attractive for inhabitants, and visitors, and to facilitate economic activities for private companies. To address these challenges, the need for sustainable and integrated urban planning processes related to mobility is widely recognized [4]. While freight transportation is getting more important to sustain normal life and to increase economical activities in cities, there exist many challenges and problems relating to increasing levels of distribution. Even in the small size cities freight transportation related problems like traffic congestion, environmental impacts, and energy consumption are disturbing the sustainability level of the cities. Urbanization is integrally connected to the three pillars of sustainable development: economic development, social development and environmental protection. Transport intensification leads to environmental degradation by contributing to pollution of air and water, global warming, resource depletion, congestion, waste disposal (hazardous, solid) and traffic accidents [5]. Chapman [6] pointed out that about 26% of global CO2 emission is the share of transport activity. So increasing freight transportation in urban and metropolitan areas contributes to the congestion, air pollution, noise (*ecological*) and raising logistics costs, and hence the price of products (*economic*) [7]. In addition, a combination of different types of vehicles on the road increases the risk of accidents (*social*)[7]. Distribution of goods has not been in accordance with people wishes regarding the city's space and environment [8]. The negative impacts of freight transportation on urban areas in terms of the sustainability concept which contains economic, ecological and social dimensions, are summarized in Table 1.

Table 1. Impacts of Freight Transportation on Sustainability of Urban Areas

Economic Impacts	Traffic Congestion Resource Waste
Ecological/Environmental Impacts	Greenhouse Gases cause Climate Change The use of non-renewable fossil fuel The effects of waste products such as tires and oil Ecosystem destruction and species extinction
Social Impacts	Negative Public Health Impacts of Pollution Crop Destruction Injuries and deaths resulting from traffic accidents

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	Noise Visual intrusion Congestion deterring passenger travel Loss of Greenfield sites and open spaces Deterioration of buildings/infrastructure

Source: [9]

Because sustainable development is getting more attraction in every field, even the development of the cities, this paper aims to analyze the leverage role of freight transportation on unsustainable urban areas with the case study of İzmir which is the third largest city of Turkey. The rest of the paper is structured as follows. Experimental section presents the most important barriers based on the sustainability field of the İzmir. In the Discussion section we summarize our results. Finally, we sum up our findings in Conclusion Section.

EXPERIMENTAL

It is not easy to handle the transportation or logistics issue in urban areas because of the great diversity in different goods, different modes and delivery schedules. In this section, we investigate the most important barriers of sustainability of the İzmir City and discuss the effects of each barrier. These barriers are determined according to the 'Best Urban Freight Solutions' (BESTUFS) [10], a report that includes analysis about city logistics and problem solution proposals with the help of these parameters.

Shipment Potential Related with the Population

The number and the density of the population are closely related with the needs for cargo movements in a city. In other words; the greater the population gets the greater the needs for logistics activities. Globally, more people live in urban areas than in rural areas, with 54 per cent of the world's population residing in urban areas in 2014 [11].

In 2015 Turkey population reached 78,6 million. It is expected to reach 95.8 million in 2030 according to the medium projection variant [2]. Following Istanbul and Ankara, İzmir takes the third rank in Turkey out of 81 cities in terms of the population (4,113,072) it hosts [12]. It is accepted by the United Nations that population with 10 million or more are megacities, 5 to 10 million are large cities and 1 to 5 million are medium-sized cities [11]. With 4,1 million citizens İzmir can be counted as medium-sized city but its population is expected to grow to the limits of large city in the forthcoming years.

İzmir has a considerable high density (inhab.km^2) of 342 making it third in the rank in terms of density following Istanbul 2.767 and Kocaeli with 477 in 2014 [13]. The average population density of EU, 116.6, is quite behind that of İzmir [14]. The higher the density means the higher economical activities and the higher cargo movements.

Another important point regarding the population characteristic of İzmir is that it has got a relatively high rate of urbanization. While the overall rate of urbanization in Turkey in 2000 was 64.9%, it was 81.07% in İzmir; these percentages in 2013 became 77.28% and 91.22% respectively [15].

More people means more consumption, so freight transportation which plays a mediator role between the production and consumption points within the city increases in parallel to the population. A city is supplied by an impressive variety of supply chains servicing a wide array of economic activities such as grocery stores, retail, restaurants, office supplies, raw materials and parts, construction materials and wastes [16]. Also by the increase of e-commerce, consumers have started to prefer their purchases from online shopping sites, nevertheless mentioned deviation in consumer purchasing behavior leads to smaller shipments to the multiple delivery points. In terms of the greater population, density and urbanization rate, Izmir does not only host a great number of logistics activities but also have the potential to host more in the light of population projection. As a whole freight transportation has the ability to destroy economic, ecological and social sustainability of the city, so it is important to generate effective measures and policies by the administrative affairs.

Number and type of vehicles

Increasing number of vehicles is one of the main barriers for sustainability of city in terms of economic, ecological and social. Combination of different types of vehicles on the road increases the congestion and the risk of accidents.

Table 2. Overall Number of Motor Vehicles Used in İzmir, 2007-2013

Year	Total	Car	Minibus	Bus	Van	Truck	Motorcycle	Special Used Vehicles	Tractor
2007	866 072	457 791	14 487	15 357	150 132	36 511	142 296	1 564	47 934
2008	910 712	477 763	14 653	15 734	159 841	37 217	155 136	1 564	48 804
2009	927 899	485 152	14 121	15 387	164 470	35 510	163 744	1 612	47 903
2010	971 366	509 117	14 114	15 783	172 686	35 816	172 716	1 794	49 340
2011	1 020 070	536 626	13 913	15 944	178 533	35 715	185 902	1 752	51 685
2012	1 062 946	558 819	13 916	16 378	184 485	36 370	198 189	1 619	53 170
2013	1 103 176	586 571	14 068	15 895	187 264	36 097	207 177	1 735	54 369

Source: [17]

Table 2 indicates the overall number of motor vehicles used in İzmir between 2007 and 2013. Automobiles take the biggest share in İzmir. Having increasingly grown, the number of automobiles has reached up to 586,571 by 2013. The number of freight vehicles (trucks and vans) in İzmir has covered 20.2 % of the overall motor vehicles. The table reveals that between 2007-2013 while the truck number decreased by 1.1%, the Vans increase by 24.7%. This attitude can be explained with the legalized restraints for tonnage and volume of vehicles permitted as well as the preference in favor of using the vehicles in full capacity. But the main aim of these kinds of restraints is to maintain livability of the city in terms of reducing congestion and prevent environmental pollution in terms of noise and GHG (Greenhouse Gas) emissions. CO_2 is a greenhouse gas (GHG) which has been found responsible for climate change. Global climate change is expected to severely affect the hydrological cycle, increase average temperatures, accelerate the melting of the ice in arctic areas and raise the sea level, literally changing the face of the earth. Especially in cities, urban freight transport accounts for 21% of the CO_2 emissions, while transiting heavy goods vehicles add another 10% of the CO_2 emissions [18].

Types of fuels used

One of the main aims of city logistics is to sustain *good-for- life* environment. In this aim, the type of fuel used in energy production becomes the main subject of fight against pollution. Particularly the quality of the fuel used in the vehicles carrying out freight transportation is of the greatest importance in terms of its effects on the environment [19]. The aim is to encourage the use of environment friendly fuels and thus minimize CO_2 emission. For instance, diesel motors are said to cause 20% less CO_2 emission, but natural gas is the least harming pollutant [20]. On the other hand, in terms of Hydrocarbon (HC) emission, diesel is said to be the most environment friendly, and LPG is thought to be the best in terms of causing particular and nitrogen oxides (NOx)[19]. Table 3 indicates the number of the vehicles and the types of fuel used in İzmir [17].

Table 3. Number of Vehicles and Bunkers Used In İzmir

Year	Petrol	Diesel	LPG
2007	432, 910	267, 130	157, 568
2008	427, 428	291, 099	184, 227
2009	414, 746	306, 440	199, 562
2010	410, 411	338, 321	215, 959
2011	406, 973	376, 820	230, 217
2012	407 337	408 835	241 438
2013	409 755	437 791	250 726

Source: [17]

The Table 3 reveals that the number of the vehicles using petrol has decreased by 5.3% since 2005, and the use of diesel oil and LPG has increased respectively by 63.8% and 59.1%. Although there is an increasing trend in using Diesel oil and LPG fuel, Petrol which is the great source of CO_2 emission, still have the higher portion.

Freight vehicles in traffic density

There is a link between traffic density and the sustainability of the cities. Table 4 shows that cars cover the highest extent in distance, followed by trucks in City of İzmir. Despite having the second rank in the distance covered, cargo carrying vehicles is the important source of the traffic congestion suffered. The Table 5 also reveals that 82% of the vehicle movements are carried out through the public roads despite the fact that highways are relatively safe, sound and proper for fast traffic in 2012.

Table4. The Traffic Density to the Types of Vehicles

	Vehicle Type-Km (000)		
	Highway	**Public R.**	**Total**
Car-Km	1.436.838	5.799.467	7.236.305
Medium Goods Vehicle-Km	0	523.667	523.667
Bus-Km	58.809	179.066	237.875
Truck-Km	172.969	1.006.265	1.179.234
Articulated Truck-Km	114.160	584.033	698.193

Source: [21]

Table5. Information about VPT/Km

	Highway	Public R.	Total
Vehicle-Km	1.782.776	8.092.498	9.875.274
Passenger-Km	5.415.174	21.997.754	27.412.928
Tone-Km	2.924.566	16.392.391	19.316.957

Source:[21]

Fuel consumption and subsequently emissions as a result of on-road vehicle activity are a significant cause of environmental externalities. As a result of increased congestion, freight transportation vehicles also affect the volume of pollutants emitted by other vehicles. In some cases congestion may actually decrease pollution by causing a reduction in average travel speeds; however, in slow-moving traffic, speed reductions cause significant increases in pollution. Emissions associated with the effects of aggregate traffic flow would be requisite to a full estimation of environmental externalities [19]. Besides the environmental concerns, congestion and noise impacts residents, particularly their commuting and social interactions as well as the general livability of a city. Also congestion affects imposes additional costs and delays in terms of economical aspect.

Warehousing Facilities and Logistics nodes

Logistics nodes are defined as the points of starting, ending and transferring the cargoes. In other words, these nodes are the access points within the borders of a city where cargo movements are commenced, transferred and ended, which help sustain the economy and welfare of the city through their access to the transport networks as well as value added logistics activities [22]. Warehousing activities are important aspects of logistics, along with transport and distribution activities. According to a report released by Istanbul Chamber of Commerce, the total number of warehouses in Turkey is 1326, and out of this number 107 warehouses are located in İzmir. This makes İzmir the third in rank following Istanbul and Kocaeli in terms of having the highest number of warehouses [23]. The warehouses of İzmir are mainly located in Aliağa, Kemalpaşa, and Torbalı [24]. The clustered areas the warehouses occupy in İzmir result in loss of greenfield sites and open spaces which can be accounted as the barrier of both ecological and social sustainability of the İzmir city. Also these regions host many residents (Torbalı-150,127; Kemalpasa-99,626; Aliağa-83,366) which means that warehouse inbound transportation's last step and outbound transportation's first step are taken in these areas with the public mobility. Based on the Figure 1, the city logistics nodes of İzmir are 4 ports, 1 airport, 7 Organized Industry Zones, 13 Small Scale Industry Sites, 8 production points, 1 wholesale Food Market, 2 free zones, 9 customs offices, 7 sewage transfer stations, 1 sewage stocking facility, and 1 refinery with oil transit station. The movements from these nodes to the center and from the center to outside constitute the basis of the city logistics for İzmir.

Figure 1 reveals that the logistics nodes of İzmir have been gathered at the center of the city, which causes a complication with cargo transport activities and city traffic acting together, and which in turn harms the competitiveness as well as the welfare state of İzmir. Logistics nodes clustered in city center can be counted as one of the barrier of sustainability of İzmir.

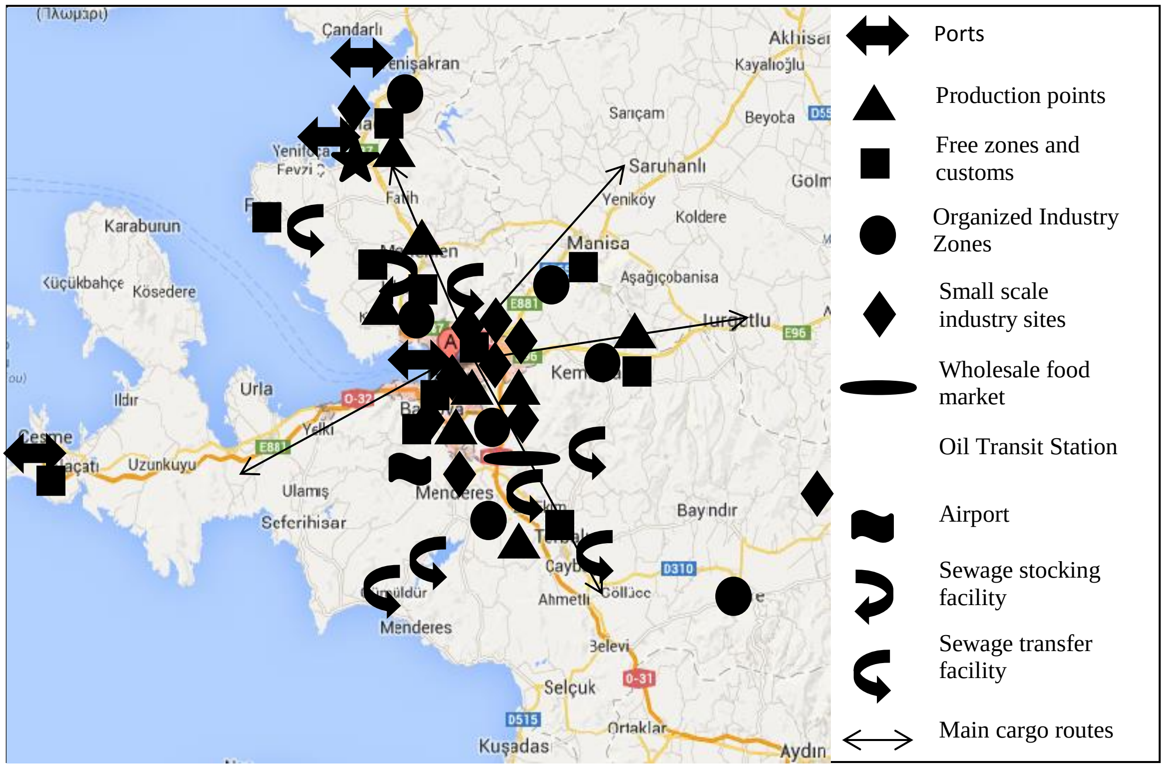

Figure 1. Logistics Nodes of İzmir

CONCLUSION

To the aim, in this study the barriers that take root from the freight transportation which affect the sustainability level of city are analyzed with the case study of İzmir. In order to carry out the aimed task; population, numbers and type of motor vehicle, types of fuel, traffic flow and density, logistics nodes and warehouses in İzmir are examined in scope of sustainability of the city. The results of the study would be a practical tool for decision makers to develop the more sustainability of İzmir city. From this study we can conclude that:

-The increasing freight transportation in urban areas contributes to congestion, air pollution, noise (*environmental*), raise logistic costs, and hence the price of products (*economic*), and have a combination of different types of vehicles on the road that increases the risk of accidents (*social*).

- In terms of the greater needs for logistics activities in the city area, the number and density of population and also the urbanization rate of İzmir appear as one of the most important barrier of economic, ecological and social sustainability of the İzmir city.

-Increasing number of vehicles especially the light goods vehicles (vans) and heavy good vehicles (trucks) prevents the sustainability possibility of Izmir city. Some political and regulatory arrangements must be done in parallel to increasing vehicle number such as vehicle emission control, allocation of land use for city logistics operations, access restriction according to weight and volume, time restrictions (night deliveries, time windows), etc.

- One of the barriers for social sustainability in İzmir is that passenger and cargo movements are both take in place in public roads instead of highways. As a result of increased congestion, freight transportation vehicles also affect the volume of pollutants emitted by other vehicles. Speed reductions cause significant increases to pollution.

- The clustered areas the warehouses occupy in İzmir result in loss of greenfield sites and open spaces which can be accounted as the barrier of both ecological and social sustainability of the İzmir city.

- Logistics nodes clustered in city center can be counted as one of the barrier of sustainability of İzmir. It causes a complication with cargo transport activities and city traffic acting together, and which in turn harms environmental, ecological and social sustainability of İzmir.

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NETWORK DESIGN OF URBAN LOGISTICS SYSTEMS: AN APPLICATION FOR MEAT PRODUCTS SECTOR

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Abstract – The aim of urban logistics is to optimize the logistic systems in urban areas as a whole by considering its impacts on private sector and the public. The movement of goods in the city has a great impact on the traffic volume which makes a logistics master plan an inevitable part of the solution for potential problems.
The transportation of the goods must be fast, economic, sustainable and ecological in an urban logistics network. This can be achieved by considering the factors like load and vehicle types, transportation modes, transportation times and the supply and demand nodes of transportation. For construction of such a network, one must first find the supply and demand nodes of freights. Then the volume of each load type must be determined. After estimating the breakdown of these volume over different transportation modes, these estimates are assigned to current road networks. In the literature, different solution methods are proposed for these types of problems.
In this research we address the logistic network problem by modeling it using a multi-commodity network flow (MCNF) model. In a MCNF, there is a network and commodities flow between the nodes of the network. Each commodity is characterized by a triple of "origin, destination and type of good". The flow should satisfy the supply and demand quantities of each node and the capacity of the network arcs should not be exceeded. The result of the model gives the route of each commodity flowing from the supply node to the demand nodes.
We obtain the data for the production rates of meat products in each Istanbul district from the reports of Turkish Statistical Institute. The vehicle types are standardized with respect to their capacity. And the demands of districts are determined according to the number of district dwellers. We solve the problem using MCNF model and in particular analyze the meat products distribution in Istanbul. It turns out that MCNF provides a good basis for constructing the urban logistics plan.

Keywords – multi commodity network flow, logistics master plan, network design, urban logistics

INTRODUCTION

City logistics is a concept that deals with transportation of freights within a congested area. In urban cities, delivery of products become a reasonably important issue nowadays, because of competition among supply chains. Throughout delivery of products and services, customers are expected to meet their demands with a high quality services in a tight time window. Since most of the population in a country live in urban cities, there occur different kind of problems such as congestion, accidents, air pollution, noise, etc. [1].

Therefore, it is obvious that there are many issues apart from delivery of products and services in city logistics. When we look at from environmental side, energy use during transportation and distribution, emissions of vehicles and noise are the basic problems that we face in urban cities. In city logistics, safety problems and accidents are other issues those are worthy of notice. Additional to these issues, transportation of goods in an urban city contribute to city's traffic congestion [1]. Therefore, it is a great problem that must be solved in İstanbul, which is the most urbanized city in Turkey. To find a solution to this problem, there is

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an ongoing logistics master plan project conducted by Yıldız Technical University and Istanbul Metropolitan Municipality.

During this project, the main problem is disaggregated into sub-problems. One of the sub-problem is sectorial distribution activities in İstanbul. In order to tackle with this problem and as an example, it is aimed to model and solve the meat products distribution in İstanbul.

When we look at the literature to solve this kind of problems, there are numerous studies about city logistics. For instance, there is a review conducted by Anand *et al.*[2] about city logistics modelling efforts. They analyze papers in the literature according to different perspectives such as planner, behavioral, policy, technology and multi-actors. Apart from the objective of reducing total cost of urban freight, there are specific objectives such as economic, efficiency, road safety, environment, infrastructure and management and urban structure [2].

Taniguchi *et al*.(2012) [3]study on the techniques for city logistics models' applications. There are mainly two types of models which are optimization and simulation models. In the optimization section of their study, it is seen that vehicle routing and scheduling problems with time windows are the most basic ones. Since there is a congested road network in an urban city, including dynamic and stochastic characteristics to travel times will be more efficient in solving these city logistics problems. Also, they discuss another important issue which is multi-objective function. Since there may be conflicting criteria, the problems can be constructed and solved within the framework of multi-objective or multi criteria decision making problems. Genetic and particle swarm optimization algorithms are some of the heuristics to obtain good results to these problems. From the simulation point of view, systems dynamics is an important approach in this area to estimate the behavior of complex systems. In system dynamics, causal loop diagrams and flow diagrams are the most common methods [3].

Moreover, there is a study conducted by Taniguchi *et al*.(2014)[4] about recent trends and techniques in city logistics. They highlight the importance of air quality, healthcare and emission issues. The modelling approaches such as network modelling, fleet modelling and routing models and life cycle models aim to construct the best city logistics model while reducing the GHGs and using more environmentally friendly techniques since it is aimed to diminish the negative effects of urban freight logistics on people's health [4].

Gonzalez-Feliu *et al*.[5] study on model construction and development approaches related to urban goods movement. In their study, they summarize the models in the literature according to the following titles: scope (partial or global), initial goals (diagnosis, policy oriented, forecasting or simulation), applications on real cases, commercial tools, unit of modelling (trip, round, commodity, movement or shipment), model development (top-down or bottom-up), and methodological frameworks. Moreover, they analyze these classifications. According to their study, these urban goods models have four main categories according to their functions: "Demand estimation models", "fixed-demand optimization models", "multi-actor simulation models" and "macro-economic and public decision support models"[5].

In the next section, explanation of the models and solution approaches are detailed. Then the models combination is applied for meat products and the results are analyzed. As the conclusion, sectorial and scientific contribution is given and some future researches are proposed.

MULTI COMMODITY NETWORK FLOW

In this study, the structure of Multi Commodity Network Flow (MCNF) problem is used. In MCNF problem, the aim is to minimize the cost of transporting commodities in a network composed of cities and roads. The mathematical model of MCNF is given in the following:

$$\min \mathrm{m}_{\mathrm{ij}}^{\mathrm{k}} \mathrm{X}_{\mathrm{ij}}^{\mathrm{k}} \tag{1}$$

s.t.

$$\sum_{\mathrm{j}} \mathrm{X}_{\mathrm{ij}}^{\mathrm{k}} - \sum_{\mathrm{j}} \mathrm{X}_{\mathrm{ji}}^{\mathrm{k}} = \mathrm{d}_{\mathrm{ik}} \qquad \forall \mathrm{i}, \mathrm{k} \tag{2}$$

$$\sum_{\mathrm{k}} \mathrm{X}_{\mathrm{ij}}^{\mathrm{k}} \leq \mathrm{w}_{\mathrm{ij}} \qquad \forall \mathrm{i}, \mathrm{j} \tag{3}$$

$$\mathrm{X}_{\mathrm{ij}}^{\mathrm{k}} \geq 0 \qquad \forall \mathrm{i}, \mathrm{j}, \mathrm{k} \tag{4}$$

The variable X_{ij}^{k}, shows the quantity of the commodity k going from city i to city j. The commodities are characterized by the tuple (origin, destination, product type). For example, the shipment of meat from Beykoz to Şişli is a different commodity type than the shipment of meat from Beykoz to Ataşehir. In another words, this study does not deal with a single commodity, the shipments from different origins and destinations will be called as different commodities.

In the model above, w_{ij} shows the road/arc capacity, m_{ij} shows the unit cost of transporting one unit of meat from city *i* to city *j*. d_{ik} shows the demand of commodity *k* at city *i* and defined as follows where t_k shows the demand of commodity *k*:

$$d_{ik} = \left\{ \begin{matrix} t_k & if\ k\ is\ produced\ at\ i \\ -t_k & if\ k\ is\ demanded\ at\ i \\ 0 & otherwise \end{matrix} \right\}$$

The Equation (1) tries to minimize the total transportation cost and the Equation (2) enables the balance of the flow between cities. The Equation (3) shows the capacity of the roads between the cities. In this study, the capacity constraints show whether there is a flow between cities or not. For example, since Çatalca and Arnavutköy are neighbours they can have a flow between them but Çatalca and Beykoz will not have a direct flow between them since they are geographically dispersed. The Equation (4) ensures that the variables are non-negative.

In order to solve the problem, the value of the commodity flows is required. The total production quantities are taken from a TUIK report considering chosen indicators for İstanbul [6], however the data about the flows between the cities cannot be obtained. One of the main reason is that there is a flow of meat outside İstanbul but this study is limited to the flows in İstanbul. As a results of this, a Transportation problem (TP) is constructed and solved to generate the flows between the cities.

The aim of the TP is to satisfy the demand of demand points in a network that is composed of demand and supply nodes. The mathematical model can be given as follows:

$$\min \mathrm{m}_{\mathrm{ij}} \mathrm{X}_{\mathrm{ij}} \tag{5}$$

s.t.

$$\sum_{\mathrm{j}} \mathrm{X}_{\mathrm{ij}} = \mathrm{d}_{\mathrm{i}}^{\mathrm{u}} \qquad \forall \mathrm{i} \in \mathrm{S} \tag{6}$$

$$\sum_{\mathrm{i}} \mathrm{X}_{\mathrm{ij}} = \mathrm{d}_{\mathrm{j}}^{\mathrm{c}} \qquad \forall \mathrm{j} \in \mathrm{D} \tag{7}$$

$$\mathrm{X}_{\mathrm{ij}} \geq 0 \qquad \forall \mathrm{i}, \mathrm{j} \tag{8}$$

Here, *S* and *D* sets shows the supply and demand nodes (cities), respectively. If a city makes production, then it belongs to the set *S*, otherwise it belongs to the set *D*.

The variable X_{ij} shows the flow from city *i* to city *j*. The value of d_i^ushows the production quantity of city *i*, d_j^c shows the demand quantity of city *j*. Finally, m_{ij} shows the unit cost of moving items from city *i* to city *j*.

The outgoing quantity from city *i* is equal to the production quantity of city *i* with the Equation (6). Similarly, the incoming quantity to city *i* is equal to the demand of city *i* with the Equation (7). The flows are nonnegative by the Equation (8).

The solution method can be summarized as follows:

1. The flows between the cities are calculated by the TP
2. These flows are converted to commodities and serve as an input to MCNF.
3. The MCNF is solved.

APPLICATION OF THE MODEL FOR MEAT PRODUCTS SECTOR IN ISTANBUL

The proposed models are applied for meat sector distribution in Istanbul City. As the first step, the supply and demand quantities should be given as an input for the TP. 38 of the 39 districts in Istanbul are considered as the demand and supply points. The number of cattle and sheep livestock in the districts are taken from the TUIK report considering chosen indicators for İstanbul [6]. Then, these numbers are converted to the bovine and ovine meat in tons as supply quantities. The total demand quantities are found by normalizing the total production quantities according to the number of population of the districts. The overall results are given in Table 1.

Table 1 The supply and demand quantities of the districts (in tones).

Cities	**Supply Point**	**Demand Point**	**Cities**	**Supply Point**	**Demand Point**
Arnavutkoy	4805,1	352,1	Gaziosmanpaşa	0	1167,7
Ataşehir	0	652	Güngören	0	526,9
Avcılar	165,8	1177,4	Kadıkoy	0	251,5
Bağcılar	0	934,7	Kağıthane	24,5	800,5
Bahçelievler	0	345,8	Kartal	80	425
Bakırköy	0	534,3	Küçükçekmece	0	448,2
Başakşehir	1002,5	421	Maltepe	174,4	638,1
Bayrampaşa	0	294,6	Pendik	1472,3	387,1
Beşiktaş	0	409,5	Sancaktepe	388,3	344,3
Beykoz	1603,6	376,8	Sarıyer	302,7	753
Beylikdüzü	45,2	348,5	Silivri	3402	702,9
Beyoğlu	0	105,9	Sultanbeyli	0	769
Büyükçekmece	811,5	716	Sultangazi	285	1035,4
Çatalca	4219,3	1071,9	Şile	2051,2	514,6
Çekmeköy	354,2	573,9	Şişli	64,8	491,5
Esenler	0	654,2	Tuzla	435,3	51.2
Esenyurt	40,5	777,2	Ümraniye	40,3	345,8

Eyüp	662,9	473,4	Üsküdar	1,4	1051,9
Fatih	0	674,4	Zeytinburnu	0	834,7

Applying of the TP determines the assignments of the supplied quantities of supply points to the demand points considering the total transportation costs. The resulting flows of the TP using the values in Table 1 is given in Table 2.

Table 2 The solution of the TP

Comm	Prod. Point	Demand Point	Quan. (tones)	Comm	Prod. Point	Demand Point	Quan (tones)
1	Arnavutköy	Bayrampaşa	294,6	20	Pendik	Ataşehir	267,9
2	Arnavutköy	Esenler	654.2	21	Pendik	Kadıkoy	251,5
3	Arnavutköy	Gaziosmanpaşa	1167,7	22	Pendik	Kartal	345
4	Arnavutköy	Kağıthane	709,2	23	Pendik	Maltepe	220,9
5	Arnavutköy	Sarıyer	450,2	24	Sancaktepe	Sultanbeyli	44
6	Arnavutköy	Sultangazi	750,4	25	Silivri	Avcılar	1011,7
7	Arnavutköy	Şişli	426,7	26	Silivri	Bağcılar	353,2
8	Başakşehir	Bağcılar	581,5	27	Silivri	Bahçelievler	345,8
9	Beykoz	Beşiktaş	219,8	28	Silivri	Bakırköy	534,3
10	Beykoz	Üsküdar	1007	29	Silivri	Beşiktaş	172,9
11	Büyükçekmece	Beylikdüzü	95,5	30	Silivri	Beylikdüzü	207,7
12	Çatalca	Esenyurt	736,7	31	Silivri	Fatih	73,5
13	Çatalca	Fatih	600,9	32	Şile	Çekmeköy	219,7
14	Çatalca	Güngören	526,9	33	Şile	Maltepe	242,9
15	Çatalca	Küçükçekmece	448,2	34	Şile	Sultanbeyli	725,1
16	Çatalca	Zeytinburnu	834,7	35	Şile	Ümraniye	305,5
17	Eyüp	Beşiktaş	16,8	36	Şile	Üsküdar	43,5
18	Eyüp	Beyoğlu	105,9	37	Tuzla	Ataşehir	384,1
19	Eyüp	Kağıthane	66,8				

The results in Table 2 can illustrated as follows. The demand of Bayrampaşa, Esenler, Gaziosmanpaşa, Sarıyer, Sultangazi and Şişli is completey satisfied by Arnavutköy. The demand of Kağıthane on the other hand, is satisfied from Arnavutköy and Eyüp.

Every line in Table 2 is a commodity. For example, the shipment of weight 294,6 tons from Arnavutköy to Bayrampaşa is commodity 1, the shipment from Pendik to Ataşehir with 267,9 tons is commodity 20. Hence, there are 37 commodities in Table 2 in total. Using these commodities as an input to MCNF, the result of the MCNF problem can be summarized in Table 3:

Table 3 MCNF problem solution

1	Ar.köy	Eyüp	B.paşa
2	Ar.köy	B.şehir	Esenler
3	Ar.köy	Eyüp	G.paşa
4	Ar.köy	Eyüp	Kağıthane
5	Ar.köy	Eyüp	Sarıyer
6	Ar.köy	B.şehir	Sultangazi
7	Ar.köy	Eyüp	Şişli

8	B.şehir	Bağcılar					
9	Beykoz	Üsküdar	Beşiktaş				
10	Beykoz	Üsküdar					
11	B.çekmece	B.düzü					
12	Çatalca	B.çekmece	Esenyurt				
13	Çatalca	Ar.köy	Eyüp	Fatih			
14	Çatalca	Ar.köy	B.şehir	Bağcılar	Güngören		
15	Çatalca	B.çekmece	Esenyurt	Avcılar	K.çekmece		
16	Çatalca	Ar.köy	Eyüp	Zeytinburnu			
17	Eyüp	Kağıthane	Beşiktaş				
18	Eyüp	Beyoğlu					
19	Eyüp	Kağıthane					
20	Pendik	Kartal	Maltepe	Ataşehir			
21	Pendik	Kartal	Maltepe	Kadıkoy			
22	Pendik	Kartal					
23	Pendik	Kartal	Maltepe				
24	Sancaktepe	Sultanbeyli					
25	Silivri	B.çekmece	Esenyurt	Avcılar			
26	Silivri	B.çekmece	Esenyurt	B.şehir	Bağcılar		
27	Silivri	B.çekmece	Esenyurt	Avcılar	K.çekmece	B.evler	
28	Silivri	B.çekmece	Esenyurt	Avcılar	K.çekmece	Bakırköy	
29	Silivri	B.çekmece	Esenyurt	B.şehir	Eyüp	Kağıthane	Beşiktaş
30	Silivri	B.çekmece	B.düzü				
31	Silivri	B.çekmece	Esenyurt	B.şehir	Eyüp	Fatih	
32	Şile	Çekmeköy					
33	Şile	Çekmeköy	Sancaktepe	Maltepe			
34	Şile	Çekmeköy	Sancaktepe	Sultanbeyli			
35	Şile	Çekmeköy	Ümraniye				
36	Şile	Çekmeköy	Ümraniye	Üsküdar			
37	Tuzla	Pendik	Kartal	Maltepe	Ataşehir		

The information in Table 3 can illustrated as follows. The commodity 1 going from Arnavutköy to Bayrampaşa transported through Eyüp. In a similar manner the flow from Çatalca to Fatih passes through Arnavutköy and Eyüp. These results are obtained considering the adjacency relationship of the districts and capacity of the roads in districts.

CONCLUSIONS

Freight flows of different sectors in a city is very important in terms of the city logistics master plans. Understanding the freight movements of different sectors in a city and making logistical plans for preventing traffic congestions require transportation network analysis. Therefore, strategic logistics plans of the cities should start with designing network patterns. In this study, firstly, we tried to find the convenient product assignments among the demand and supply points (districts in the Istanbul). Then, we found the optimum routes between those points considering the transportation costs and the capacity of the roads in the districts. Here, only one sector is chosen to prove the convenience of the proposed model to this kind of problems. It is applied for the meat products distribution in Istanbul.

In future researches, supplied quantities from outside of the city may also be considered since the local meat products production does not satisfy the total demand of the cities like Istanbul. On the other hand, since the traffic congestion is a result of total freight transportation activities, using only one sector is not meaningful to produce acceptable solutions. Therefore, next attempt will be solving different sectors' transportation activities concurrently. Also different vehicle types and some environmental issues may be considered. While the problem size is getting larger, different solution procedures like heuristics or relaxation technics may be required.

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VEHICLE ROUTING IN CITY LOGISTICS: (2005-2015) A Literature Analysis

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Abstract- *Cities are the areas that consumer goods, building materials, household goods, many different types of waste and cargo are constantly in transit. Efficient and sustainable delivery solutions in urban areas are concluded by city logistics concepts. City logistics aims at the fast and reliable transportation of goods in terms of efficient and environmentally acceptable delivery tours. Concerning transportation, it seeks for approaches allowing for fast, accurate and reliable pickup and delivery operations as conducted by parcel services or waste disposal services.*

In this respect, effective vehicle routing approach is gaining more importance for improvement of urban freight transport efficiency and productivity, reducing traffic congestion, reducing the impact on the environment, correction adverse geographical results (migration, increased freight traffic, etc.). In this study vehicle routing in urban/city logistics publications will be analysed and a recent literature review was conducted and implementations are sequenced. The paper presents a comprehensive analysis of the studies in the field of vehicle routing for city logistics, between the (2005) and the present day (2015).

Keywords: *City Logistics, Vehicle Routing, Optimization*

1. INTRODUCTION

Since its introduction in 1959, the Vehicle Routing Problem (VRP) has been studied extensively and many variants have been discussed. The VRP deals with the distribution of goods between a depot and a set of customers who have known demands. The distribution is performed by a fleet of vehicles which are based at the depot. The VRP is described on a graph which represents the road network. It consists of road sections, customer locations, depots and road junctions. Road sections are represented by arcs which are either directed or undirected, depending on whether they can be traversed in only one direction or in both directions. Each arc is associated with a certain cost which corresponds to its length. Customer locations, depots and road junctions are represented by nodes. The basic version of the VRP is the CVRP. In this problem each vehicle has a limited capacity and each customer is associated with a fixed demand which is not allowed to be divided.

Variants of the VRP can be listed as follows:

- The Distance-Constrained VRP
- The VRP with Time Windows
- The VRP with Backhauls (VRPB)
- The VRP with Pickup and Delivery (VRPPD)

Vehicle routing problems define a class of combinatorial optimization problems that allow optimizing itineraries of a fleet of vehicles, when these vehicles operate round trips (that is, have multiple stops along their itinerary). This situation represents a large part of the flow of vehicles for good distribution in cities. Previous research has demonstrated how vehicle routing optimization can lead to significant economic savings (estimated between 5–30 % by [1] or 5–20 % by [2]).

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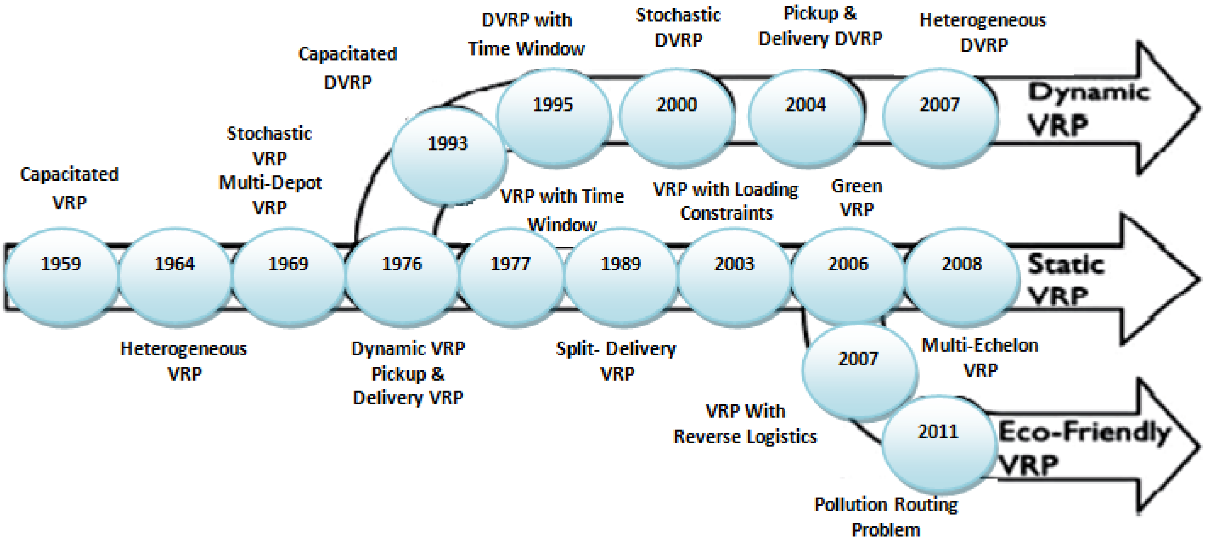

Fig. 1. Historical Timeline of Vehicle Routing Research [3].

2. FROM VRP TO CITY VRP

A variety of different types of freights such as consumer goods, materials, mails/packages, and waste products flow through the city. Notably, these flows account for one fourth of street traffic in a typical city [4]. Growth of city logistics research has been driven by the increase in city population, traffic problems, and public pressure [5]. The culmination of all the above factors calls for city Vehicle Routing Problem (VRP), which attempts to address the concerns above as a whole. This is in contrast with general studies in VRP, which typically focuses on solving the problems partially. Accordingly, VRP, particularly City VRP, which provides the core solutions in city logistics [6] has recently received renewed attention among researchers and practitioners of transportation and logistics study. Despite the trend, there has been a lack of survey on the state of art in City VRP.

Taniguchi *et al.* [6], [7] defined city logistics as "*the process of totally optimising the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy*". They further established that "*the aim of City Logistics is to globally optimise logistics systems within an urban area by considering the costs and benefits of schemes to the public as well as the private sector*".

According to Taniguchi *et al.* [6], there are four key stakeholders in city logistics, namely, the shippers, freight carriers, residents and administrators. Shippers aim to sell their products to customers while attempting to maximize their customer service levels. Carriers provide transportation services from shippers to customers while minimizing the transportation cost incurred. Residents wish to live in a pleasant environment free of pollution, traffic congestion, and accidents. Administrators, on the other hand, are more interested in raising the economic and environmental conditions of the city.

VRP was formulated as a mathematical programming model by Dantzig and Ramser [8]. In 1964, a seminal heuristic method was proposed by Clark and Wright [9]. In 1981, Lenstra and Rinnooy Kan [10] proved that VRP is NP-hard. Over the past decades, extensive studies on VRP models and their solutions have been conducted and reported. Dulac *et al.* (1980) [11] and Chapleau *et al.* (1985) [12] proposed a solution method for school bus routing in urban areas. They decomposed the problem into two stages: assignment and routing to solve the VRP. Public transit in a big city was also discussed in 1990. The work of Taniguchi *et al.* (1999) [7] on 'City Logistics' has led to renewed interest in VRP, particularly, City VRP among researchers and practitioners. For excellent reviews on city logistics, the reader is referred to (T. G. Crainic, 2009) [5] and (E.Taniguchi,2001) [6]. Real time traffic information has been a key driver in City VRP (B. Fleischmann2009) [13] , where intelligent transportation system (ITS) has been introduced to harness real time data in providing sensible routes (H. J. Quak,2009) [14]. Vehicle and access time regulations have emerged to reduce air or noise pollution and control traffic flows in urban area. More recently, topics pertaining to fuel consumption and environmental issues have also received increasing attention among the researchers of City VRP.

3. LITERATURE REVIEW ON VEHICLE ROUTING FOR CITY LOGISTICS

Two main objectives motivate vehicle route optimization in cities. The first, and the most common one, is reducing congestion and increasing mobility of freight transportation services in urban areas at minimum cost. The second is to contribute positively to the environment and to the sustainable development, by reducing pollution and noise or by improving living conditions of city inhabitants. Since several stakeholders are seen in urban areas, the goals differ depending on the actors involved [15]. Public authorities' stakes are mainly related to collective utility. Their objectives can be in conflict with the individual performance and the goals of private stakeholders, who seek mainly to increase their economic benefits by both reducing their costs and ensuring a good quality of service. Furthermore, the leverage to attain these objectives strongly differs between these two stakeholders. While carriers control vehicle flows, local authorities can only influence them with adapted regulations. The combination of a different objective and a different leverage makes the vehicle routing models developed for these two stakeholders very different. In the case of local authorities, models typically aim at evaluating the impact of new policies. Decisions are tactical in nature and data can only be estimated. These models are surveyed in Sect. 3.1. In the case of private companies, the objective is generally to satisfy a daily demand at minimal cost. Problems are operational and the data fluctuates from day to day or can even evolve during the day. These models are surveyed in Sect. 3.2.

3.1. From the Perspective of Local Authorities

A first type of regulation, investigated by Munuzuri et al. [16], is to limit the access to some special zones at some periods. The problem that arises is called Vehicle Routing Problem with Access Time Windows (VRPATW). Access time windows (access TW) differ from the TW considered in the VRP with time windows (VRPTW): they restrict the access to the overall concerned area (usually called restricted zone). Hence, they do not concern delivery times, but the time vehicles have the right to enter the zone. Also, they do not depend on the customer. Munuzuri et al. [16] show how this type of regulations imposes extra costs to the carriers, forcing them to use more vehicles. Limited access can be combined with the construction of a city distribution center (CDC) where goods are loaded in more environmental-friendly vehicles for final delivery. In this case, restricted zones are not constrained at some periods but for some types of vehicles. Crainic et al. [17] discuss in details these types of architectures and show how it would reduce the number of truckkilometers in city centers. Crainic et al. [18] model this setting as a two-echelon VRP (2E-VRP) and evaluate how the use of CDC can reduce global costs comparing with VRP solution costs.

More recently, variants of these models were explored in Grangier [19], Masson et al. [20], Nguyen et al. [21] or Nguyen et al. [22], where temporal decisions and synchronization issues between the different categories of vehicles are considered in more details. Quak and de Koster [23] also study the impact of TW and vehicle restrictions on good distribution in cities. They compute routes with the solution of a classical VRPTW, changing the data to simulate the different scenarios that they want to compare.

Boschetti and Maniezzo [24] develop an application to help authorities to evaluate different organizational scenarios of a delivery system based on a single CDC located nearby a medium-sized city. The problem that arises is a rich variant of the Multi-Trip VRP with TW where both pickups and deliveries are considered, as well as a heterogeneous fleet of vehicles.

3.2. From the Perspective of Companies

A first important aspect that planners should take into account is the strong relationship in urban areas between time of the day and travel times. With the development of information technologies, larger amount of data are available that can be exploited in the models. Several authors follow this line and include time-dependency in their VRP models: Taniguchi and Shimamoto [25], Ando and Taniguchi [26], Ehmke and Mattfeld [27] and Kritzinger et al. [28]. Results show how it helps reducing CO_2 emissions (7%, Maden et al. [29]) and time windows violations (solutions calculated without taking into account time-dependent travel times result in up to 60 % of missed time windows when evaluated in a time-dependent context, Donati et al. [30].

Another characteristic of cities is their dynamics. Technical solutions now exist to handle unforeseen events by monitoring the fleet during the working time and react to these events with an intelligent re-routing of vehicles. Several authors investigate how route optimization can benefit from this information: Zeimpekis and Giaglis [31], Novaes et al. [32] and Qureshi et al. [33].

A third difficulty carriers often have to face when delivering goods in urban areas is the road-network structure, especially in old cities: streets are narrow with no or few parking lots and are often one-way (Crainic et al. [17]; Munuzuri et al. [16]). Then, big trucks cannot easily enter city centers due to structural limitations and small vehicles must be used. Due to their limited capacity, these smaller vehicles perform several round trips during the day. Route optimization then differs from the traditional VRP where a single trip is allowed for each vehicle.

Authors that investigated this situation (in the context of city logistics) are: Fleischmann [34], Browne et al. [35] and Delaıtre and De Barbeyrac [36]. Fleischmann [34] was the first to consider this issue, for the delivery of miscellaneous goods in Berlin, fresh food in Duisburg or beverages in Dortmund, and demonstrated how it helps better exploiting the time horizon and the vehicle capacity. Consolidation and collaboration, already evoked in Sect. 3.1, are also subjects that raised a lot of interest for companies. Examples are Thompson and Hassall [37], Qureshi and Hanaoka [38], Quak [39] and Browne et al. [35] that all show how the use of intermediate facilities and collaborative systems can improve the quality of service, the routing cost, and eventually decrease CO_2 emissions. Finally, Chang and Yen [40] consider the case of a city-courier company in Taipei.

4. ANALYSIS OF RESULTS OF THE BIBLIOMETRIC STUDY

A literature Review was performed, by selecting the "categories" field in the databases. Only logistics related categories were taken. Analysing this filter, it was essential for the elimination of the significant number of articles related to other areas. Table 1 represents the items selected to the study, totalling 57 papers.

Table 1. Search by database according to category filters

Search (“vehicle routing”^“city-urban logistics”)	**Records**
Science Direct	14
Google Scholar	40
Books	3

In this section, we present and discuss the results of the quantitative data and bibliometric analysis. Initially, data was structured in lists and arrays, and then the knowledge networks of the field of vehicle routing for city logistics were analysed.

Table 2 presents the top journals in number of publications. European Journal of Operational Research is responsible for 24% of publications, Transportation Research and Procedia Social and Behavioural Sciences follow with 13% of publications. In addition to this list various university journals have 33% of publications, especially with highest number of Wien and Germany.

Table 2. Main Magazines in Vehicle Routing for City Logistics

Search	Journal	Records
Top magazines in number of publications	European Journal Of Operational Research	9
	Transportation Research	5
	Procedia Social And Behavioral Sciences	5
	Journal Of Computational Science	3
	Computers & Operations Research	2
	Computers & Industrial Engineering	2
	Euro J Transp. Logist.	2
	Cities	2
	International Journal Of Engineering Research And Development	2
	International Journal Of Production Research	1
Magazines that published fewer articles	IEEE Transactıons On Intellıgent Transportatıon Systems	1
	Computers in Industry	1
	Transportation Research Procedia	1
	International Journal of Research And Development	1
	Journal of Engineering And Natural Sciences	1

A review about the articles published considering the degree of industrial and economic development of countries where the researches were held was also developed. The classification of developed, developing and underdeveloped countries adopted was based on that proposed by the International Monetary Fund (IMF), according to Nielsen (2011). Table 3 presents the found results.

Table 3. Distribution of Publications Per Countries by Level of Development

Developed countries	Paper	Developing countries	Paper
Austria	3	China	1
Canada	3	Turkey	11
France	3	Taiwan	1
Germany	11		
USA	7		
Greece	1		
Italy	1		
Japan	3		
Norway	1		
Singapore	1		
Spain	4		
UK	1		

Table 4. Top Ten Countries in Number of Publications

Countries	Germany	Turkey	USA	Spain	Austria	Canada	France	Japan	Italy	Taiwan
Records	%20	%20	%12	%7	%5	%5	%5	%5	%2	%2

Table 4 presents the 10 countries that published the most of studies on the time period. These countries are responsible for 83% of publications, being the Germany alone the source of about 20% the published studies. And the other countries Greece, UK, Norway, Colombia, China, Wien, Korea and Singapore are responsible for 17% of publications.

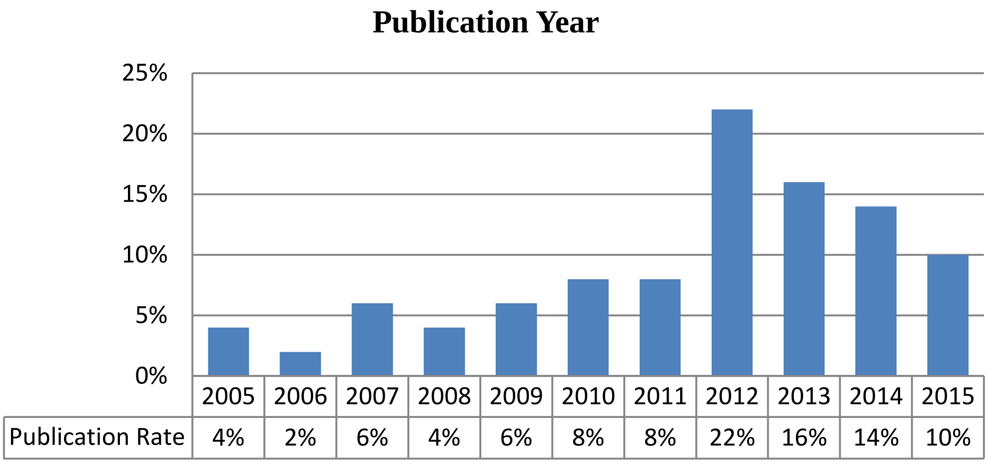

Fig. 2. Annual Scientific Production on City VRP Published in International Journals

Figure 2 shows the distribution over time of 57 scientific articles identified in the data bases. Besides, based on Figure 2, it is possible to note the growing trend of studies in the field of City VRP. It can be observed in Figure 2 that until 2011 very few articles on the topic were published. After 2011, with increasing importance of urban logistics draw attention to this research topic that has been growing since then. Academic publication showed a considerable increase in the years 2012, threefold the amount published in the previous years.

Table 5. Main keywords raised by research

Main Keywords	Records
Vehicle Routing	22
Time Windows - Time-dependent	18
City Logistics	12
Transportation	7
Algorithm	6
Optimization	4
Urban Logistics	3
Pickup And Delivery	3
Dynamic Vehicle Routing	3
Metaheuristics	2
Fleet management	2
Intelligent Transportation Systems	2
Simultaneous	2
Vehicle Scheduling	1

		Research Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		#Records	22	18	12	7	6	4	3	3	3	2	2	2	2	1
Research Area	#Records		Vehicle Routing	Time Windows - Time-dependent	City Logistics	Transportation	Algorithm	Optimization	Urban Logistics	Pickup And Delivery	Dynamic Vehicle Routing	Heuristics-Metaheuristics	Fleet management	Intelligent Transportation Systems	Simultaneous	Vehicle Scheduling
1	10	Operations Research and Management Science	7	5	2	2	1	3		3	3	4				1
2	6	Business and Economics	5	4	4	1	2	3	1				1			1
3	6	Engineering	6	2	2	2	5	3	2	3	1	1			4	
4	9	Computer Science	4	2	1		4					2	1			1
5	10	Transportation	6	5	6	2	1	2	1		2		3	1		1

Fig. 3. Crossing Matrix (search area vs keywords) based in the records

5. CONCLUSION

In this study, 57 papers published in international journals related to vehicle routing for city logistics were identified. The list of articles was filtered and analysed according to several criteria in order to identify a profile of the study in City VRP. Although the results presented in this study indicate that there is a growing trend of studies in the field of City VRP at an international level, the national field studies are still quite rare. Based on the results, bibliometric analysis directs researchers to gain a better understanding of the major themes, concepts and relationships associated with the City VRP.

The proposed methodology can also be applied to other areas of logistics as well. The presentation of the evolution of knowledge about City VRP, from 2005 to 2015, will assist researchers as a statistical tool towards new themes.

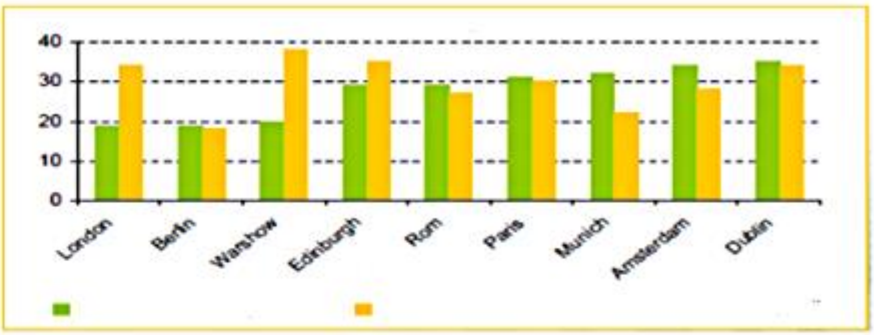

Figure 4. Percentage of Average Speed and Stuck Roads (Source: DHL, 2012)

In the analysis conducted by DHL shown that the average speed in London is 16 km/h.This is almost even less without substitution made with non-motorized vehicles. This shows that the solution of urban traffic congestion and routing problem in city logistics requires urgency. In parallel to the technological developments for vehicle routing studies theoretical studies has left the place to the implementation. It was observed that applications run with the results in computer environment and public sector. In today the need for dynamic data works of instant data collection and evaluation have gained importance. From that reason gained importance in the routing problem too models that being convenient to the instant changes.

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DETERMINATION OF THE MOST APPROPRIATE CARGO TRANSPORT MODEL FOR ISTANBUL CARGO TRAFFIC BY USING ANALYTIC HIERARCHY PROCESS

Kayıhan Ozdemir Turan[94]

Abstract-Until last quarter of this century, the connection between two sides of Istanbul city was only by waterway. Later by the construction of two bridges on Bosphorus, the uninterrupted road connection was realized. In recent years the railway connection under boshoprus has started to serve and finally within a few years, the construction of third bridge, having both road and railway on it, will be a new solution for city life. After the last solution is in force, there will be three alternative transport models for Istanbul cargo traffic, direct road transport, RoRo and RoLa Intermodal transport. In this case, the selection of appropriate transport model for both urban cargo logistics and transit cargo transport within the city is a multi-criteria decision-making problem. The aim of this study is to determine the most appropriate alternative cargo transport model for Istanbul cargo traffic by taking into account four critearias as route distance, time, fuel cost and greenhouse gas emissions by using one of the multi-criteria decision making process, AHP (Analytic Hierarchy Process). It is strongly recommended that at the end of this study having the best method as RoLa, should be taken into consideration in the future plans by city management.

KEYWORDS

İstanbul, AHP, Urban Cargo Transport, RoRo, RoLa

1.INTRODUCTION

The most important reality of today's world in the urban areas that attracts the population, is to handover the product or any other material that human requires in urban areas. This is only possible incase the logistics network plan is done and executed properly. City management and all share holders should act within same understanding and for the same target to realize a logistics system for the benefit of city life. Otherwise the path will lead all to a traffic congestion, accidents, air pollution, noise and all other negative effects. City managers and decision makers, should decide on correct logistics method, mode and system with positive effects of execution by using modern decision making methods (Taniguchi, 2014).

Sustainable healty city life is a result of correct decisions. The results of decisions taken by city managers shows whether this decision is correct or not by the social and economical outcomes of these decisions. To do so it is vital important to collect information, duration of analyzing of the information, detailed study and to chose best decision making method (Ricardo ve diğ. 2014).

The logistics planning should have the most priorty in Istanbul as a mega city which is geographically located on the east-west direction and enlarging continuously on european and asian side together with people both living and working on both sides who are using currently 2 bridges and in the close future including a 3rd one, by both private cars and taxis and public transportation with huge numbers of vehicles (URL3).

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Additional to daily urban traffic, Fatih Sultan Bridge which is used also for transit road transportation between Asia and Europe, is located in the center of the city. The 3rd bridge which will be openned within 2-3 years time and will also have a railway line, will have a positive effect to minimize the traffic jam on these 2 bridges and will move that transit road transportation out of city life. But it will not last long since the urban life and area is enlarging every year.

The current solution for cargo transportation of Istanbul city together with international transit road transportation is direct road route and the other two alternative solutions are RoRo lines in east-west direction and RoLa route using railway line on the 3rd bridge. In this study, the three alternatives will be evaluated and decided the best one based on route distance, time, fuel cost and greenhouse gaz emissions by using one of the the multi-criteria decision making process, AHP (Analytic Hierarchy Process).

This study consists of 5 sections . Introduction is the first section. In the second section, literature is searched and same samples are given. In the third section, general description and expalanations are given about AHP. In the fourth section, one application is explained in details using AHP, together with data collection method, explanation of criterias, the methodology of solving the problem. Fifth section is the final part with concluding remarks.

2.RELEATED LITERATURE

When we have searched the literature for both national and international studies, it is common to see too many studies about decision making process on different topics using AHP. The main common point of all these studies is the need of deciding targets, criterias and alternatives by a group of specialist on the related subject. After these main three topics are decided the solving of the problem is a mathematical analysis. The studies are on subjects such as, the best one of investment models, deciding best subcontractor, the reasons and results of accidents, deciding best model for public transport vehicle, targeted best market for a chosen sector.

Among all these studies, we have not found any study focusing on deciding on three alternative transport modes for freight logistics in a city. That’s why this study should be taken into account seriously with the results on cost and social effects under the topics of distance, time, fuel cost and greenhouse emissions for Istanbul as a mega city which has a chance of executing 3 modes of transport, road, rail and sea.

Some of national and international studies and topics are listed below :

- “A model proposal for investment decions : AHP method”, a real life application for industrial facility manufacturer to make an investment desision, (Gülenç and others, 2010).
- “Determining the districts that can be a province in Turkey using AHP”, determining priority ranking of districts which is eligible to become a province in Turkey, (Güngör and others, 2010).
- “Determination of target market in Aegean region for furniture sector by using AHP”, an application to chose market in Aegean region for furniture sector, (Toksarı, 2007).“T
- “Analysis and evaluation of the relation between the reasons and consequences of the traffic accidents by using topss and AHP methods”, mathematical calculation and analysis of relation between reaons and consequences of the traffic accidents, (Alp and Engin, 2011).
- “Supplier selection based on AHP methods in garment sector”, solving the problem of choosing the most suitable supplier for fabric raw material for a company operating in Konya, (Güleş and others, 2014)
- “AHP method in selection of logistics suppliers : an application in Mondial Company”, selection the best logistics supplier for Mondial Motorcycle company, (Şenkayas and others, 2010)
- “Application of AHP method for multi-criteria evaluation of variants of the integration of urban public transport”, economic, technical and environmental and social aspects of urban transport, example of Cracow, (Nosal and others, 2014).

- “Judgment scales and consistency measure in AHP”, nteminde tutarlılık ve karar skalalarının ölçütü”, analyze the impact of using different judgment scales on the resulting priorities and consistency, (Franek and Kraste, 2014)
- “Study on the status evaluation of urban road intersections traffic congestion base on AHP-topsis modal”, analysis and comparison of influence factors for the intersections traffic congestion, (Yu and others, 2013)
- “Simulation-enhanced approach for ranking major transport projects”, rnaking major transport projects to determine implementation priorities and budget allocations, (Su and others, 2006).

3.ANALYTIC HIERARCHY PROCESS

The analytic hierarchy process (AHP) was first mentioned by Myers and Alperts in year 1968 and developed as a decision making methodology to solve problems by Professor T.L. Salty in year 1977 and has been extensively studied and refined since then.

Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem, tangible or intangible, carefully measured or roughly estimated, well or poorly understood, anything at all that applies to the decision at hand.

Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, but they typically use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations.

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action.

İt is not needed high level mathematical talent and information and historical data to desing a model and application of the model and calculation and solution of the problem. This is the most important feature of AHP to overcome other decision making methods (Saaty, 1994).

The procedure for using the AHP can be summarized as follows :

The first step in the analytic hierarchy process is to model the problem as a *hierarchy,* containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives. An AHP hierarchy is a structured means of modeling the decision at hand. It consists of an overall *goal,* a group of alternatives for reaching the goal, and a group of criteria that relate the alternatives to the goal. The design of any AHP hierarchy will depend not only on the nature of the problem at hand, but also on the knowledge, judgments, values, opinions, needs, wants, etc. of the participants in the decision-making process. The Hierarchy chart is given in figure 1.

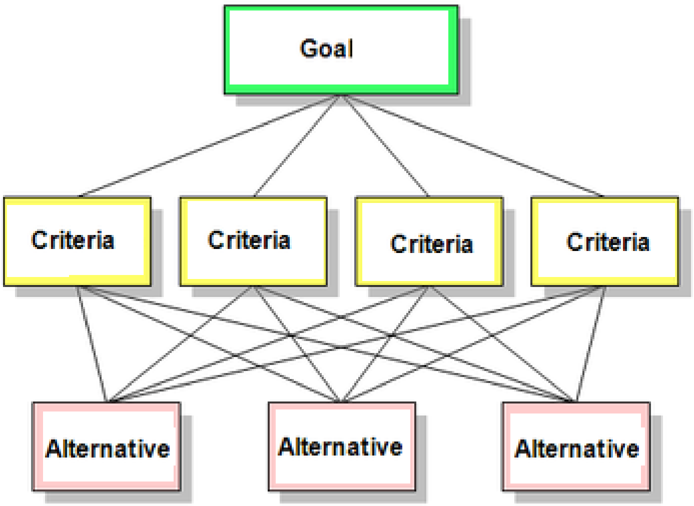

Figure 1 : AHP Hierarchy Chart

Source: Saaty, Thomas L. and Vargas G. Luis; (2001), Model, Methods, Concepts & Applicati-ons of The Analytic Hierarcy Process, Kluwer's International Series, pp.3.

The second step is to establish priorities among the elements of the hierarchy by making a series of judgments based on pairwise comparisons of the elements. The comparisions are processed mathematically and values of pairwaise comparisons are shown in a nxn matrix as in Table 1.

Table 1: Pairwise Comparision Matrix

	Criteria 1	Criteria 2	Criteria n
Criteria 1	w1 / w 1	w1 / w2	w1 / wn
Criteria 2	w2 / w1	w2 / w2	w2 / wn
Criteria n	wn / w1	wn / w2	wn / wn

Source : Vargas, G. Luis; (1990), "An Overview of The Analytic Hierarchy Process and Its Applications", European Journal of Operational Research, 48(1), pp.2-8.

If hierarchy consists of n criteria, matrix should have n(n-1)/2 number of comparision. In this matrix, wi/wj values are assigned relative weights to each other. In assigning the weights AHP fundemental scale is used (Table 2).

Tablo 2: Saaty Scale

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment moderately favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities of 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

Source: Saaty, Thomas L. and Vargas, G. Luis; (2006), Decision Making with the Analytic Network Process, Springer's International Series, pp.3.

The third step is to synthesize these judgments to yield a set of overall priorities for the hierarchy. After knowing the priorities of the criteria with respect to the goal and the priorities of the alternatives with respect to the criteria, we can calculate the priorities of the alternatives with respect to the goal. This is a straightforward matter of multiplying and adding, carried out over the whole of the hierarchy.

The fourth step is to check the consistency of the judgments. The AHP incorporates an effective technique for checking the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process. At this step, Consistency Index (CI) and Consistency Ratio (CR) is calculated by use of Random Consistency Index (RI) in below formulas.

$$CI = \frac{\lambda - n}{n - 1} \quad , \quad CR = \frac{CI}{RI}$$

A perfectly consistent decision maker should always obtain CI=0, but small values of inconsistency may be tolerated. In particular, if CR< 0.1, the inconsistencies are tolerable, and a reliable result may be expected from the AHP.

Fifth and final step is to come to a final decision based on the results of this process.

4.MODEL

Model is based on determination of usage of bridges for freight trasnportation together with alternative transport modes. The specialist group is formed by 12 top managers of logistics and freight forwarding service providing companies. Data collection is done by field questionary form for passengerss and drivers who are stuck in traffic congestion on route to FSM bridge. Total 50 drivers and passengers are questioned. All drivers are male, age between 25 – 50 years old, married and not married, with primary and middle school education. Passengers are both male and female, age between 20-35 years old, most of them are university educated, married and not married.

4.1. Description of the problem

The most important problem of Istanbul city is traffic congestion. This congestion is the reuslt of in and out freight movements plus the international transit road transportation on route via FSM bridge. The 3rd bridge under construction is taken into account as a solution to divert this traffic from route of FSM bridge which is within the city limits, to north part of the city which is not used commenly by urban life, yet. This is again a road based solution and which will not last long.

For the time being, during rush hours between 0600-1000 and 1600-2200, usage of FSM bridge by trucks is forbidden. By the end of limited time period, the waiting trucks are starting to move and then the traffic jam increasing more and then rush hours are exceeding then the planned one. During these periods the average speed on roads connecting the bridge is 5-6 km per hour. This is totaly waste of energy.

After 3rd birdge is to be used, the trucks will use that new route and as far as known there will not be any limited time period applicable. This will of course have a positive effect on route of FSM bridge.

The second solution is “The Sea”. The usage of the sea, on both north and south of the city, for transportation is far below the expectations. The carriage of transit trucks and the trucks coming out of the city and heading the other side of the bosphorus on east – west direction, by RoRo ships will be the real solution for minimizing the traffic on bridges. Roll-on/Roll-off ships are used for transport of vehicles and other rolling equipment (Turan, 2014).

The usage of such an on east/west direction RoRo route will minimize traffic congestion, fuel consumption and grees gas emissions and be a resting time instead of source of stress during the voyage of RoRo vessel.

The third solution will be RoLa, “*Ro*llende *La*ndstrasse” in german, which is transportation of trailers by rail both accompanied or unaccompanied. RoLa is not used in Turkey yet, but could be by the railway which is planned to exist on 3rd bridge (Figure 2). Eventhough the rail route is not decided and announced yet, it is estimated that parallel to road route via 3rd bridge, there will be a railway route also.

Figure 2 : Alternatives

In our study, we will determine the most appropriate alternative cargo transport model for Istanbul cargo traffic by taking into account four critearias as route distance, time, fuel cost and greenhouse gas emissions by using one of the multi-criteria decision making process, AHP (Analytic Hierarchy Process). These criterias has beed calculated based on opinions of specialist group. Additionally, it is seen that these criterias were used also in other studies(Taniguchi, 2014. URL4, URL5).

4.2. Application

At first, a questionare is used for data collection for the effects of freight transport on daily city life. During data collection, it is asked the main topics on this subject to passengers and drivers using FSM bridge route while they are stuck in the traffic congestion. At the end of the analysis, four main topics were seen as time, fuel cost, distance and greenhouse gas emission. Based on the negative side effects of traffic congestion on daily city life, the hierarchy structure of the problem is shown in figure 3.

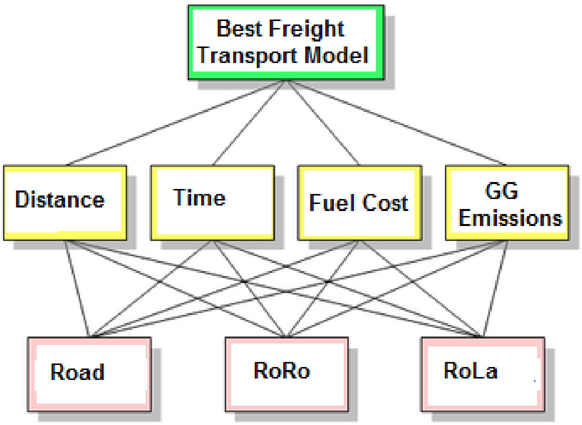

Figure 3 : Decomposition of the problem into a hierarchy

After the hierarchy is built, the priorities among the elements of the hierarchy are established by making a series of judgments based on pairwise comparisons of the elements. According to Saaty Scale (Table 2), the matrix of pairwise comparisons of the criterias decided by Specialist Group, consisting of top managers of Logistics and Freight Forwarding service providing companies are shown in Table 3.

Tablo 3: Pairwise comparison matrix for the first level

	DISTANCE	TIME	FUEL COST	GG EMISSION
DISTANCE	1	1 / 5	1 / 3	3
TIME	5	1	5	9
FUEL COST	3	1 / 5	1	5
GG EMISSION	1 / 3	1 / 9	1 / 5	1

At the next step, priority weights of each criteria respectively are calculated by geometric average method and shown in Table 4.

Tablo 4: Calculation of priority weights

	DISTANCE	TIME	FUEL COST	GG EMISSION
DISTANCE	1	0,2	0,33	3
TIME	5	1	5	9
FUEL COST	3	0,2	1	5
GG EMISSION	0,33	0,11	0,2	1
	9,33	**1,51**	**6,53**	**18**

	DISTANCE	TIME	FUEL COST	GG EMISSION
DISTANCE	0,11	0,13	0,05	0,17
TIME	0,54	0,66	0,77	0,5
FUEL COST	0,32	0,13	0,15	0,28
GG EMISSION	0,04	0,07	0,03	0,06
	1	**1**	**1**	**1**

Thenafter final priority vector is calculated as shown in Table 5.

Tablo 5: Final priority vector

	DISTANCE	TIME	FUEL COST	GG EMISSION	**wi**
DISTANCE	0,11	0,13	0,05	0,17	**0,11**
TIME	0,54	0,66	0,77	0,5	**0,62**
FUEL COST	0,32	0,13	0,15	0,28	**0,22**
GG EMISSION	0,04	0,07	0,03	0,06	**0,05**

Next step is to check the consistency of the judgments. The AHP incorporates an effective technique for checking the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process. At this step, Consistency Index (CI) and Consistency Ratio (CR) is calculated by use of Random Consistency Index (RI) in below formulas (Table 6).

$$CI = \frac{\lambda - n}{n - 1}, \quad CR = \frac{CI}{RI}$$

Tablo 6: Consistency Ratio

	DISTANCE	TIME	FUEL COST	GG EMISSION		wi		di		Ei=di/wi
DISTANCE	1,00	0,20	0,33	3,00		0,11		0,46		4,00
TIME	5,00	1,00	5,00	9,00	X	0,62	=	2,73	=	4,44
FUEL COST	3,00	0,20	1,00	5,00		0,22		0,93		4,21
GG EMISSION	0,33	0,11	0,20	1,00		0,05		0,2		4,10
										16,74
									λ=∑Ei/n	4,19

Random consistency Index (RI) is given in Table 7.

Tablo 7: Random Consistency Index (RI) for n=1.2…15

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RG	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,53	1,56	1,57	1,59

Based on above results, here is the calculation of CI and CR.

CI = (4,19 – 4) / (4 – 1) = 0,06

RI = 0,90 for n=4

CR = CI / RI = 0,06 / 0,90 = 0,068 < 0,10

Since CR is 0,068 and less than 0.10, the inconsistencies are tolerable.

Next step is to check the consistency of the judgments. The AHP incorporates an effective technique for checking the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process. At this step, Consistency

After knowing the priorities of the criteria with respect to the goal and the priorities of the alternatives with respect to the criteria, we can calculate the priorities of the alternatives with respect to the goal. This is a straightforward matter of multiplying and adding, carried out over the whole of the hierarchy. The result is shown as Decision Matrix in Table 8 and combined matrix & integrated priority vectors in Table 9.

Table 8: Decision Matrix

	DISTANCE	TIME	FUEL COST	GG EMISSION
ROAD	0,11	0,17	0,11	0,07
RORO	0,58	0,39	0,31	0,34
ROLA	0,31	0,44	0,58	0,59

Table 9: Combined Matrix & Integrated Priority Vectors

	DISTANCE	TIME	FUEL COST	GG EMISSION	Integrated Priority Vector
wi	0,11	0,62	0,22	0,05	
ROAD	0,11x0,11	0,17x0,62	0,11x0,22	0,07x0,05	**0,15**
RORO	0,58x0,11	0,39x0,62	0,31x0,22	0,34x0,05	**0,39**
ROLA	0,31x0,11	0,44x0,62	0,58x0,22	0,59x0,05	**0,46**

At the end of all these evaluations and calculations and analysis, as summurazied in Table 10, the most appropriate transport mode for Istanbul freight transportation is RoLa. The second one is RoRo which also has a close value to RoLa. Road mode is the last one which really has a lessek value compared to other modes.

Table 10: Result

TRANSPORT MODE	SCORE	
ROAD	0,15	15%
RORO	0,39	39%
ROLA	0,46	46%

5.CONCLUDING REMARKS

Main problem for a human being living in Istanbul is traffic jam. The two source of this traffic jam is public and freight transport. Eventhough there are active solutions for public transport such as metro, metrobus, car ferry, ships and recently marmaray, there are not so many solutions for freight transport in Istanbul city.

For freight transport in Istanbul between to sides of the city, there is no alternative solution other the main and only route via FSM bridge. The 3rd bridge under sonstruction will have both road and rail route. Solution for Istanbul is at sea or on rail. Because for today, both city managers and share holders in governing the city, should use modern technology, new systems and execute supportive politics and strategy to solve the problems of mega cities. To do so, they need to use appropriate modern decision making process to decide the best alternative.

In this study, RoLa is determined as the most appropriate alternative cargo transport model for Istanbul cargo traffic under four critearias as route distance, time, fuel cost and greenhouse gas emissions, by using one of the multi-criteria decision making process, AHP (Analytic Hierarchy Process).

Eventhough the result of consistency analysis is within the limits for this study, AHP hierarchy can be built by different decision makers in a different way for the same decision problem. Based on the model used for this study, different decision makers can make their own model with different criterias and can evaluate whether they have the same result or not.

It is not acceptable for all people who live in Istanbul, not to protest road based freight transport solutions in this city which has both sea and rail alternatives, while road transport is not "environment-friendly" way of transport, while everything is produced and manufactured and consumed with *"environment-friendly"* slogan in today's world. While "sea" exists as an alternative to "road" and RoRo is a potential transport solution, not to use this transport mode is a result of wrong city management planning and executions. Sea must be used for city life since there are a lot people in this city who likes "sea".

Eventhough it is not a transport model used in our country, RoLa, an intermodal transport by rail, is used commonly in Europe. At the end of this study RoLa is decided as the most appropriate alternative cargo transport model for Istanbul cargo traffic by the top managers of logistics and freight forwarding service providing companies and this is an important and valuable sign of expectations for city managers.

İn today’s world, center of manufacture is far east, and center of consumption is Europe and America. Within this scope, sea transportation is the main model for many years to deliver finish products from far east to consumption markets. Usage of trans-sibirian train for the last a few years with an improving better transit time as an alternative route to sea transport for the transport of finish products from far east to europe is a sign of increasing importance of rail transportation in the world.

Execution of rail linked transport chain in Istanbul both highlighted by top managers in logistics sector and with increasing trends to use more rail transport in logistics in the world, is an important necessity.

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EVALUATING THE PREPARATIONS FOR A POSSIBLE EARTHQUAKE IN ISTANBUL AND PROPOSALS FOR THE FUTURE WORKS

Zafer YILMAZ[95], Feyza ALTUNTAŞ[96], Alaattin ALTUNTAŞ[97]

Abstract - Fifteen million people which is 18% percent of total population of Turkey are living in approximately 1250000 buildings in Istanbul. Since Istanbul is located so close to North Anatolian Fault Line the probability of a possible earthquake is so high. There are 5 different regions in in Istanbul with respect to earthquake risk. The regions close to Marmara Sea are under biggest earthquake risk and the least earthquake risky regions are located near to Black Sea part of Istanbul. After an earthquake in Istanbul, it is estimated that thousands of people will die, maybe millions of people will be left without houses and there will be more than 50 billion dollars economic lose. The probability of a big earthquake in Istanbul in 30 years.is 62% according to Earthquake Master Plan for Istanbul. 1999 Marmara Earthquake was a start for the preparations of a big earthquake in Istanbul.

In this study, we first explained the past earthquakes and their results in Istanbul. Then we evaluate all preparations done by the government, Istanbul Municipality, military, public and private companies. The Prime Ministry Disaster and Emergency Management Authority (AFAD in Turkish) which started its activities since 2009, is the legal authority for preparations of disasters. The Disaster Coordination Center of Istanbul Municipality (AKOM) started to coordinate activities for a probable disaster in 2002. We also evaluate other public and private organizations for disaster management. Finally, we proposed what should be done to be prepared for a big earthquake in Istanbul.

Keywords: Disaster Logistics, Istanbul Earthquakes, AKOM, AFAD.

INTRODUCTION

Turkey is an earthquake-prone country, where there are many small, medium and large scale earthquakes in the history. Loss of lives, physiological problems, loss of property, damages in the buildings and roads are the main results of earthquakes [1].

Earthquake is the most destructive disaster in Turkey according to the statistics. Due to the earthquake region map which is currently in effect, the % 96 of Turkey's land is in different ratio of risk of earthquake region and % 98 of population are living in this regions.

Earthquake is the most feared type of disaster in Turkey because of the high frequency of seismic activities. Geologically, Turkey is located at the boundary area where the Arabian Plate and African Plate are moving north towards the Eurasian Plate. A large scale fault line called North Anatolian Fault (NAF) is formed more than 1,000 km long from east to west in the northern territory of Turkey and historically, many strong earthquakes have occurred along this fault line. North Anatolian Fault Line is the most active one. The danger exposed by this fault line can be considered as important since nearly one third of Turkey's population lives in regions that are close to this faulty line. According to seismologist, there are five categories of earthquake zones. These are;

- First degree earthquake zones: An earthquake of magnitude 9 Richter or greater is very likely to occur in the future, or has already occurred in this zone.
- Second degree earthquake zones: An earthquake of magnitude between 8 Richter and 9 Richter is very likely to occur in the future, or has already occurred in this zone.
- Third degree earthquake zones: An earthquake of magnitude between 7 Richter and 8 Richter is very likely to occur in the future, or has already occurred in this zone.

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- Fourth degree earthquake zones: An earthquake of magnitude between 6 Richter and 7 Richter is very likely to occur in the future, or has already occurred in this zone.
- Fifth degree earthquake zones: These zones are exposed to no or little earthquake risk.

Starting from 20th century, thousands of earthquakes occurred in Turkey. Most of them were small scaled and did not cause any destruction or loss of life. However, there are also lots of them that have death tolls[2]. In recent years (1939 and 1992), very strong earthquakes occurred in Erzincan City, which is situated in the eastern part of Turkey. More than 30 thousand died in the earthquake of 1939 while 700 people perished in 1992. There was heavy damage to property, including the collapse of a number of buildings and infrastructures [3]. Although the 1932 Erzincan earthquake has the greatest death toll, most studies were conducted on the aftermath of the 1999 Kocaeli earthquake [2].

The active fault zone in the Marmara Sea which is a part of (NAF) that lies about 20 km south of Istanbul poses an extremely high seismic hazard risk [4]. Earthquake probability calculations for the Marmara Sea in Parsons [5] show that the probability of a 7 or larger magnitude earthquake is 38%, and incorporation of stress transfer raises it to 53 with 18% error margin .In addition, the rapid and unplanned growth of the city within the last 30 years increases the vulnerability.

Istanbul is a city suffering from the earthquakes in every century and detection of the magnitude and epicenters of the earthquakes has a vital importance for the future works that should be done for Istanbul. Therefore the following three organizations have permanent strong ground motion stations around Istanbul.

- KOERI : Kandilli Observatory and Earthquake Research Institute, Bogaziçi University
- ITU : Istanbul Technical University
- ERD : Earthquake Research Department of General Directorate of Disaster Affairs

Based on worldwide historical catalogues, Istanbul has suffered from earthquakes repeatedly. The seismic intensity in Istanbul for some earthquakes is estimated by the damage mentioned quite precisely in existing literature. Istanbul has experienced earthquakes equal or greater than intensity nine at least 14 times in historical years which means Istanbul has suffered damage from earthquakes every 100 years, on average [3].

In this study, in the first part we explained the past earthquakes and their results in Istanbul. In the second part, we explained the structures and duties of governmental and non-governmental organizations responsible for the disaster and emergency management. In the third part, we proposed what should be done to be prepared for a big earthquake in Istanbul and we finalized our study with a conclusion and future works part.

THE HISTORY OF EARTHQUAKES IN OR AROUND ISTANBUL

According to statistics, Turkey suffers from many earthquakes in every century. Especially earthquakes with a magnitude over 5 cause damages in Turkey. 65% of total deaths and property damage in Turkey were the results of earthquakes. For this aspect, when we mention about disasters, most of the people remembers earthquakes and this forces the government and other organizations to work on precautions for earthquakes. The most destructive earthquakes in Marmara region for the last 20 years were Kocaeli and Düzce earthquakes in 1999. According to data from AFAD, between the years 1900 and 2005, there were 1170 earthquakes with a magnitude 5.0-5.9, 155 earthquakes with a magnitude of 6.0-6.9, 34 earthquakes with a magnitude 7.0-8.0. the earthquakes caused 58202 deaths, 122096 injuries, 411465 building damage for the last 58 years. This means that, on the average, earthquakes causes 1003 deaths and 7094 buildings damages annually.

As mentioned above, on 17th August 1999, an earthquake hit the Marmara region of Turkey, where approximately one third of the Turkish population lives. As a consequence, 17127 people lost their lives and about 600,000 people were direct victims. In addition to homes, many commercial buildings were also damaged and infrastructure of the region was highly damaged [2]. Table 1 gives the list of earthquakes with a magnitude over 5.5 in Turkey.

Table 1: Earthquakes with a Magnitude over 5.5 in Turkey

DATE	EVENT	MAGNITUDE	INJURED PEOPLE	DEAD TOLL
30.10.1983	Erzurum	6.8	1,142	1,155
18.09.1984	Erzurum-Balkaya	5.9	35	3
06.06.1986	Malatya-Sürgü	5.6	20	1
07.12.1988	Kars-Akyaka	6.9	11	4
13.03.1992	Erzincan	6.8	3,850	653
01.10.1995	Dinar	6.0	240	96
27.06.1998	Adana-Ceyhan	6.3	1,041	145
17.08.1999	Kocaeli	7.4	43,953	17,127
13.09.1999	Kocaeli	5.8	-	-
12.11.1999	Bolu-Düzce	7.2	4,948	845
06.06.2000	Çankırı-Orta	6.1	1,766	2
23.08.2000	Sakarya-Hendek	5.8	9	-
15.12.2000	Afyon-Sultandağı	5.8	547	6
27.01.2003	Tunceli-Pülümür	6.2	7	1
10.04.2003	İzmir-Urla	5.6	-	-
01.05.2003	Bingöl	6.4	520	176
11.08.2004	Elazığ-Sivrice	5.5	12	-
25.01.2005	Hakkari	5.5	5	2
12.03.2005	Bingöl-Karlıova	5.7	16	-
14.03.2005	Bingöl-Karlıova	5.9	-	-
20.12.2007	Ankara- Bala	5.6	-	-

Source [6]

Experiencing the devastating consequences of the 1999 earthquake that was epicentered 110 km east of Istanbul underlined the need for earthquake preparedness and response planning. The 7.4 M earthquake also resulted in over 50,000 injuries and estimated 3 to 6.5 billion U.S. dollars damage in Istanbul, Kocaeli and Sakarya Provinces [5]. When we just focus on the earthquakes in or around Istanbul, there were 32 earthquakes with a magnitude over 5.5. The epicenters of these earthquakes can be seen in Figure 1 and magnitudes and the places of them can be seen in Table 2.

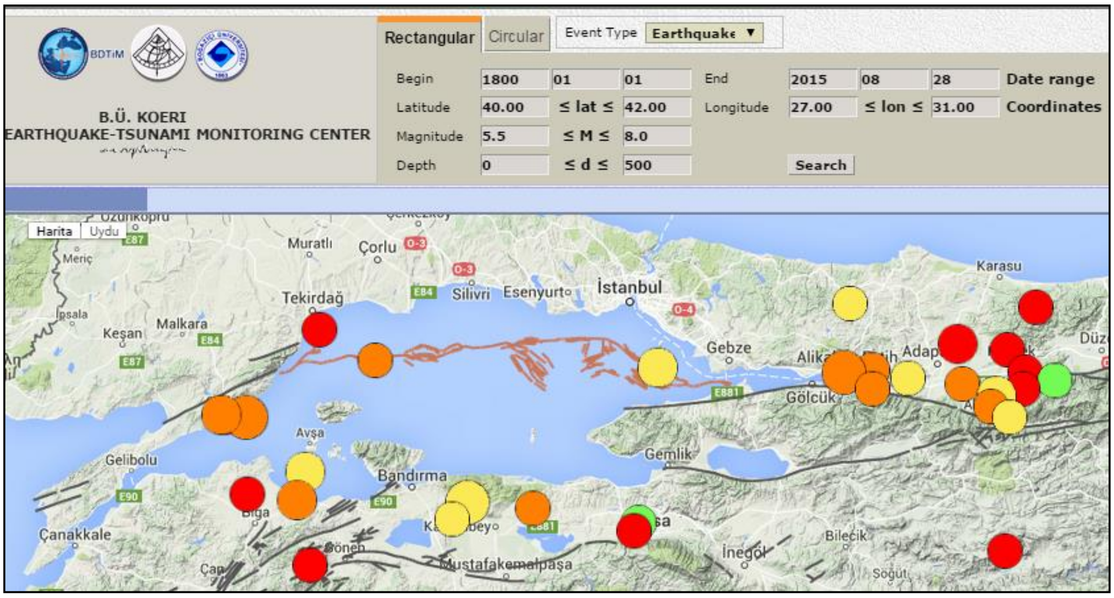

Figure 1: The Epicenters of Earthquakes in or Around Istanbul [7]

Table 2: Earthquakes with a Magnitude over 5.5 in Turkey [7]

Date	Latitude	Longtitude	M	Location
1999.11.11	40.7400	30.2700	5.7	ASAGIDEREKOY-SERDIVAN (SAKARYA) [South 1.6 km]
1999.09.13	40.7700	30.1000	5.8	BAYRAKTAR-IZMIT (KOCAELI) [South East 2.0 km]
1999.08.17	40.6400	30.6500	5.5	KUZULUK-AKYAZI (SAKARYA) [North East 1.5 km]
1999.08.17	40.7600	29.9700	7.4	BASISKELE (KOCAELI) [North East 2.0 km]
1983.07.05	40.3300	27.2100	5.9	TOKATKIRI-BIGA (ÇANAKKALE) [South West 1.0 km]
1969.03.03	40.0800	27.5000	5.8	ALACAOLUK-GONEN (BALIKESIR) [South West 2.6 km]
1967.07.30	40.7200	30.5200	5.7	TEKETABAN-KARAPURCEK (SAKARYA) [North 3.8 km]
1967.07.22	40.7000	30.8000	5.5	BAKACAK-HENDEK (SAKARYA) [South West 0.5 km]
1967.07.22	40.6700	30.6900	6.8	GUZLEK-AKYAZI (SAKARYA) [North 1.5 km]
1964.10.06	40.3000	28.2300	7.0	OKCULAR-KARACABEY (BURSA) [North East 1.5 km]
1964.10.06	40.2400	28.1600	5.7	TOPHISAR-KARACABEY (BURSA) [North 2.2 km]
1963.09.18	40.7700	29.1200	6.3	ADALAR (ISTANBUL) [South 11.7 km]
1959.07.26	40.9100	27.5400	5.5	BARBAROS- (TEKIRDAG) [East 6.1 km]
1957.05.27	40.7300	30.9500	5.8	SACMALIPINAR-GOLYAKA (DUZCE) [South West 0.6 km]
1957.05.26	40.7600	30.8100	5.9	HARMANTEPE-HENDEK (SAKARYA) [South 0.9 km]
1957.05.26	40.6000	30.7400	5.5	DURMUSLAR-AKYAZI (SAKARYA) [North West 1.0 km]
1953.06.03	40.2800	28.5300	5.5	SUBASI-KARACABEY (BURSA) [North West 1.3 km]
1948.11.13	40.2300	29.0200	5.7	NILUFER (BURSA) [North East 4.1 km]
1943.06.20	40.8400	30.7300	5.6	KAHRAMAN-HENDEK (SAKARYA) [North 3.0 km]
1943.06.20	40.8500	30.5100	6.6	TURKBEYLIKKISLA-SOGUTLU (SAKARYA)[South East 0.9km]
1942.06.16	40.8000	27.8000	5.7	MARMARA DENIZI
1935.01.04	40.3000	27.4500	6.3	GUVEMALANI-BIGA (ÇANAKKALE) [North West 2.3 km]
1935.01.04	40.4000	27.4900	6.4	ERDEK KÖRFEZI (MARMARA DENIZI)
1928.01.24	40.9900	30.8600	5.5	KOVUKPELIT-KOCAALI (SAKARYA) [South East 0.7 km]
1926.12.16	40.1300	30.7200	5.8	BEYYAYLA-SARICAKAYA (ESKISEHIR) [South East 1.5 km]
1923.05.29	41.0000	30.0000	5.6	HACISEYH-KANDIRA (KOCAELI) [North West 0.9 km]
1917.04.10	40.6000	27.1000	5.5	SARKOY (TEKIRDAG) [South West 2.0 km]
1912.08.10	40.6000	27.1000	5.5	SARKOY (TEKIRDAG) [South West 2.0 km]
1912.08.10	40.6000	27.1000	6.3	SARKOY (TEKIRDAG) [South West 2.0 km]
1912.08.09	40.6000	27.2000	7.3	ERIKLICE-SARKOY (TEKIRDAG) [South East 4.3 km]
1907.08.21	40.7000	30.1000	5.6	SIRINSULHIYE-KARTEPE (KOCAELI) [East 0.3 km]
1905.04.15	40.2000	29.0000	5.7	NILUFER (BURSA) [South East 2.4 km]

When we refer to catalogs of earthquakes, we notice that there were 245 earthquakes from 5th to 19th century around Marmara Sea. Among 245 earthquakes only 38 of them were caused serious results with death and property loss [8].

Except deaths, injuries, diseases, the effects of historical earthquakes on Istanbul were damages on tower of Ayasofya, Galata, Boğaziçi Fortress, the buildings of Bakırköy and Yeşilköy province.

When we sort the important earthquakes according to their regions;

484, 824, 1083, 1354, 1659 and 1912 earthquakes were between Soros Gulf and west of Marmara Sea,
543, 797, 1063, 1343, 1569 and 1766-August earthquakes were west Coast of Marmara Sea,
542, 795, 1032, 1346, 1556, 1766-May earthquakes were North Coast of Marmara Sea and in Istanbul,
478, 732, 1011, 1332, 1542, 1754 earthquakes were west of Istanbul and in old Istanbul province.

The most devastating earthquakes of Istanbul were in 557, 989 and 1509 years. These earthquakes caused many deaths, injuries, damages on property with a tsunami afterwards.

GOVERNMENTAL AND NON-GOVERNMENTAL ORGANIZATIONS RESPONSIBLE FOR DISASTER AND EMERGENCY MANAGEMENT

With the experience of two earthquakes in Turkey in 1999, many disaster management governmental and non-governmental organizations were established at various levels, from prime ministry to municipality. In order to improve disaster risk management and preparedness, the Istanbul Governorship and the Istanbul Metropolitan Municipality, respectively, instituted the Disaster Management Center (AYM) and the Disaster Coordination Center (AKOM). The emergency response functions in Istanbul are currently based upon these parallel institutions, derived from the dual administrative systems that govern the metropolis. Istanbul and other metropolitan areas, in particular, some of the institutions established by central government are empowered to prepare their individual disaster risk management plans in areas under their jurisdiction.[9].There is no accepted unique classification for these organization. However we can classify these organizations as;

1. Governmental Organizations
    a. Central Government
        - Prime Ministry Disaster Crisis Management Centre
        - Prime Ministry Disaster and Emergency Management Authority (AFAD)
        - Civil Defense
        - Turkish Red Crescent
        - Natural Disasters Search and Rescue Battalion (NDSAR)
    b. Provincial Government
        - Governorship Disaster Management Centre (AYM)
    c. Istanbul Metropolitan Municipality government
        - AKOM
    d. District Disaster Management Center
2. Non-Governmental Organizations
    a. AKUT
    b. Turkish Earthquake Foundation (TEF)

The following describes the foundation, organization and function of these organizations:

1. Governmental Organizations:

Organizations Responsible From Coordination;

Prime Ministry Disaster Crisis Management Centre:

The Prime Ministry Crisis Management Centre was established at the time of 1999 Marmara Earthquake to integrate the disaster response of the government. Later, the General Directorate of Emergency Management under the Prime Ministry was established as a permanent organization to ensure efficiency in emergency management. The activities of the general directorate are as follows:

- To establish emergency management centers within local governments, determine their principles and carry out inter-institutional coordination
- To carry out preliminary actions, make short- and long-term plans, monitor and evaluate databases in order to prevent and mitigate disasters
- To coordinate the utilization of public and civilian vehicles and facilities in case of emergencies
- To promote volunteer efforts by organizations and individuals in emergencies
- To coordinate the procurement, warehousing and distribution of relief materials

Istanbul Metropolitan Municipality Government-AKOM:

In order to alleviate damages of a potential disaster, Istanbul Metropolitan Municipality (IMM) collaborated with the Japan International Cooperation Agency (JICA) on developing a disaster prevention and mitigation plan. The resulting JICA report (JICA, 2002) identifies potential earthquake scenarios and damage estimates for Istanbul, and also suggests that lack of preparedness exacerbated the impact of the Izmit earthquake. IMM initiated various preparedness activities to improve both pre-disaster and post-disaster operations, including the preparation of an earthquake master plan, and established a Disaster Coordination Center (abbreviated as AKOM in Turkish) in 2000. AKOM is planning to open facilities throughout Istanbul to execute its post-disaster response operations [10].

AKOM was established due to the necessity to establish a communication channel within IBB, by the order from mayor and authorization by the Municipal Assembly. The initial members of the centre were the fire department, health department, ISKI and IGDAS. Planning, mapping, and other departments joined later on to form the current organization. The object of AKOM is to coordinate tasks among organizations within Istanbul metropolitan Municipality.

Organizations Responsible For Preparations and Response to Disasters;

Prime Ministry Disaster and Emergency Management Authority (AFAD):

Turkey's disaster policy dates back to the aftermath of the 1939 Erzincan earthquake, which claimed nearly 33.000 lives and left at least 100.000 injured. Two decades later, the Turkish Parliament adopted the Law on Precautions to be taken due to Disaster Affecting Public Life and Assistance to be provided (No.7269) in order to fill the long-existing legal void. The legislative effort on disaster continued with the 1988 by-law on the Principles of the Organization and Planning of Emergency Assistance Regarding Disasters.

The 1999 Marmara earthquake, however, marked the turning point in the area of disaster management and coordination. This devastating disaster clearly demonstrated the need to reform disaster management and compelled the country to establish a single government institution to single-handedly coordinate and exercise legal authority in cases of disaster and emergencies. In line with this approach, the Turkish Parliament passed Law No.5902 in 2009 to form the Disaster and Emergency Management Authority (AFAD) under the Prime Ministry and abolish various agencies under whose jurisdiction the issue previously fell. AFAD currently has 81 provincial branches across Turkey in addition to 11 search and rescue units [11].

Disaster and Emergency Management Authority, an institution working to prevent disasters and minimize disaster-related damages, plan and coordinate post-disaster response, and promote cooperation among various government agencies.

Notwithstanding its position as the sole authority on disasters and emergencies, AFAD cooperates with a range of government institutions and non-governmental organizations depending on the nature and severity of individual cases.

The Turkish Red Crescent:

Turkish Red Crescent was founded in 1868 Turkish 1868, and has 648 branches across the country [12].
Duties of TRCS during disasters:

- To provide tents, blankets, health service, food and clothing
- With International Federation of Red Cross and Red Crescent, coordinate international aids
- Blood- transfusion
- Disaster Operation Center of TRCS is on duty 24 hours of day.

Kizilay reorganized and standardized its stocks around the country to meet needs properly. It replenishes them regularly. It began responding to floods, village fires and avalanches in addition to small-scale tremors that take place on a more or less daily basis in this quake-prone country. The National Society now runs its own tent production unit and can meet the emergency shelter and nutrition needs of 250,000 people in a major disaster.

The Turkish Red Crescent Society is aware of the increasing competition in the humanitarian field and the need for well-trained, highly qualified staff. Completing its restructuring and branch development process, as well as building a response capacity for newly emerging threats, such as environmental problems and global warming, will enable it to meet future challenges.

General Directorate Civil Defense:

The Civil Defense Law Number 7126 that went into force 1958 established GD of Civil Defense within the Ministry of Interior. The goal and purpose of the Civil Defense Organization is to minimize the life losses and other types of losses during warfare or a natural disaster. Civil Defense Law explains the main purposes of the organization as follows:

- To secure the lives and belongings of the civil people during a war,
- Saving lives and belongings of people during natural disasters,
- To reduce the damage to the lives and the belongings of victims in a fire,
- In case of damage, to renew, repair and protect private and government institutes that have vital importance,
- To build up morale among the civilians.

Natural Disasters Search and Rescue Battalion (NDSAR):

Turkish Armed Forces Natural Disasters Search and Rescue Battalion (NDSAR) was established with the direction of General Staff on May 31st, 2001 (after the August 17th 1999 earthquake) to carry out special tasks for natural or man-made disasters such as earthquake, conflagration, flood, avalanche, erosion or SAR missions for the missing personnel, Weapons of Mass Destruction (WMD) -Chemical, Biological, Radiological and Nuclear (CBRN)- attacks. NDSAR is well equipped and trained to carry out any assigned mission worldwide [13]. It carries out its activities in the earthquake region by coordinating with AFAD.

Organizations Responsible For Education and Information Systems of Disaster;

Bogazici University Kandilli Observatory Earthquake Research Institute Disaster Preparedness Education Unit:

The Disaster Preparedness Education Unit (DPEU) at Bogazici University's Kandilli Observatory and Earthquake Research Institute (KOERI) was initially established a year after the 1999 Kocaeli earthquake, as the "Disaster Preparedness Education Project" (DPEP), a five-year program funded by the United States Agency for International Development’s Office of Foreign Disaster Assistance (USAID-OFDA). The financial administration of the project was carried out by the Bogazici University Trust [14].

The goal of the project is to contribute to the efforts to prepare Istanbul for the likelihood of a damaging earthquake. It seeks to improve public disaster awareness, local preparedness, and first response organization and skills in order to decrease the loss of life and property in the event of such an earthquake.

İTÜ and ERD are two organizations which detect and save the information about earthquakes.

2. Non-Governmental Organization:

Organizations Responsible For Preparations and Response to Disasters;

AKUT

"AKUT is entirely a voluntary, non-governmental organization involved in searching, assisting and rescuing all who require aid within its authority and means, in mountain or other nature-related accidents, natural disasters and all other emergency conditions by means of trained, disciplined, high-standard personnel and equipment, passing on knowledge to society with no political affiliation."

AKUT has an administrative structure in accordance with the legal definition of a democratic civil society association, but also enshrines its overarching mission within its bylaws. AKUT's values are: volunteerism, integrity, reliability, helpfulness/humanitarianism, and respect for human life. With an organizational structure that allows it to react rapidly to a wide variety of emergency situations, AKUT has the ability to make quick decisions in the face of crisis.

Today, AKUT is indisputably the #1 search and rescue organization in Turkey, with the largest number of members and the broadest variety of specialized skills. Not only does it have over 200 permanent members and another 1300 volunteer members, it owns state of the art technology that can be mobilized in an instant. AKUT also runs projects that will increase search and rescue competency in Turkish society. With local branches across 32 provinces in Turkey as well as Istanbul on call 24/7, AKUT is always standing by, ready to accept the duty of serving people in need both inside and outside Turkey, to perform operations according to its mission, provide training, organize drills, cooperate with local and international institutions, and to share its experience and knowledge at home or abroad [15].

Organizations Responsible For Education and Information Systems of Disaster;

Turkish Earthquake Foundation (TEF):

Turkish Earthquake Foundation (TEF) was established in 1993. In addition to be having a more flexible organizational structure, one of the main purposes of the establishment of TEF was the support the Turkish National Committee on Earthquake Engineering (TNCEE). TNCEE has been very active in the field of Earthquake Engineering since it was established. The most important missions of TEF is to contribute for the development of all earthquake engineering fields in Turkey and to cooperate and establish joint projects with national and international institutions and agencies to mitigate earthquake losses [16].

PROPOSALS TO BE PREPARED FOR FUTURE EARTHQUAKES

The earthquake clock goes on for Marmara region which suffered from many devastating earthquakes with its 27 century history. If this expected earthquake becomes true, Istanbul will feel the effects of earthquake mostly since even though its crowded population has lack of preparation plans for a possible earthquake. Istanbul which is among the most crowded 25 cities in the world is growing very fast. With this speed Istanbul will host one fourth of total population of Turkey until 2025. It is not difficult to estimate how Istanbul will suffer from a possible earthquake in future.

According to the results of the study which is held by the cooperation of Istanbul Metropolitan Municipality and JICA, it is estimated that an earthquake with a magnitude 7.4 in future will cause 50.000 death, 60-70 million dollars economic loses. It is calculated that there will be 130.000 injuries which are required to be cured in hospitals. We regret to say that 30% of total hospitals are located in most risky region of Istanbul.

The proposals according to the reports of JICA are as follows;

- Each member organization should make its own plans and be checked on its conformity to these plans.
- Communication within service groups should be made.

- Inter-organizational cooperation should be considered.
- Methods of provision of information to the public should be studied.
- Training of trainees and simplified courses should be considered.
- Use of helicopter should be well planned
- Resource inventories should be organized and checked.
- Joint disaster drills including citizens should be exercised.
- Building damage inspections should be completed in a shorter time.
- Evaluation of ground study results and its use is unjust.
- Necessity of Community-based Disaster Management Activities [3]

After the Kocaeli earthquake (17 August, 1999), there were hundreds of thousands of victims who are in need of relief and more than 200 national and international agencies were trying to reach the area and help people. However, there were some major operational challenges which prevented agencies from providing efficient relief to those in need. The most important challenge for the agencies was Turkish bureaucracy. While providing relief, most of the time was wasted because of the bureaucratic processes such as clearing relief materials from customs and the process of obtaining permission to use vehicles and equipment that belong to the state.

Moreover, a disaster response plan didn’t exist. This lack of plan resulted in a chaos and therefore slowed down the relief providing process. Also, lack of communication was an issue. Apart from the absence of related equipment, there were limited numbers of Turkish officials who can speak English, which made it even harder for international aid workers.

To overcome these effects in the future, many operational and structural changes in Turkish laws and institutions those are responsible for disaster management. Most notable ones are as follows [2];

- Turkish Red Crescent (TRC) initiated a restructuring process following the earthquake. AFOM (disaster operations center), regional and local disaster response and logistics centers were founded. Stock levels and standards were revised and technological infrastructure was renewed.
- Obstacles that were occurred by the laws were addressed.
- Disaster trainings became more important, individualism during the survival process was brought front.
- Every institution that is responsible for disaster relief started to form their own disaster plan.
- Number of non-governmental organizations working towards disaster relief increased.
- New law codes for state administration and regional and local municipalities were determined.
- Plans for the cooperation of civilians and military in case of a disaster were developed.
- Housing standards were revised.
- In eleven provinces, search and rescue teams were located.
- The Ministry of Health initiated new disaster response standards, such as forming national medical rescue teams.
- Reception centers for international relief aids were established in airports.
- Communication problems were addressed. [17]

We cannot underestimate the preparation being done by governmental or no-governmental organization, but there are many preparations that should be done in near future. Especially locating the logistics depots in proper locations has a crucial importance. If we locate the depots to right regions, the relief trucks will reach the demand point in optimal time. While conducting exercises to be prepared to earthquakes, we usually educate people where to stay or what to do during an earthquake. The emergency response teams make exercises how to rescue people from damaged buildings. Reaching people in proper time is the most important issue after an earthquake. If you reach in optimal time, you can rescue many lives. Therefore, the relief teams must also conduct exercises to reach the scene in time.

CONCLUSION AND FUTURE WORKS

In this study, we first give brief information about earthquakes, earthquake zones of Turkey, the organizations which give online information about earthquakes. Next, we explained the past earthquakes and their results in Turkey and in Istanbul. Then we summarized the structure, functions and duties of governmental (AFAD, AKOM, Kızılay, IBB, NDSAR, Kandilli etc.) and non-governmental organizations (AKUT, TEF) that are established to be prepared to precautions and after actions of earthquakes. Finally, we proposed what should be done to be prepared for a big earthquake in Istanbul.

Many studies show that the time for a very big earthquake with a magnitude over 7.0 is not so far for Istanbul. This fact forces all organizations and researchers to focus on possible earthquakes in especially Marmara region. For future works, facility location problems for logistics depots must be studied in detail. The exercises to be prepared to earthquakes should include conducting exercises to reach demand points in optimal time.

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AN APPLICATION OF HYBRID MULTI CRITERIA DECISION MAKING APPROACH FOR PERSONNEL SELECTION IN THE LOGISTICS INDUSTRY

Gülçin Büyüközkan[98], Nazlı Göker[99]

Abstract *- Personnel selection is one of the most important activities of human resources departments since the success of a company directly depends on the employees' efficiency. Multi Criteria Decision Making (MCDM) is a powerful tool that is widely used for evaluating and ranking problems containing multiple, usually conflicting criteria. This paper proposes a hybrid MCDM based decision framework for effectively evaluating employee alternatives for logistics companies. Personnel selection criteria are determined through an extensive literature survey and discussions with experts from the logistics industry. The identified criteria are integrated into a hybrid MCDM model which combines the Decision Making Trial and Evaluation Laboratory Model (DEMATEL), the Analytical Network Process (ANP), and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS). Finally, an industrial application is given to validate the proposed approach.*

Keywords – Personnel selection, multi criteria decision making, ANP, DEMATEL, TOPSIS, logistics employee selection

INTRODUCTION

Personnel selection is one of the managerial processes of selecting candidates who meet the requirements for performing the defined task in an appropriate way. It takes into account the qualitative inputs of personnel and has a strategic decision framework in human resources management. Due to the increase of global competition in markets, organizations must focus on personnel selection process [1]. The future survival of firms is directly related to employees' performance such as knowledge, capability and the other skills which are organizational success indicators. Thus, to maintain its presence in market, it is crucial for a company to put more and more emphasis on personnel selection process [2].

Effective personnel selection is one of the most significant problems performed by managers of firms generally. Appointing the right employee to the right position and being able to manage teams containing those employees are crucial for maintaining the business performance of the company. Due to the personal and professional differences among candidates and since the subjective assessment of decision makers may be included to selection process, a human resources manager should utilize several criteria to deal with that problem. Hence, in this way he/she can solve the problem more effectively [3]. Moreover, the fact that this process is completed effectively and successfully provides two-way benefits: that is beneficial to employees; because people become happier and enjoy performing their job, that is beneficial to companies; because talented, appropriate and well-assigned employees tend to work much more than the others. It also contains the strategies which are adapted to attract and recruit qualified employees and maintaining better environments at workplaces [4].

Though personnel selection process must be implemented for surviving in global competition of market, a lot of companies are not ready to allocate vast amount of funds for this process. Therefore, it is crucial to develop new decision-making tools for organizations which enable them to use technological, financial and human resources capacities effectively [5]. These tools have to deal with some issues such that "how to properly set

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the importance weight of criteria, how to use linguistic and numerical scales to evaluate the applicants under multiple criteria and how to aggregate the evaluation results and then rank the applicants" [6].

LITERATURE REVIEW

Over the last decade, several studies have been performed about personnel selection. We searched for all the studies with the keywords "personnel selection and multi-criteria decision-making" and "human resources management and multi-criteria decision-making" and reviewed the databases such as Science Direct, Taylor & Francis, Springer, Emerald and Web of Science. Liao & Chang (2009) applied analytic network process to public relations personnel selection [7]. Celik et al. (2009) proposed a fuzzy integrated multi-stages evaluation model (Fuzzy AHP, Fuzzy TOPSIS, Buckley's Algorithm) for academic personnel selection and added SWOT analysis [8].Huang et al. (2009) applied fuzzy goal programming for an employee selection to Taiwanese manufacturing company [3]. Dursun & Karsak (2010) proposed a fuzzy MCDM approach to personnel selection. They suggested a fusion of 2-tuple linguistic representation model and TOPSIS; furthermore they used ordered weighted averaging (OWA). Their proposal is about hiring an industrial engineer to a manufacturing company [1]. Kelemenis & Askounis (2010) used fuzzy TOPSIS to recruit CIO for a multinational IT firm [9]. Kersuliene and Turskis (2011) integrated a fuzzy multi-criteria decision making (MCDM) algorithm using the principles of fusion of fuzzy information, additive ratio assessment (ARAS) method with fuzzy numbers (ARAS-F) and step-wise weight assessment ratio analysis (SWARA) technique for architect selection [6]. Zhang and Liu (2011) utilized Grey relational analysis (GRA) and Intuitionistic fuzzy set (IFS) for system analysis engineer selection for a software company [2]. Balezentis et al. (2012) solved personnel selection problem through Fuzzy MULTIMOORA [5]. Kabak et al. (2012) proposed a hybrid approach (Fuzzy ANP, Fuzzy TOPSIS, Fuzzy ELECTRE) for sniper selection [10]. Rouyendegh et Erkan (2012) applied Fuzzy AHP to academic staff selection [11]. El-Santawy and El-Dean (2012) used VIKOR to choose an employee from a multinational telecommunication company to make join a two-year course provided by one of its suppliers in Europe [12]. Roy et al. (2012) integrated DEMATEL and AHP for personnel selection [4]. Balezentis and Zeng (2013) proposed an extended form of MULTIMOORA with type-2 fuzzy sets to select a R&D manager for a telecommunication company [13]. Rouyendegh and Erkan (2013) utilized Fuzzy ELECTRE methodology for academic staff selection [14]. El-Santawy and Ahmed combined MOORA and standart deviation weight method for personnel training selection problem[15]. Kersuliene and Turskis (2014) proposed a model with ARAS-F and AHP for chief accountant selection process [16]. Taylan et al. (2014) combined Fuzzy TOPSIS and DEA methods for air traffic controller selection [17]. Dağdeviren (2010) proposed a model combined with ANP and TOPSIS for personnel selection [18]. Andres et al. (2010) applied a goal programming approach for evaluating employees' performance [19]. Gürbüz and Albayrak (2014) integrated ANP and Choquet Integral for human resources performance evaluation [20]. Gürbüz (2010) combined Choquet Integral and MACBETH to human performance evaluation [21].

In this study, we propose a hybrid model that combines DEMATEL and ANP for weighting employee selection criteria, afterwards, alternatives will be ranked by using TOPSIS methodology. The integration of the ANP method is preferred because of the presence of interrelationship among criteria. To identify the relationship network among criteria, DEMATEL method is applied to support ANP. Subsequently, TOPSIS method is used to rank all competing alternatives based on their performance. Since there is no study about personnel selection in logistics industry, the novelty of this paper is not argumentative.

METHODOLOGY

In the proposed approach, after having reached criteria through a literature survey, validated criteria and determined relations among criteria by expert opinion, we decided to use DEMATEL method for revealing inner dependences, ANP for related area and TOPSIS methodology to select the most appropriate alternative.

DEMATEL Methodology

The DEMATEL method, developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976, was used for researching and solving complicated problems.

Steps of the DEMATEL method are as follows [22]:

Step 1: **Find the average matrix**

Step 2: **Calculate the Normalized Initial Direct-Relation matrix**

Step 3: **Compute the total relation matrix**

Step 4**: Set a threshold value and obtain the impact-relations-map**

ANP Methodology

The Analytic Network Process (ANP) is "a multi measurement theory used to take relative priority of the balance of absolute numbers of individual judgments that also belong to the fundamental scale of absolute numbers" [23]. Steps of ANP are as follows [24]:

Step **1:** Describe the control hierarchies in detail including their criteria for comparing the components of the system and their subcriteria for comparing the elements of the system.

Step **2:** Determine the hierarchy or network of clusters (or components) and their elements

Step **3:** For each control criterion or subcriterion, determine the clusters of the general feedback system with their elements and connect them according to their outer and inner dependence influences.

Step **4:** Determine the approach you want to follow in the analysis of each cluster or element, influencing the preferred approach other clusters and elements with respect to a criterion, or being influenced by other clusters and elements.

Step **5:** For each control criterion, construct the supermatrix by laying out the clusters in the order they are numbered and all the elements in each cluster both vertically on the left and horizontally at the top.

Step **6:** Perform paired comparisons on the elements within the clusters themselves according to their influence on each element in another cluster they are connected to (outer dependence) or on elements in their own cluster (inner dependence).

Step **7:** Perform paired comparisons on the clusters as they influence each cluster to which they are connected with respect to the given control criterion.

Step **8:** Compute the limiting priorities of the stochastic supermatrix according to whether it is irreducible (primitive or imprimitive [cyclic]) or it is reducible with one being a simple or a multiple root and whether the system is cyclic or not.

Step **9:** Synthesize the limiting priorities by weighting each idealized limit vector by the weight of its control criterion

TOPSIS Methodology

TOPSIS (Technique for Order Performance by Similarity to Ideal Solution), one of the classical Multi-criteria decision making methods, was first developed by Hwang and Yoon [25]. Steps of TOPSIS are as follows [26]:

Step 1: Decision matrix is normalized.

Step 2: Weighted normalized decision matrix is obtained by multiplying normalized matrix with the weights of the criteria.

Step 3: PIS (maximum values) and NIS (minimum values) are determined.

Step 4: The distance of each alternative from PIS and NIS is calculated.

Step 5: The closeness coefficient of each alternative (CC_i) is calculated.

Step 6: At the end of the analysis, the ranking of alternatives is determined by comparing CC_i values.

CASE STUDY

In this section, a case study is presented to prove the proposed approach's applicability and validity in order to make it more understandable especially for decision-makers who involve in the personnel selection process in a logistics company. The ABC Logistics, located in Istanbul, is a well-known Turkish logistics firm and it provides 3PL integrated logistics services. It has 450,000 m^2 of closed area distribution centers, 100,000 m^2 of facilities in Germany, Italy, Greece, France, Ukraine, Bosnia and Romania.

The ABC Logistics has approximately 4,000 Turkish and 1,200 European employees. The Company announce that its hiring process aim to ensure the placement of best talents to embrace the corporate culture and values of ABC Logistics and the applicable position, and to contribute to happiness and future of the organization. The applicants of ABC Logistics are interviewed with reference to their qualifications.

Table 1 shows criteria influencing business development manager selection for ABC Logistics. Those criteria were identified by a literature survey and confirmed by the company's experts. The identification of criteria weights and the evaluation of alternatives have been realized with the HR Specialist of the ABC Logistics.

Table 1: Dimensions and Criteria

Dimensions	Criteria	Explanation	Reference
Academic Background (C1)	Educational background (C11)	Graduated high school and university qualifications	[5], [6], [9]
	Foreign language knowledge (C12)	Proficiency in English firstly, German or French preferably	[7], [14], [15]
	GPA – Bachelor degree (C13)	Grade point average – diploma grade	[14]
	Mathematical reasoning (C14)	Ability to analytic thinking by utilizing mathematics knowledge	[17]
Professional Factors (C2)	Work experience (C21)	Practices in different firms in the past	[1], [4], [5], [6], [7], [12], [13], [15]
	Strategic thinking (C22)	Being able to think in a managerial way	[6]
	Computer skills (C23)	Ability to use computers professionally	[6], [9], [15]
	Risk management (C24)	Being able to making strategic decisions in hazardous situations	[9]
Individual Factors (C3)	Responsibility (C31)	Completing projects or assignments successfully at the right time	[6]
	Motivation to work in particular position (C32)	Willingness for working in current position	[6]
	Leadership (C33)	Having qualifications as a leader in team works	[5], [6], [9]
	Self-confidence (C34)	Power of believing in oneself	[1], [13], [14]
Capabilities (C4)	Team work capability (C41)	Ability to adapt easily for working in team	[5], [6], [14]
	Comprehension (C42)	Ability to comprehending all stuff rapidly	[1]
	Compatibility (C43)	Adaptation ability to firm	[7], [14]
	Creativity and innovation (C44)	Ability to generate new ideas about logistics problems	[4], [5]

Application of DEMATEL

Inner dependences were determined by using DEMATEL method. By taking into consideration that all the dimensions have inner dependences, we formed the matrices as given in Tables 2-11.

Table 2: The initial direct-relation matrix for Dimensions

	C1	C2	C3	C4
C1	0	3	1	1
C2	0	0	1	0
C3	4	3	0	4
C4	2	2	3	0

Table 3: Inner dependence matrix for Dimensions

	C1	C2	C3	C4
C1	0,100148	0,255875	0,193179	0,185416
C2	0,050815	0,040662	0,116861	0,054754
C3	0,508152	0,406617	0,277367	0,547536
C4	0,340885	0,296846	0,412592	0,212295

Table 4: The initial direct-relation matrix for Academic Background (C1)

	C11	C12	C13	C14
C11	0	4	2	3
C12	0	0	1	0
C13	0	0	0	1
C14	2	0	3	0

Table 5: Inner dependence matrix for Academic Background (C2)

	C11	C12	C13	C14
C11	0,225941	0,813758	0,409023	0,612708
C12	0,006974	0,001678	0,11651	0,018911
C13	0,069735	0,016779	0,043133	0,189107
C14	0,69735	0,167785	0,431334	0,179274

Table 6: The initial direct-relation matrix for Professional Factors (C2)

	C21	C22	C23	C24
C21	0	2	3	1
C22	0	0	0	2
C23	0	2	0	1
C24	2	3	0	0

Table 7: Inner dependence matrix for Professional Factors (C2)

	C21	C22	C23	C24
C21	0,11958	0,314274	0,778146	0,294308
C22	0,131406	0,073996	0,033113	0,323415
C23	0,091984	0,241749	0,023179	0,226391
C24	0,65703	0,369981	0,165563	0,155886

Table 8: The initial direct-relation matrix for Individual Factors (C3)

	C31	C32	C33	C34
C31	0	2	3	2
C32	1	0	0	1
C33	3	2	0	4
C34	1	0	4	0

Table 9: Inner dependence matrix for Individual Factors (C3)

	C31	C32	C33	C34
C31	0,201285	0,361267	0,325394	0,293618
C32	0,121643	0,055375	0,06793	0,104379
C33	0,415423	0,390879	0,252768	0,409029
C34	0,261648	0,192479	0,353908	0,192974

Table 10: The initial direct-relation matrix for Capabilities (C4)

	C41	C42	C43	C44
C41	0	0	4	0
C42	1	0	2	1
C43	3	4	0	0
C44	0	0	1	0

Table 11: Inner dependence matrix for Capabilities (C4)

	C41	C42	C43	C44
C41	0,20208	0,228571	0,412371	0,108108
C42	0,242199	0,142857	0,257732	0,594595
C43	0,505201	0,571429	0,226804	0,27027
C44	0,05052	0,057143	0,103093	0,027027

Application of ANP

After having identified the inner dependences of clusters, weighting of each criterion was completed through ANP methodology. Data from DEMATEL method were replaced in the unweighted supermatrix (see Table 12) and the other relations among criteria were determined by using ANP method. A weighted supermatrix is transformed first to be stochastic as shown in Table 13. After entering the normalized values into the supermatrix and completing the column stochastic, the supermatrix is then increased to sufficient large power until convergence occurs. Table 14 provides a final limit matrix. This limit matrix is column stochastic and represents the final eigenvector. According to obtained results, the individual factors, most precisely, leadership, self-confidence, responsibility and educational background are determined as the most important criteria for the selection of the ABC Logistics business development manager.

Table 14: The limit supermatrix

	C1	C2	C3	C4	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	C43	C44
C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101	0,101
C12	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004
C13	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006
C14	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026
C21	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003
C22	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
C23	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
C24	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
C31	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272	0,272
C32	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067
C33	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322	0,322
C34	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179	0,179
C41	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002

C42	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
C43	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001
C44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Application of TOPSIS

After having reached the final criteria weights, the most suitable business development manager for ABC Logistics was selected by using TOPSIS methodology. There were four possible candidates that are thought they have specific business development manager competencies. According to TOPSIS method (See Tables 15-19), candidate 4 is the most preferable for ABC Logistics.

Table 15: Decision matrix

Alternatives	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	C43	C44
1	2	4	2,89	70	3	4	4	2	3	5	4	4	2	5	5	3
2	5	3	3,3	80	2	3	5	3	2	4	4	3	5	4	3	2
3	3	1	3,42	60	1	3	4	1	3	2	4	4	3	3	4	5
4	4	5	3,58	70	2	4	4	2	4	3	3	3	4	5	4	4

Table 16: Weighted normalized decision matrix

Alternatives	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	C43	C44
1	0,027	0,002	0,002	0,012	0,002	0,001	0,000	0,000	0,132	0,045	0,170	0,101	0,000	0,001	0,000	0
2	0,068	0,001	0,002	0,014	0,001	0,000	0,001	0,001	0,088	0,036	0,170	0,075	0,001	0,000	0,000	0
3	0,041	0,000	0,003	0,011	0,000	0,000	0,000	0,000	0,132	0,018	0,170	0,101	0,000	0,000	0,000	0
4	0,054	0,002	0,003	0,012	0,001	0,001	0,000	0,000	0,176	0,027	0,127	0,075	0,001	0,001	0,000	0

Table 12: The unweighted supermatrix

	C1	C2	C3	C4	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	C43	C44
C1	0,100148	0,255875	0,193179	0,185416	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0,050815	0,040662	0,116861	0,054754	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	0,508152	0,406617	0,277367	0,547536	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	0,340885	0,296846	0,412592	0,212295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	0	0	0	0	0,225941	0,813758	0,409023	0,612708	0	0	0	0	0	0	0	0	0	0,4	0	0
C12	0	0	0	0	0,006974	0,001678	0,11651	0,018911	0	0,5	0,8	0,5	0	0	0	0	0	0,1	0	0
C13	0	0	0	0	0,069735	0,016779	0,043133	0,189107	0	0	0	0	0	0	0	0	0	0	0	0
C14	0	0	0	0	0,69735	0,167785	0,431334	0,179274	0	0,5	0,2	0,5	0	0	0	0	0	0,5	0	0
C21	0	0	0	0	0	0	0	0	0,11958	0,314274	0,778146	0,294308	0	0	0	0	0,5	0,4	0	0
C22	0	0	0	0	0	0	0,45	0	0,131406	0,073996	0,033113	0,323415	0	0	0	0	0	0,3	0	0
C23	0	0	0	0	0	0	0,35	0	0,091984	0,241749	0,023179	0,226391	0	0	0	0	0	0,3	0	0
C24	0	0	0	0	0	0	0,2	0	0,65703	0,369981	0,165563	0,155886	0	0	0	0	0,5	0	0	0
C31	0	0	0	0	0	0	0	0	0	0	0	0	0,201285	0,361267	0,325394	0,293618	0	0	0	0
C32	0	0	0	0	0	0	0	0	0	0	0	0	0,121643	0,055375	0,06793	0,104379	0	0	0	0
C33	0	0	0	0	0	0	0	0	0	0	0	0	0,415423	0,390879	0,252768	0,409029	0	0	0	0
C34	0	0	0	0	0	0	0	0	0	0	0	0	0,261648	0,192479	0,353908	0,192974	0	0	0	0
C41	0	0	0	0	0	0	0	0	0	0,5	0	0,3	0	0	0,5	0	0,20208	0,228571	0,412371	0,108108
C42	0	0	0	0	0	0	0	0	0	0,5	0	0,4	0	0	0,5	0	0,242199	0,142857	0,257732	0,594595
C43	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0,505201	0,571429	0,226804	0,27027
C44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,05052	0,057143	0,103093	0,027027

Table 13: The weighted supermatrix

	C1	C2	C3	C4	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	C43	C44
C1	0,100148	0,255875	0,193179	0,185416	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0,050815	0,040662	0,116861	0,054754	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	0,508152	0,406617	0,277367	0,547536	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	0,340885	0,296846	0,412592	0,212295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	0	0	0	0	0,158158	0,569630	0,286316	0,428895	0	0	0	0	0	0	0	0	0	0,12	0	0
C12	0	0	0	0	0,004881	0,001174	0,08155	0,013237	0	0,15	0,24	0,15	0	0	0	0	0	0,03	0	0
C13	0	0	0	0	0,048814	0,011745	0,030193	0,132374	0	0	0	0	0	0	0	0	0	0	0	0
C14	0	0	0	0	0,48814	0,117449	0,301933	0,125491	0	0,15	0,06	0,15	0	0	0	0	0	0,15	0	0
C21	0	0	0	0	0	0	0	0	0,047832	0,125709	0,311258	0,117723	0	0	0	0	0,15	0,12	0	0
C22	0	0	0	0	0	0	0,135	0	0,052562	0,029598	0,013245	0,12936	0	0	0	0	0	0,09	0	0
C23	0	0	0	0	0	0	0,105	0	0,036793	0,096699	0,009271	0,090556	0	0	0	0	0	0,09	0	0
C24	0	0	0	0	0	0	0,06	0	0,262812	0,147992	0,066225	0,062354	0	0	0	0	0,15	0	0	0
C31	0	0	0	0	0	0	0	0	0	0	0	0	0,161028	0,289013	0,260315	0,234894	0	0	0	0
C32	0	0	0	0	0	0	0	0	0	0	0	0	0,097314	0,0443	0,054344	0,083503	0	0	0	0
C33	0	0	0	0	0	0	0	0	0	0	0	0	0,332338	0,312703	0,202214	0,327223	0	0	0	0
C34	0	0	0	0	0	0	0	0	0	0	0	0	0,209318	0,153983	0,283126	0,154379	0	0	0	0
C41	0	0	0	0	0	0	0	0	0	0,15	0	0,09	0	0	0	0	0,080832	0,091428	0,164948	0,043243
C42	0	0	0	0	0	0	0	0	0	0,15	0	0,12	0	0	0	0	0,096879	0,057142	0,103092	0,237838
C43	0	0	0	0	0	0	0	0	0	0	0	0,09	0	0	0	0	0,202080	0,228571	0,090721	0,108108
C44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,020208	0,022857	0,041237	0,010810

Table 17: Ideal distances (S_i^*) matrix

Alternatives	S_i^*
1	0,06043
2	0,092271
3	0,05893
4	0,05464

Table 18: Anti-ideal distances (S_i^-) matrix

Alternatives	S_i^-
1	0,07186
2	0,0622
3	0,067794
4	0,092934

Table 19: Solution matrix

Alternatives	C_i^*	Rank
1	0,543198	2
2	0,402667	4
3	0,534972	3
4	0,629746	1

CONCLUSION

This study suggests a hybrid MCDM approach to evaluate candidates for the need of improving personnel selection initiatives. Based on the literature survey and with the validation of industrial experts, possible personnel evaluation criteria were defined and an evaluation model was formulated. To support and investigate the effectiveness of the proposed approach an empirical case study from logistics industry was used. The combined ANP and DEMATEL approaches used in this study offered a more precise and accurate analysis by integrating interdependent relationships within and among a set of criteria. Moreover, TOPSIS method helped to choose the alternative for ideal solution of this problem efficiently.

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SENSOR TECHNOLOGY SELECTION FOR LOGISTICS COMPANIES

Gülçin Büyüközkan[100], Doğan Aybars İlhan[101]

Abstract - Rapid development of sensor technology holds an increasing importance in the Logistics and Supply Chain industry. Selecting the right technology among different products with different specifications is an important decision problem for logistics companies. Multi Criteria Decision Making (MCDM) is a powerful tool that is widely used for evaluating and ranking problems containing multiple, usually conflicting criteria. Given the multi-dimensional characteristics of the sensor technology, MCDM provides an effective evaluation framework. This paper proposes an MCDM-based decision framework for effectively evaluating sensor technology alternatives for logistics companies. In the first step, after identifying several evaluation criteria, the criteria weights are determined using Analytic Hierarchy Process (AHP). In the second step, the Fuzzy Axiomatic Design (AD) method is adopted to perform the evaluation. A case study is provided in order to demonstrate the potential of the proposed approach.

Keywords - Analytic Hierarchy Process, Fuzzy Axiomatic Design, Logistics Sector, Multi Criteria Decision Making, Sensor Technology Selection.

INTRODUCTION

The increasing technology development in the industry gains more and more importance as it makes all operations much more efficient. Time, cost and quality are crucial for every industry segment and process. Companies aim to select the proper product from the right supplier among a variety of different alternatives. Therefore, the selection of the best high technology product presents a complex problem.

Sensors are widely used and popular in logistics activities such as warehouse automation, distribution, inventory control and tracking. Automated systems are getting more and more common in the industry and sensors are the key elements of such systems. They are high technology equipments and provide more efficiency in operations, compared to traditional methods. Data is transferred fastly with minimum error. That makes operations easier and more secure.

With emerging demand, various models with wide-range features become more available in the market. Sensors and sensor-based systems can be found for different types of purposes with acceptable costs. The point is to select a proper sensor or sensor-based system and keep in track with the sensor technology.

In this study a two-phase fuzzy multi criteria decision making (MCDM) methodology is proposed for making effective evaluation for product alternatives. Evaluation criteria of product alternatives are defined. A case study is also proposed to evaluate sensors that have a wide variety of application areas in the logistics industry.

MCDM is one of the highly used techniques for evaluating and ranking problems. Decision makers make use of this technique directly to get solution for complex problems. That is why MCDM proposes an effective and powerful framework for such problems.

The Axiomatic Design (AD) methodology [1], an MCDM technique, is used for design a process, organisation, system, product, software etc. [2]. Also, AD provides an opportunity to measure how functional requirements (FRs) can be met by system capabilities. AD basically has two axioms; independence axiom and information axiom, respectively. The cecond axiom enables the selection of the alternative that has the minimum information content. Information axiom is widely used for complex selection problems. Fuzzy logic is preferred when judgement and opinions are subjective, blurred and not certain [3].

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AD and Fuzzy Axiomatic Design (FAD) methodologies have been proposed in previous studies for different design problems. Cebi and Kahraman [4] proposed a FAD method by using both independence and information axioms for passenger car indicator design. Ferrer et al [5] developed a design for a manufacturing model by using the independence axiom of AD. Lee et al [6] designed a chemical product by applying the first axiom of AD. Vinodh [7] studied agile production system design applying the independence axiom of AD. Similarly, Hong and Park [8] proposed a modular product design by applying the first axiom of AD. A system interface design for structuring ship design project approval mechanism towards installation of operator was developed by Cebi et al [9].

AD and FAD methodologies have been used in recent studies for supplier and product evaluation and selection problems in the literature. To name some of them, the following papers can be cited. Cebi and Kahraman [10] developed a group decision support system for the information axiom and applied a method for selection of optimal location for health emergency service in İstanbul. Cicek and Celik [11] developed a FAD model selection interface and applied it to different material selection problem concepts. Büyüközkan [12] proposed an AD based fuzzy MCDM approach for green supplier evaluation. Weng and Jeng [13] proposed a method for equipment selection for agile manufacturing unit, using both the first and second axioms. Büyüközkan et al [14] developed a two-phase fuzzy MCDM method for personal digital assistant selection problem. Atalay and Eraslan [15] studied the evaluation of electronic devices for customer use. FTOPSIS FAHP and FAD were compared in the study. Bilisik et al [16] applied an integrated fuzzy AHP and FAD method for location selection for public transportation systems. Recently, Bahadır and Satoğlu [17] proposed an AD approach for robot arm selection problem while Kannan et al [18] applied FAD method for green supplier selection problem.

Following these researches, by considering the product selection problem's complex nature, an integrated AHP-FAD methodology is proposed in this study for effective sensor technology selection problem. A case study covering the selection of the most appropriate sensor technology among alternatives for a logistics company is also given to validate the effectiveness of the methodology.

This study is organized as follows. In section 2, related studies in the literature are proposed. Section 3 proposes the methods and techniques used in the study. A case study is given in section 4. Finally, the study is concluded in section 5 with some remarks.

METHODOLOGY

Studies show that the MCDM technique is a well-suited and accurate methodology to solve multi-criteria problems such as the evaluation and selection [19]. MCDM techniques are used in a large variety of fields. Considering the type of the problem, fuzzy MCDM technique is used in this study to provide more objective and unbiased conclusions. In this paper a two phase methodology is used by applying MCDM.

Phase one is the preparation part for the application of the MCDM. In this phase expert's opinions are gathered to specify the selection criteria for product evaluations. Criteria is defined and divided into groups. Then AHP is used to calculate the defined criteria weights. Finally, alternatives are also determined.

In the phase two, experts determine the system and design ranges by using a linguistic scale. Figure 1 shows the system design range and common area in a fuzzy environment. Then, these linguistic terms are fuzzified and aggregated for FAD methodology. Afterwards, product alternatives are ranked in increasing order of the information content. The best product is selected.

AD is a systematic method introduced by Suh and is used for variety of design process. Also, AD provides the opportunity to measure how functional requirements (FRs) can be met by system capabilities. AD basically has two axioms; independence axiom and information axiom respectively. The first one is the independence axiom. This axiom states that the independence of the functional requirements (FRs) should be maintained. On the other hand, the second axiom is the information axiom. This one states that the design that takes the minimum information content among the designs satisfying FRs is the best design. Thus, the second axiom presents the selection of alternatives that has the minimum information content. The information axiom is widely used for complex selection problems. Fuzzy axiomatic design (FAD) is preferred when judgment and opinions are subjective, blurred and not certain. Therefore the FAD methodology is proposed in this study for product selection problem by considering the problem's complex nature. Figure 2 shows the main steps of the proposed methodology.

Related formulations for the technique are shown in Equations 1-2-3-4-5-6-7-8.

$$I_i = \log_2\left(\frac{1}{p_i}\right) \tag{1}$$

I_i represents the information content of a design with a probability of success p_i for a given FR_i. The probability of succes is given by the design and system ranges. Probability of success is formulated by:

$$p_i = \int_l^u p(\mathrm{FR}_i)\,d\mathrm{FR}_i \tag{2}$$

l is the lower and u is the upper limit of the design range, where p is the probability density function of a given FR_i.

P_i equals to the common area A_c. Therefore, I_i can be expressed as;

$$I_i = \log_2\left(\frac{1}{A_c}\right) \tag{3}$$

If the probability density function is uniform;

$$p_i = \frac{\text{common range}}{\text{system range}}. \tag{4}$$

Therefore the information content can be expressed as;

$$I_i = \log_2\left(\frac{\text{system range}}{\text{common range}}\right) \tag{5}$$

Information content in a fuzzy environment is;

$$I_i = \left\{ \infty, \quad \text{no intersection}, log_2\left(\frac{\text{area of system range}}{\text{common area}}\right), \text{otherwise}, \right. \tag{6}$$

Total weighted information content for the main criteria is calculated by;

$$I = \sum_{i=1}^{n} w_i I_i \tag{7}$$

where n is the number of main criteria.

Similarly, the weighted information content for sub-criteria for criterion i is expressed as;

$$I_i = \sum_{j=1}^{m} w_{ij} I_{ij} \tag{8}$$

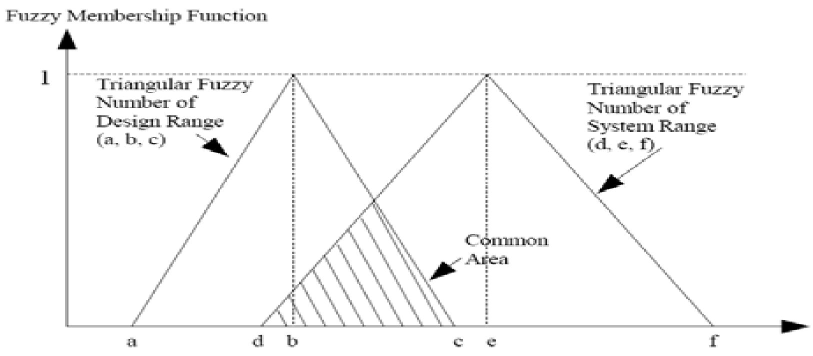

Figure 1: System Range, Design Range and Common Area in Fuzzy Environment

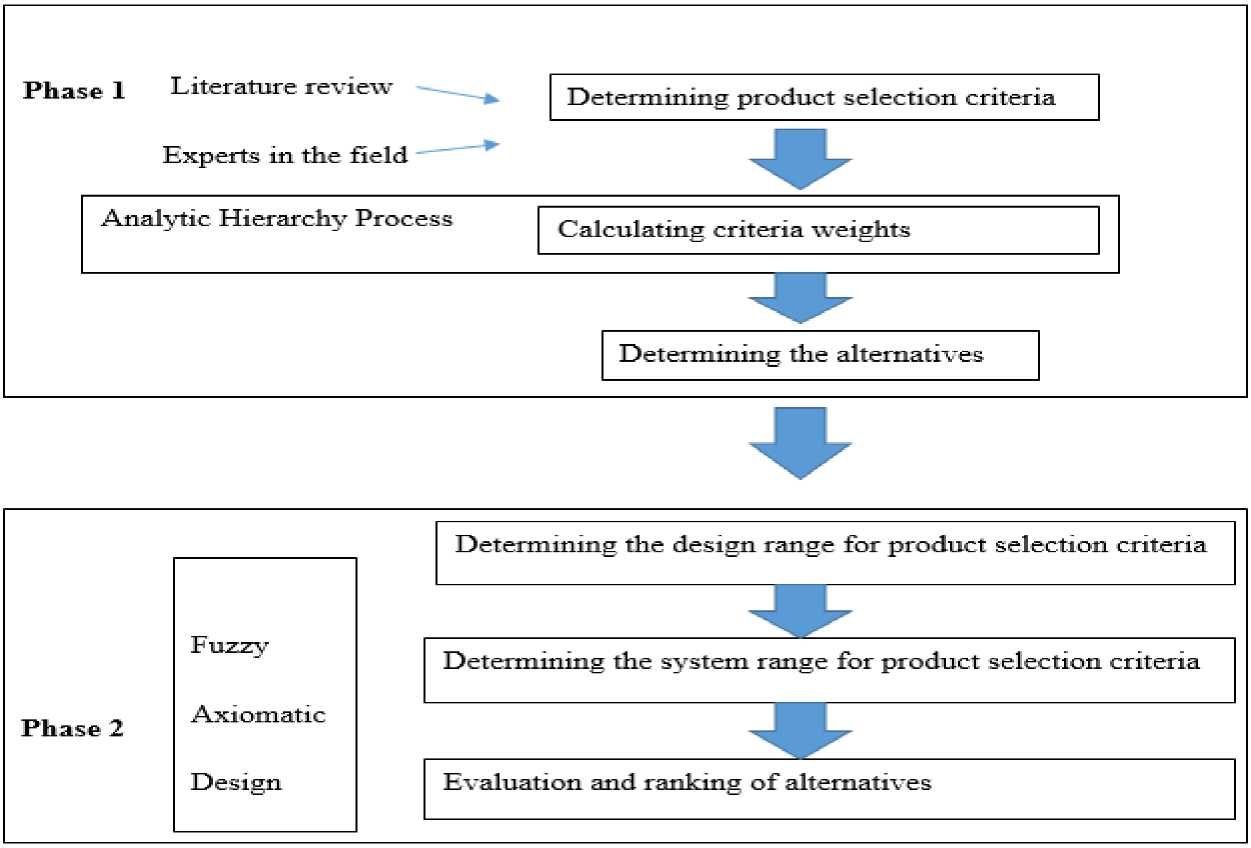

Figure 2: Main Steps of the Proposed Methodology

CASE STUDY

With technological improvements, sensors are widely used in different areas for a variety of processes. Sensors provide high efficiency and therefore competitiveness to companies. Technological developments have a positive impact on reducing the cost of sensors. This leads companies to invest in the sensor technology. Consequently, sensor selection becomes an important issue for companies which plan to invest in this technology. The case is studied to show the implementation of the methodology to a real problem.

In this part, the proposed methodology is applied for the logistics industry. The real case covers the sensor selection problem. Track and trace systems are highly used in the logistics industry for a variety of operations.

The consideration of the operation diversity selection of the most suitable track and trace system is the aim of this real case. Criteria are identified with the consultation of experts and consideration of the literature. Table 1 shows the selected criteria. Price is commonly considered when making selection decisions. In effective life period, a product continues to work with high efficiency so effective life of a product affects the decision. Functionality of a product provides flexibility in those operations the product is used for. Speed is one of the most important criteria for efficiency. Operating and maintenance cost for a product should be within acceptable limits, otherwise it affects the selection decision negatively.

Alternatives are chosen from the firm SICK, one of the leader companies in the sensor market, because of its relatively wide product range for track and trace systems. Table 2 and Fig. 3 show the alternatives.

Table 1: Sensor Selection Criteria

Criteria	Name	
C1	Price	[21],[22],[23]
C2	Effective life	[24],[25],[26]
C3	Functionality	[22],[23],[27]
C4	Speed	[24],[25],[26]
C5	Operating and maintenance costs	[21],[22],[23]

Alternative 1 **Alternative 2** **Alternative 3** **Alternative 4**

Figure 3: Track and Trace System Alternatives

Table 2: Track and Trace Systems Alternatives

Alternatives	Short Description
A1 DWS520	• Dimensioning, weighing and identification data with the push of a button • Complete solution with integrated frame and roller conveyor • Commissioning within a few minutes • Legal-for-trade approved (according to OIML, MID and NAWI) • Special versions for irregular and oversized objects available
A 2 OPS400	• Compact housing • Plug-and-play (optimised CLV Setup) • Integrated tracking for minimum object distances • Scanning /decoder frequency max. 1,200 Hz

	• Real-time autofocus function • Variants: standard, high or low density • No supplementary components necessary for detection of object distances • Reliable code recognition in real time through SMART technology • Flash-PROM for Firmware
A 3 RF GS Pro	• Remotely assigns tags to objects and detects the direction of the moving object • Remotely distinguishes between moving and static tags and filters them for the host message • Distinguishes between pallet and person • Stand-alone gate with integrated controller • Central interface for all sensors via CAN and TC P/IP network • Integrated service, monitoring and diagnostic tools • Parameter cloning of sensors via SD card
A 4 RFMS Pro	• Standard modules with or without antenna • Self-supporting modules • Proven assignment algorithm for RFID tags on objects • Static tag detection and filtering • Integrated service, monitoring and diagnostic tools • Object-based data output on relevant interfaces such as Ethernet, serial interface or PROFIBUS • Parameter cloning of all components

First of all, the weights of the criteria are calculated by using AHP [20]. Table 3 gives the initialization matrix. Consistency ratio is 0.05, less than 0.1, so is acceptable. Table 4 shows these criteria weights.

Table 3: Initialization Matrix

	C1	C2	C3	C4	C5
C1	1	2	1	2	2
C2	0,5	1	0,33	0,25	0,33
C3	1	3	1	2	3
C4	0,5	4	0,5	1	2
C5	0,5	3	0,33	0,5	1

Table 4: Sensor Selection Criteria Weights

Criteria	Weights
C1	%26
C2	%9
C3	%31
C4	%21
C5	%13

Design and system ranges are determined by using 5-scaled linguistic terms. Table 5 shows the scale and its corresponding fuzzy membership function. Fig. 4 and 5 indicates the membership functions for system and design ranges respectively. Experts' evaluations on alternatives for system range and defined minimum requirements of the criteria for design range are shown on Table 6.

Table 5: Scale for Linguistic Terms

Term	Abbr.	Membership	Term	Abbr.	Membership
Poor	P	0, 0, 0.3	At least Poor	LP	0, 1, 1
Fair	F	0.2, 0.35, 0.5	At least Fair	LF	0.1, 1, 1
Good	G	0.4, 0.55, 0.7	At least Good	LG	0.4, 1, 1
Very good	VG	0.6, 0.75, 0.9	At least Very good	LVG	0.6, 1, 1
Excellent	E	0.8, 1, 1	At least Excellent	LE	0.8, 1, 1

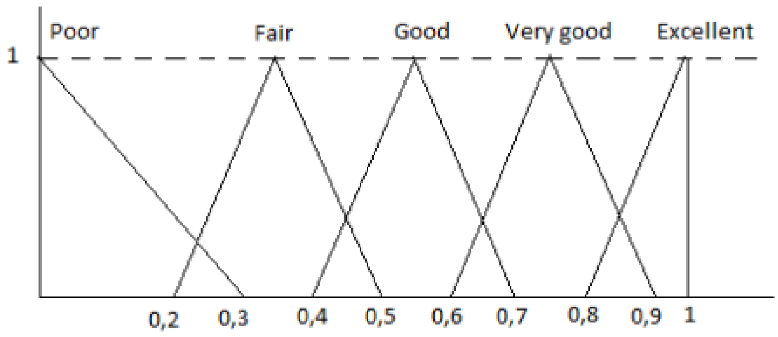

Figure 4: Membership Functions for System Range

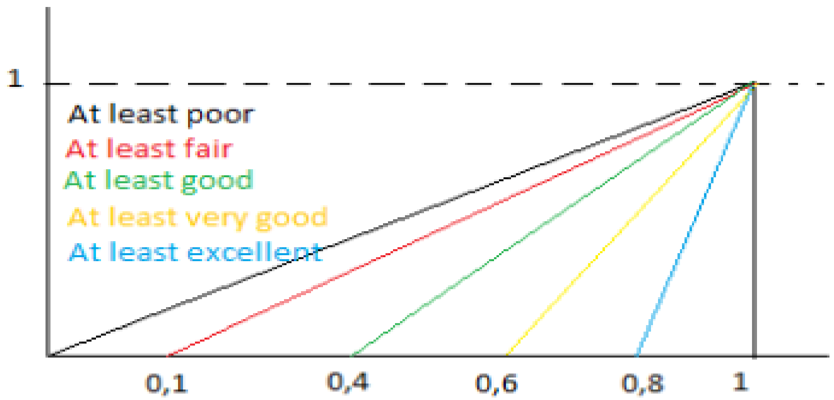

Figure 5: Membership Functions for Design Range

Table 6: Design Range and System Range

		System range			
Criteria	Design range	A1	A2	A3	A4
C1	LG	VG	VG	G	F
C2	LG	G	VG	VG	G
C3	LF	G	G	F	G
C4	LVG	G	VG	F	VG
C5	LG	G	VG	VG	G

Evaluations are aggregated into fuzzy numbers. The proposed methodology is applied to calculate the information contents and weighted information contents. Table 7 shows the information contents. Weighted information contents and their ranking are shown on Table 8.

Table 7: Calculated Information Content for Alternatives

	A1	A2	A3	A4
IC1	0,295	0,295	1,322	4,492
IC2	1,322	0,295	0,295	1,322
IC3	0,429	0,429	1,109	0,429
IC4	4,044	0,874	∞	0,874
IC5	1,322	0,295	0,295	1,322
ITOT	7,412	2,188	∞	8,439

Table 8: Weighted Information Content and Ranking for Alternatives

	A1	A2	A3	A4
WIC1	0,0767	0,0767	0,34372	1,16792
WIC2	0,11898	0,02655	0,02655	0,11898
WIC3	0,13299	0,13299	0,34379	0,13299
WIC4	0,84924	0,18354	∞	0,18354
WIC5	0,17186	0,03835	0,03835	0,17186
WITOT	1,34977	0,45813	∞	1,77529
Ranking	2	1	-	3

It is seen that the ranking of alternatives is as the following: A2, A1, A4. A3 is eliminated because it does not have a satisfactory level for C4.

CONCLUSION

Technological developments and the competitive nature of the industry brings about a need for high technology equipment investments to increase efficiency. Companies aim to select the right product from the right supplier among a variety of alternatives. Partner and product selection becomes a key issue for companies. Complexity of this type of problems makes decision making even more difficult.

Sensors are used for wide range of processes and systems from production, manufacturing to logistics and control. Therefore, sensor selection problems gains importance.

In this study, a fuzzy multi-criteria decision making framework was proposed for the sensor evaluation problem. In addition, a case study was done for sensor selection. Several applications of FAD in recent studies proved that the technique is an appropriate method for decision making problems. Therefore, FAD was used in this study to eliminate the alternatives that are not able to satisfy the requirements and afterwards rank the remaining alternatives by considering their values.

This study shows that the FAD technique can be used for the selection of sensors. On the other hand, the presented case study verified the potential of the proposed methodology with the implementation on logistics sector. In future studies, other industrial sectors or cases will be performed with different criteria.

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QUALITY IMPROVEMENT IN THE SERVICE SECTOR: APPLICATION ON A LOGISTIC COMPANY

Özlem Akçay Kasapoğlu[102] , Umman Tuğba Gürsoy[103]

Abstract_ *In this global world of today the logistics providers have to compete not only with many players in the sector, but with the time. Their task is not easy, besides being reliable, they have to continuously improve their service level. In service sector customer contact is higher and worker skill levels are lower. In logistics service performance is affected by many factors; Services might hire many low-skill, workers and employee turnover might be higher, the service performance can be affected by worker's personal factors and the consequence could be damage in distribution or loses of the items. The damage or losses in logistics may cause degradation of the quality of service. This also affects the reputation of the company. Therefore, examining the factors that effects the service level, the root causes of the these factors and taking preventive actions are very important. In this study data is extraced from the large databases of the logistics company by data mining tools and quality improvement techniques are applied to able to create knowledge about the quality.*

Keywords_ Quality improvement tools, Damage assessment, Logistics, Data mining tools

INTRODUCTION

Fierce competition in various sectors including logistics warrants the implementation of Total Quality Management (TQM) system in logistics services for the improvement of supply chains at local and global levels. Companies looking for logistics economics may undergo ongoing improvement in their services cost-effectively through efficient use of information system and teamwork.

Industry continually strives to provide value added products and services with increased customer satisfaction. Value addition and customer satisfaction become strategic missions as they drive businesses' market shares in the local and global marketplace. Logistics services play a significant role in establishing value addition and customer satisfaction through customised services. Logistics outsourcing is also seen as a strategic move towards accomplishing core values by delivering products and services to the right place at the right time and cost.

TQM in product and service management plays an important role in achieving value addition. Resources are optimised and used in the most effective manner both qualitatively and quantitatively, thus offering better returns for management. TQM also refines management's cultural values, thereby helping to achieve excellence in overall corporate governance. Thus TQM is the ultimate strategic tool for accruing comprehensive benefits in manufacturing and service industries [13].

Value-addition in a logistic company is a very important issue in every step to able to compete with the other companies, which is the difference between the cost of inputs and the value or price of outputs.The greater the value-added, the greater the effectiveness of these operations. In profit organizations, value-added output is measured by prices that customers are willing to pay for those goods and services. The greater the value-added, the greater the amount of funds available for these purposes. Because there are relatively few pure goods and pure services and therefore companies sell product packages for their own benefit or interest. Product packages are a combination of goods and services, which is the case in logistic companies. Product packages can make a company more competitive. Manufacturing and service are often different in terms of what is done but quite similar in terms of how it is done.

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There are Challenges of Managing Services**:** Service jobs are often less structured than manufacturing jobs, Customer contact is higher,Worker skill levels are lower, Services hire many low-skill, entry-level workers, Employee turnover is higher, Input variability is higher, and Service performance can be affected by worker's personal factors [10].

LOGISTIC SERVICE QUALITY

Quality is a predictable degree of uniformity and dependebility, at low cost and suited to the market. Improvement and innovation are both required if a form is to be healty in the future. The purpose of process improvement is to modify current methods to continuously reduce the difference between customer needs and process performance. Continuous quality improvement and cost reduction are necessarry for an organizaton's health and competitive ecomomy. Quality improvement requires never ending reduction of variation in product and or process performance around nominal values. Society`s loss due to performance variation is frequently proportional to the square of the deviation of the performance characteristic from its nominal value [4].

The best and the most direct route to world class competitiveness for the products and services is through variability reduction on the processes. This variability reduction decreases defect rates, improves yields, lowers scrap rates, expands market potential, reduces rework, warranty costs and the difference between customer needs and process performance [8].

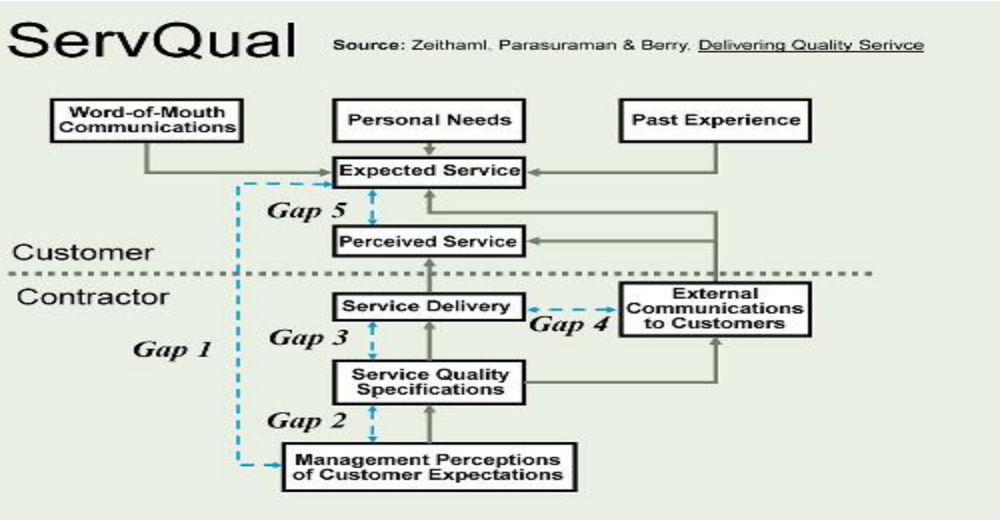

Figure 1. Service Quality

As it could be understand from many the Parasuraman's publications (1990) and from the Figure 1, there are gaps between percieved service and service quality. Total quality managent tools are the best tools to narrow those gaps and succeed in logistics service sector.

The discrepancy between what customers expect and what they recieve in terms of logistics service quality is the most important gap. In effect the magnitude of this gap depends on the extend to which gaps 1 through 4 are seen to exist. Thus closing gap 5 depends on meaningful application of quality analysis techniques like benchmarking, customer research, quality function deployment, statistical quality control, as well as measurement accuracy and comminication between supplier and customer [7].

Logistics service quality is not only difficult to define, but to measure as well customer satisfaction depends on various factors such as the perceived quality of service, customer mood, emotion, social interaction, customers' associates' experience and other specific subjective factors. In addition, it is necessary to keep in mind that customer satisfaction with the quality of service is not the objective assessment of the real situation, but an element of emotional nature. Customer expectations' satisfaction is generally seen as a positive opinion of the client about the service after the service is performed. In other words, this is evaluation of the results of the process. In summary, we can say that, in general, the quality of service can be defined as services which must meet customers' expectations and to satisfy customer needs and requirements [9].

The main definitions of quality of service focus on the fact that the service has to meet the customer's needs and expectations and is interpreted as a difference of terms of service provision and customers' expectations of perceived service. If the customer's expectations are higher than the result of the service process, then customer perceived service quality is not satisfactory. Logistics service quality is the result received comparing customers' expectations with customers' perception of service quality.

Clients, prior to ordering the service, already have expectations of what the service provider should offer them. Therefore the quality of logistical service perceived by the client is the difference between the perceived service and expectation. The quality of service is closely related to customer expectations. In today's competitive environment, the pursuit of customer satisfaction highly depends on the organization's overall service quality [9].

To able to improve the logistics service quality TQM rules should be adopted by the company. Total quality mangement refers to the quality emphasis that encompasses the entire organization, from supplier to customer. TQM stresses acommitment by management to have a companywide drive toward excellence in all aspects of products and services that are important to the customer. TQM requires never ending process of continuous improvement that covers people, equipment, suppliers, materials and procedures. The basis of the philosophy is that every aspect of an operation can be improved. The end goal is perfection, which is never achieved but always sought [6].

The key areas of focus regarding TQM in logistics services for effective supply chains to manage the challenges of logistics economics and globalisation are:

- TQM in logistics services management: excellence models in logistics management for local and global logistics management.
- TQM in logistics management decisions: various Decision Support System (DSS), Multi-Criteria Decision Models (MCDM) and models based on soft computing to aid logistics managers in decision making.
- TQM implementation in logistics services: frameworks related to TQM implementation in logistics services.
- TQM benefits in logistics: TQM benefits derived in terms of higher market share, customer satisfaction, customer loyalty, etc.
- Cost control and service improvement: rapid and constant change are rocking this traditionally stable area and management must to adapt for growth [13].

For the implementation of the TQM everyone in the organization must be trained in the techniques of TQM. Two of the Seven Quality tools, Pareto Analysis and Cause and Effect diagrams as simple but effective tools applied to the data. Cause and effect diagrams are also known as Ishikawa diagrams and it is schematic technique to discover possible locations of quality problems. Pareto charts are method of organizing errors, problems or defects to help focus on problem solving efforts. They are based on work of Vilfredo Pareto, a nineteenth centurty economist. Joseph Juran popularized Pareto's work when he suggested that 80% of a firm's problems are a result of 20% of the causes [6].

DATA MINING

Data mining has attracted a great deal of attention in the information industry and in society as a whole in recent years, due to the wide availability of huge amounts of data and the need for turning such data into useful information and knowledge. The information and knowledge gained can be used for applications ranging from market analysis, fraud detection and customer retention, to production control and science exploration [5].

Data mining can be viewed as a result of the natural evolution of information technology. The database system industry has witnessed an evolutinoary path in the development of the following functionalities: data collection and database creation, data management and advanced data analysis. Data mining is an integral part of knowledge discovery in databases, which is the overall process of converting raw data into useful information. This process consists of a series of transformation steps, from data preprocessing to postprocessing of data mining results [11].

Data mining is widely used in diverse areas. There are a number of commercial data mining system available today and yet there are many challenges in this field [1].
Data mining is widely used for:

- Financial Data Analysis
- Retail Industry
- Telecommunication Industry
- Logistics Sector
- Biological Data Analysis
- Other Scientific Applications
- Intrusion Detection

With the rapid development of database technology and the wide application of database management system, data mining is more and more used in logistics enterprise. It is a key problem how to use data mining with low cost and high efficiency [2].

APPLICATION

This study was conducted using the data of a Logistics provider in Turkey and analyzed with data mining tools, to know what works and what doesn’t, to find the root causes of the problems, to correct the delivery service problems and to be able to improve quality of services. The company aimed to analyze the problems faced by the damage or loss in the physical distribution process and also wants to determine the source of the problems

Data set consists of 56 variables and 2038 records. Data set compose from the automation system, delivery of documents, bills and customers damaged or lost invoices. Data is related with products, which customers they are belong to, region, shipping information, which vehicle they are loaded, time information about vehicles, which transfer centers they are in and out, delivery status and important correspondence or documents belonging to product delivery. The damage or losses may cause degradation of the quality of service. This also affects the reputation of the company. Therefore, examining the errors that cause these problems and taking preventive actions are very important.

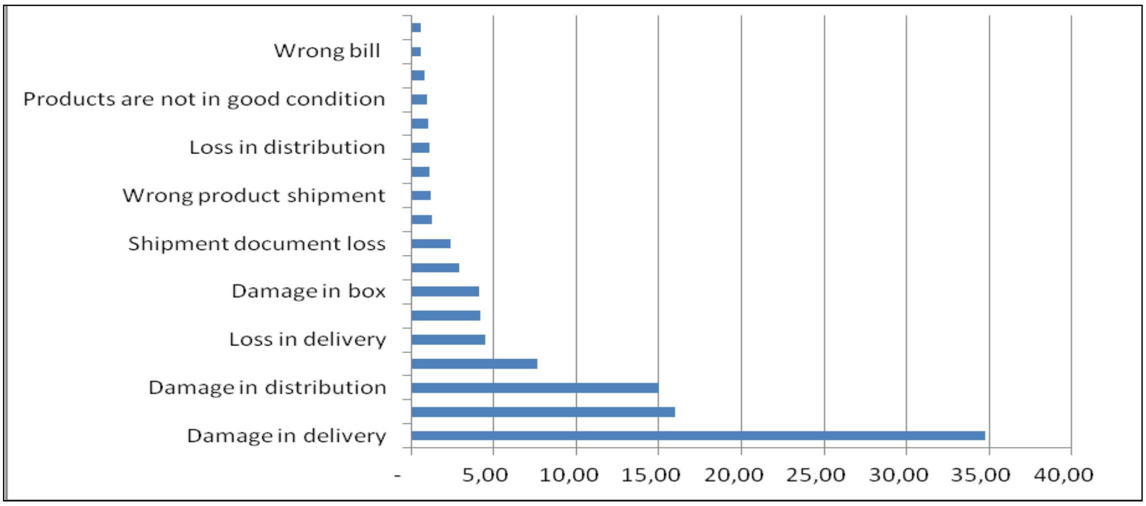

Figure 2. Damage/ Loss Frequencies

Due to the Figure 2 damage in delivery and damage in distribution have the highest frequencies, so the reason for those damages are examined in this study.

In the analysis it is found that with 1262 different license plates 5349 shipments are done, and each shipment approximatelly 5 damage records are taken. Pareto analysis is applied to the license plates to able to find which license plate to focus on.

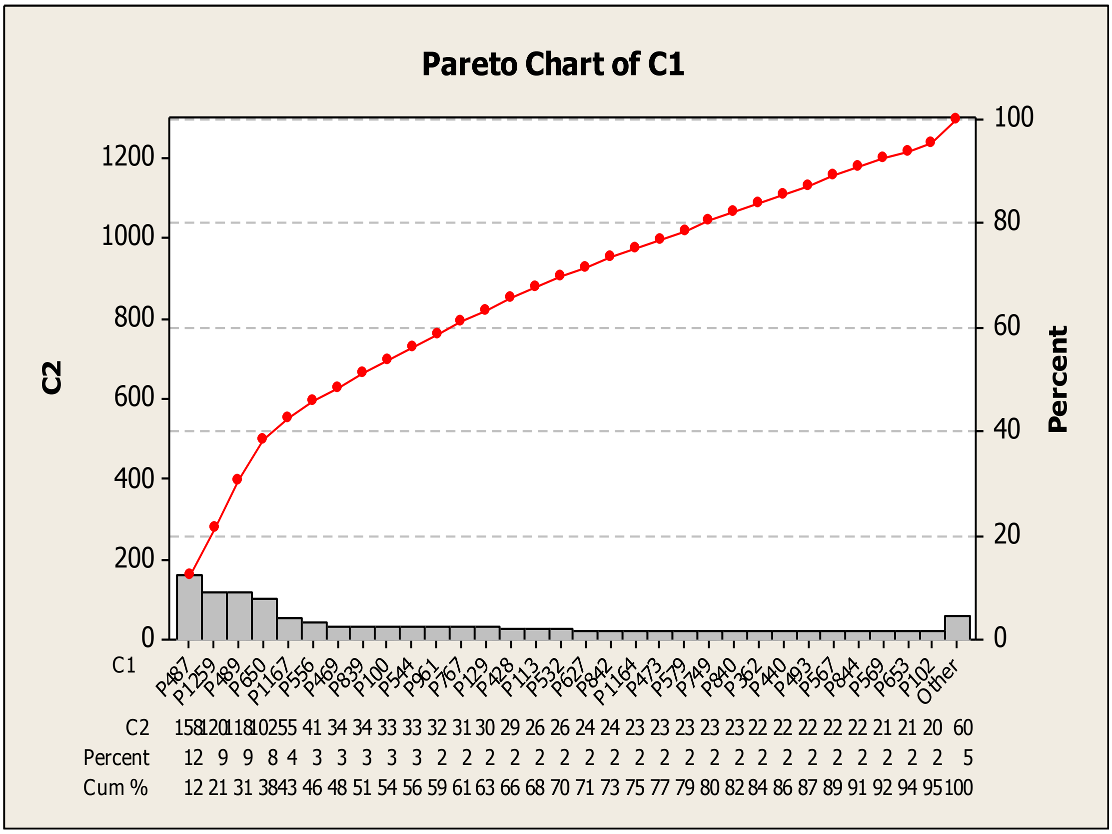

Figure 3. Pareto Chart

In the pareto diagram it can be seen that License plate 487 is the one who did the biggest number of shipments. License plate 1259 is the second one. According to our data it is known that shipments are done mostly with these vehicles. This is why the damage records are coming from those vehicles. Root causes analysis are done on those vehichles.

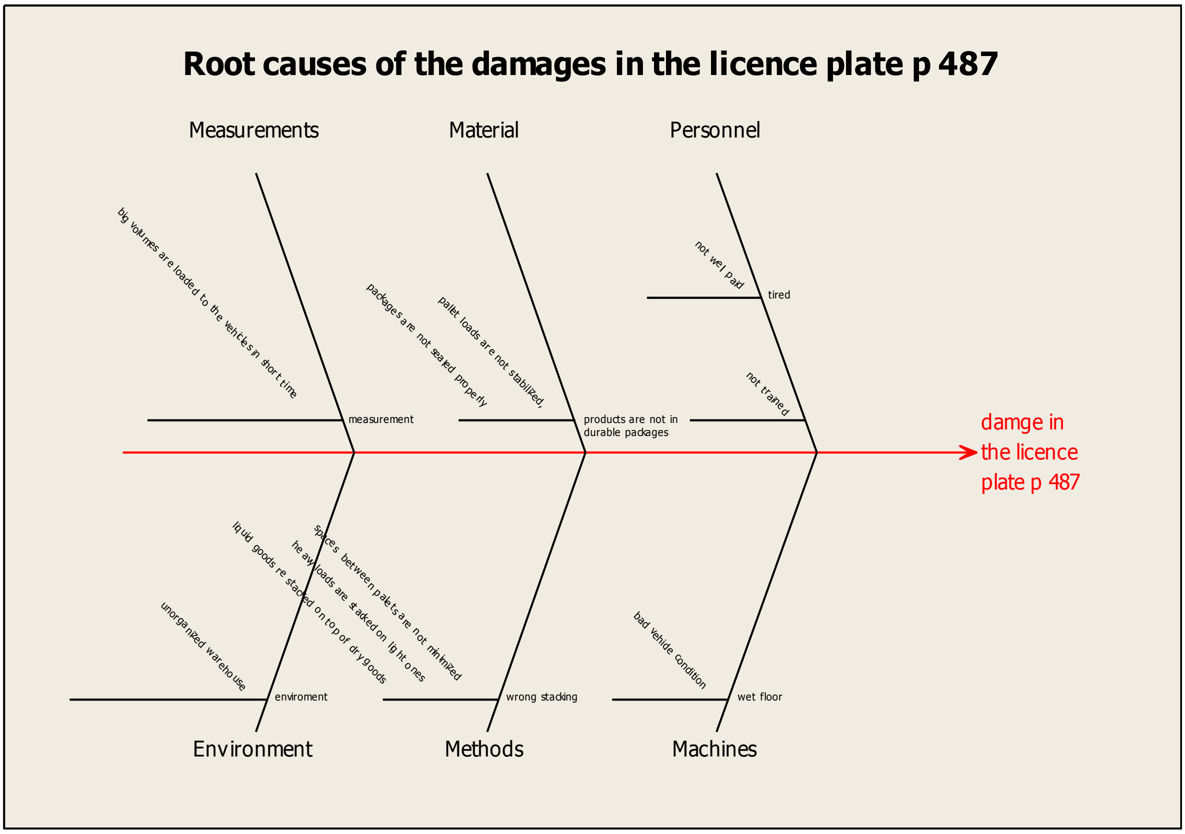

Figure 4. Cause and Effect Diagram

After the Pareto analysis the license plate with the biggest frequency is taken and the root causes of the problems related to damage in the vehicles are examined by brain storming and the Cause and effect diagram are used to visualize the causes.

In the Cause and effect diagram the root causes of the damages in licence plate 487 is investigated in 6 titles, Personel, material, measurements, machines, methods and enviroment. It is found that;

Damages due to personel: are because of the causes of being tired; overtime working, not get well paid, and not getting enough training.

Damages due to material: are related to packaging and palet building, and they are caused by putting products not in durable packages, palet loads are not stabilized, packages are not sealed properly.

Damages due to measurements: are caused by putting big volumes in vehicles in short time.

Damages due to machines: because the vehichle having wet floor, and having a bad physical condition.

Damages due to enviroment: are because of the warehouse being unorganized.

Damages due to methods are: about wrong stacking practices The spaces between pallets are not minimized, Heavy loads are stacked on light ones, liquid goods are stacked on top of dry goods.

In the analysis' results it is found that the product type that get damaged during delivery is the pharmaceutical goods which can be seen in Figure 5.

Value	Proportion	%	Count
PHARMACEUTICAL PRODUCTS		22,5	730
APPLIANCES		15,32	497
FURNITURE		14,36	466
GLASSWARE		8,6	279
ELECTRONIC		8,26	268
BATH FURNITURE		8,23	267
SMALL APPLIANCES		5,39	175
AUTOMOTIVE		4,25	138
INSTALLATION MATERIAL		4,25	138
MACHINERY UNITS		3,08	100
TEXTILE		2,28	74
SPORTS EQUIPMENT		1,63	53
PLASTIC		1,57	51
CONSTRUCTION EQUIPMENTS		0,25	8

Figure 5. Distribution of Product Type

Packaging is important in logistics. In the Figure 6 the highest damage occured in cartoon packaging among with plastic bag, wood box and palet.

Value	Proportion	%	Count
CARDBOARD		92,79	1582
PLASTIC BAG		6,04	103
WOOD BOX		0,65	11
PALLET		0,53	9

Figure 6. Distribution of Package Type

Value	Proportion	%	Count
1.000		30,7	1642
2.000		28,19	1508
3.000		16,58	887
4.000		9,18	491
5.000		15,35	821

Figure 7. Distribution of Volume

Deci= Length* Width * Height / 3000= 50 cm X50 cm X100 cm / 3000 = 83. 33 (1)

Table 1. Volume

VOLUME (DECI)	
0-5000	1
5001-10000	2
10001-15000	3
15001-20000	4
20001+	5

According to the Figure 7, 30.7% of the boxes are in the 0-5000 deci range. 28.19% are in 5001-10.000 deci range. 59.86% of the shipment loaded on the vehicles in 0-1 hour. %11.7 of the shipment are done in 1:01-2:00 hour. %6.642 of the shipment are done in more than 10 hours. The loading process can not take 10 hours. We expect idle times in loading the vehicle.

Table 2. Shipment Duration

Duration (hour)	
0-1	**1**
1,01-2	**2**
2,01-3	**3**
3,01-4	**4**
4,01-5	**5**
5,01-6	**6**
6,01-7	**7**
7,01-8	**8**
8,01-9	**9**
9,01-10	**10**
10,01 +	**11**

Value	Proportion	%	Count
1.000		59,86	3202
2.000		11,7	626
3.000		4,23	226
4.000		3,68	197
5.000		3,38	181
6.000		2,41	129
7.000		2,97	159
8.000		2,22	119
9.000		1,61	86
10.000		1,29	69
11.000		6,64	355

Figure 8. Distribution of The Shipment Duration

The correspondance of the volume loaded on the vehicle and the time of the loading process is important. On time shipment is so important in logistics, for this reason this process should be managed carefully. A problem in an organization might cause the products to arrive to the transshipment centers late which cause to the vehicles to be late to the distribution center. There is a competition in time and there is a continuous circulation of products in transshipment centers. Loading time of the handling personel due to this concerns the duration is so important.

Table 3. Correspondancy of The Volume and Duration

	1	2	3	4	5
1.0	1414	1056	442	121	169
10.0	0	5	16	10	38
11.0	17	15	28	98	197
2.0	157	253	119	65	32
3.0	19	66	75	33	33
4.0	12	33	59	34	59
5.0	13	30	45	20	73
6.0	4	17	31	29	48
7.0	4	18	37	30	70
8.0	1	9	20	39	50
9.0	1	6	15	12	52

CONCLUSION

In this study the data of the Logistics Company which operates in Turkey is used. Data mining tools and SPSS Clementine programme is applied to the data. Invoices that are dated on 2012 and 2013 are considered on this analysis.

To able to decrease the discrepancy between what customers expect and what they recieve in terms of logistics service quality meaningful application of quality analysis techniques are done. Two of the Seven quality tools, Pareto analysis and Cause and effect diagrams as simple but effective tools applied to the data. Pareto charts are used to organize problems due to damages in order to help focus on problem solving efforts Cause and effect diagrams are also known as Ishikawa diagrams is used to discover possible locations of quality problems.

In the Pareto diagram it is seen that License plate 487 is the one who did the biggest number of shipments. License plate 1259 is the second one. In in the analysis it is identified that the highest claim rates are from pharmaceutical products, home appliances and furniture. Logistics company should focus on preventing steps to lower these rates. The highest damage occured in cartoon packaging. The correspondance of the volume loaded on the vehicle and the time of the loading process is important. On time shipment is so important in logistics, for this reason this process should be managed carefully. A problem in an organization might cause the products to arrive to the transshipment centers late which cause to the vehicles to be late to the distribution center. There is a competition in time and there is a continuous circulation of products in transshipment centers. Loading time of the handling personel due to this concerns the duration is so important.

The planning, management and control in logistics is so complicated due to the many factors like man, machine and material. Decision making in logistics regarding those factors are curitial. Improvement of the service quality is dependent on finding the root causes of the damages, they should be studied and improvements should be done on the problems.

Because most of the damages occured more on the vehicles, distribution and transshipment center, the effect of human factor should be considered. Doing the right stacking, handling or the organization of the distribution center are all dependent on human. So the training efforts on the company should be increased.

The understanding of continuous quality improvement can increase customer satisfaction, reduce production waste and improve company performance in logistics. This is especially important for specialty goods, where there is a low tolerance for error and customer returns or rejected products are costly. Continuous quality improvement requires commitment from management and a continuous effort to improve company processes and output. All employees should be aware of the importance of quality. High quality logistics services improve the competitiveness of a country's exports by reducing the cost involved in transporting goods.

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APPENDICES

License Plate	Frequency
P487	1580
P1259	1200
P489	1180
P650	1020
P1167	550
P556	410
P469	340
P839	340
P100	330
P544	330
P961	320
P767	310
P129	300
P428	290
P113	260
P532	260
P627	240
P842	240
P1164	230
P473	230
P579	230
P749	230

P840	230
P362	220
P440	220
P493	220
P567	220
P844	220
P569	210
P653	210
P102	200
P1171	200
P364	200
P606	200

PROVIDING CONTENT BASED ON LOCATION THROUGH BEACON TECHNOLOGY: HOSPITALAR 2015 FAIR "GENERAL ELECTRIC HEALTHCARE" APPLICATION

Ural Gökay Çiçekli[104], Yunus Kaymaz[105], Kamil Sözen[106]

Astract- Today, as in many areas, the traditional definitions of many concepts exceed their meanings. Thus, logistics and transportation concepts which aim to deliver the right product at the right time in the right place are also changing due to the developing technology and increasing competition to achieve the goal of being more innovative and efficient. In order to realize this purpose, today companies use wireless location identification equipment during transportation and to determine the location of a lost item during transportation in order to ensure the customer satisfaction. While these expectations are being fulfilled, the costs and eases of use are being considered. In this concept, the retail sector being the meeting point of the products and consumers is going to be the right point in the perspective of realizing the availability of wireless location identification equipment and data gathering.

In this study, beacon technology which is used as wireless location identification equipment was examined through a mobile application in fair area.

Key Words: Beacon, Location Identification Equipments, Fair Visitor Monitoring System

1. Introduction

As competition has become stronger in today's world, there has been an increase in the willingness of enterprises to gain competitive advantage. Thus, the number of data types needed by enterprises to maintain their current customers and enhance customer satisfaction has risen. As developments have occurred in technology and in the field of monitoring devices, enterprises have turned to integrating monitoring and tracking devices into their own systems. An important reason for the common use of faster, cheaper, and more traceable systems in enterprises is the efficient use of wireless communication. The adoption of wireless and mobiles systems by industries has brought along advantages such as accessing customer data and turning these data into competitive advantage in the market.

Wireless Sensor Networks (WSN) that facilitate short-term communication are used in more fields every passing day. Their usage is different in different fields. RFID (Radio Frequency Identification) has increased the interest in WSNs and made them widespread. Rapid developments in information and communication technologies have given birth to beacon technology. Beacon technology is used in various fields such as retailing, logistics, and health.

2. Wireless Sensor Networks (WSN)

Wireless sensor networks (WSNs) that allow communication are defined as low-cost structures that consume low energy, have multi-functional sensors, and facilitate short-distance communication (Akyıldız et al., 2002:393). Türker and Tarımer (2011:75) state that WSNs are used in the fields of military, environment, health, and trade and have sensors that can explore and determine a lot of environmental factors such as humidity, pressure, and sound in various situations. Baronti et al. (2007:1656) note that developments in microelectromechanical systems have led to the emergence of micro devices that are low-cost and consume low energy for the exploration of relations of physical phenomena with their environment; the sensing functions of such devices increase when they are combined with wireless intermediaries; and WSN applications are employed in a great variety of fields.

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As WSN has become widespread, applications have been developed in a lot of fields, and added-values have been introduced to such fields. Some of its uses in different fields are as follows: tracking patients and health check-up devices in the field of health; tracking and examining pollution measurements in the field of agriculture; exploring the locations and populations of species in the field of environment; identifying the locations of military units and observing delicate equipment in the field of military; and inventory tracking and action tracking in the field of trade (Baronti et al., 2007:1657).

Yick, Mukherjee, and Ghosal (2008:2294) explain the working principle of WSN and say that microelectromechanical systems bring about smart sensors and that these sensor nodes may have one or more sensors and are used in the measurement of environmental values together with chemical, magnetic, optical, or biological sensors that may be created depending on the situation of the environment. The authors also report that WSN does not need any infrastructure, and nothing other than sensor nodes is required.

As sensor nodes spread over a wide area, information access is quick in the created network, and such networks do not need any infrastructure. Figure 1 illustrates sensory network structure as indicated in Kalaycı (2009:37).

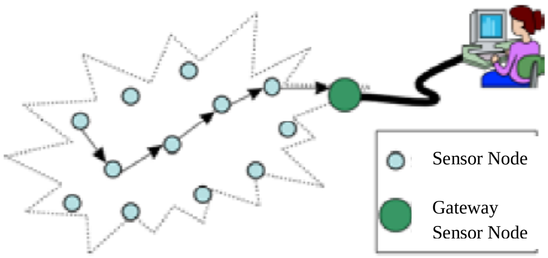

Figure 1: Sensor Network Structure
Source: Kalaycı (2009: 2009:37)

WSNs are currently employed in various sectors and provide both users and decision-makers with great conveniences. Alemdar and Ersoy (2010:2688) examined WSNs in terms of healthcare services and highlighted what sort of added-values they can create. The authors also mentioned that WSNs provide consumers and health professionals with great innovations in checking and exploring health statuses of old age population that has increased thanks to the improvements in living conditions.

Arora et al. (2004:606) focused on designation, classification, and tracking of targets entering a prohibited military zone through the WSN system they prepared for military use. Arora et al. (2004:631) emphasize that the existence of sensor networks composed of hundreds or thousands of nodes may pose a disadvantage for decision-makers because these structures are difficult to control. In addition, they argued that the systems with fewer nodes developed by them look promising though they have certain faults and thus are more feasible for classification, identification, calculation, tracking, and localization.

Another field where WSN applications are common is supply chain. It has been realized that customer satisfaction may be ensured by establishing technological infrastructure in supply chains whereby products are transferred from producers to consumers in today’s world where customer demands change continuously; the concept of customer value is understood by enterprises; and enterprises try to meet such demands and act accordingly. In this regard, information technology is important for supply chains that provide enterprises with an opportunity to gain advantage by making a difference.

Zhang et al. (2009) introduced a system in which WSNs are used for retailing and logistics. The authors stated that the currently designed and produced nodes are not suitable for the control of retailing process and logistics for two reasons: 1- coverage area 2- cost and size. Thus, the authors developed a two-layer structure that uses GSM/GPRS (Global System for Mobile communication / General Packet Radio Service) in the system instead of the current node and RFID (Radio Frequency Identification). In this way, they both expanded coverage area and eliminated the positioning problems experienced in RFID devices.

Connolly and O'Reilly (2005) handled sensor networks for food industry and noted that smart sensor networks are a system that uses Bluetooth to establish a communication between sensors, which eliminates the limitations caused by the traditional use of barcodes and tags.

Evers et al. (2005:1) studied a case and stated that wheeled containers where recycled products are conserved are identified with optical barcode readers in the current system, but error rate may change in this system depending on the position of the barcode, and reading each container is a time-consuming activity. They highlighted that the created wireless sensor network allows tracking and controlling the handling and distribution of all products. It can be said that product tracking and product information that are very important in today's logistics and retailing systems make use of these systems in creating customer value.

RFID (Radio Frequency Identification) is another wireless technology which becomes more important every passing day and is used in almost every field just like wireless sensor networks. The basic logic underlying RFID technology is tagging products or items and the transfer of data to RFID readers by these tags via transmitters (Weinstein, 2005:27). Landt (2005:11) said that the history of RFID technology started with military use in the 1940s and became widespread in the 2000s. At the present time, RFID technology is used in a lot of fields and industries. This technology is used in a lot of fields such as tracking products and preventing losses in the field of retailing; controlling and tracking products that are in storage or moving in the field of logistics; and tracking patients and health status in the field of health. It is a wireless communication tool. One of the most important reasons why this technology has become widespread is decrease in the cost of RFID tags. Want (2006:25) reports that RFID tags are active or passive; active RFIDs need a power supply and tag life is limited to such power supply (i.e. it depends on power supply life); and thus passive RFIDs are more useful for industries like retailing industry as they do not need any such power.

Prater and Frazier (2005) examined RFID use in grocery store chains. They argue that automatic renewal program is implemented in this field where supply chains are not used flexibly, but it must be supported by RFID technology so that it can be used efficiently (Prater and Frazier, 2005:141).

Choi et al. (2015) examined RFID use in the clothing industry and aimed to improve the shopping experiences of customers through RFID tags that provide various advantages such as receiving data during shopping real-timely and enjoying an interactive environment contrary to traditional retailers who experience problems about providing customers with relevant products, location of desired products, and long pay periods.

Shin and Ekşioğlu (2015) explored the US retailing supply chain efficiency and highlighted that the enterprises using RFID have lower product scan error rates and higher efficiency in comparison to the enterprises not using RFID. According to Collins et al. (2010), RFID technology may make supply chain a more efficient system apart from creating customer value.

Borriello (2005) noted that passive tags will be used not only in non-living objects but also in living objects in the future and that RFID technology is more efficient than other identification systems.

3. Beacon Technology

Though Beacon devices are not a new technology, they are transmitters that are short-distance and consume low energy. They also stand out as devices that can send messages to mobile devices within an area of 70 meters. In addition, these devices use Bluetooth Low Energy (BLE). Thus, only part of the standard Bluetooth power of these devices is used, and short-distance wireless communication is ensured in this way. The basic working principle of Beacon devices is based on the special software in the receiver device. When the application in the receiver device enters the area of beacon device, pre-determined messages enter the system of the application in the receiver device (Nash, 2015: 3).

The article on the use of beacon in retail industry in *Guardian* (2014) says that beacon devices enable customers to access the products about which they would like to have information in a rapid an easy way and provide customer with a new experience in today's world where new and innovative ways of improving customer service are sought. The same article compares beacon technology which provides information about customers' in-store behaviors and actions as well as the products about which they obtain information with NFC (Near Field Communication) which is a system close to the beacon technology and highlights that beacon technology is more advantageous in data acquisition and processing.

Beacon devices are used not only in customers' points of meeting with products but also in the tracking of logistic activities. Beacon devices, which are used, besides other uses, for tracking the productivity of employees and transmitting and tracking information about which tasks employees have to fulfill and when they have to fulfill them and information about how long a specific employee has to stay in a specific area, are also useful for the tracking and control of suppliers' activities by retailers as the parties in the supply chain are also included in the process (http://www.theguardian.com/media-network/media-network-blog/2014/sep/04/beacon-technology-house-of-fraser-waitrose).

Kazama et al. (2000a) put a device in trucks and transmitted information about drivers and trucks to the equipment in mobile control centers via optical beacons and noted that use of optical beacons as a communication tool is lower-cost in comparison to the current infrastructure costs and thus allows logistics system to work in high efficiency. They also state that the use of these systems is more feasible for small and medium sized enterprises and these systems allow enterprises to obtain information about daily distribution operations and the current positions of trucks real-timely and help enterprises prepare necessary operational plans for trucks by acquiring statistical time-related data needed for distribution routes for each truck and each driver.

They stated that infrared beacons used as a communication tool located trucks, did not involve signal errors like those emerging in busy areas in cities in the case of GPS, and could store big amount of information, thereby allowing the use of information like cargo information in the system (Kazama et al. 2000b:264).

Another study on beacon devices focused on the expansion of product tracking area thanks to the radio beacon put on PHSs (personal handy-phone system) for the tracking of products and lost goods in logistics systems and located loss products (Kawahara et al. 2008:92). As is seen and explained in Figure 2, the lost product of a person with a personal telephone that had radio beacon was reached through PHS terminal. In this sense, the beacon system that allows accessing the lost product can be used both in the retail industry and for storage in logistics systems and enables product tracking to be done. It was found out that a PHS device combined with radio beacon has a wider seek area than the current PHS device and the battery life of the terminal is adequate for practical use and it can be used in the field of logistics.

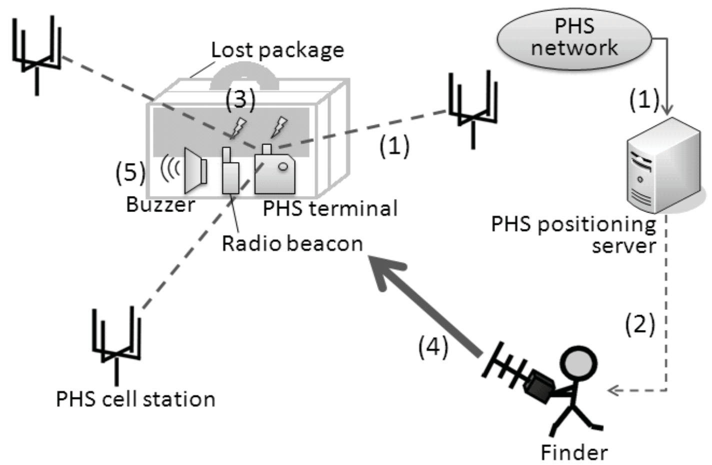

Figure 2: Positioning and seeking through a PHS terminal having a radio beacon
Source: (Kawahara et al., 2008:92)

Uckelmann (2008) put beacons in real-time location system within the scope of the concept of "smart logistics", but said that they may be used less because of their cost and that radio frequency (RF) is used for real-time location in just a few fields.

In another study on beacon devices, Lu et al. (2007) pointed out that beacon devices are similar to RFID tags but use Bluetooth system to establish communication. The authors tried to prevent interruptions in vehicle tracking through collective use of GPS and Dead Reckoning. In the study for concrete mixer illustrated in Figure 3, when no signal can be received via GPS, position is calculated via DR and the location of the vehicle is determined via BB. In this way, positioning is achieved in areas where no location information can be acquired through GPS. As a result, an incessant communication and data flow are achieved.

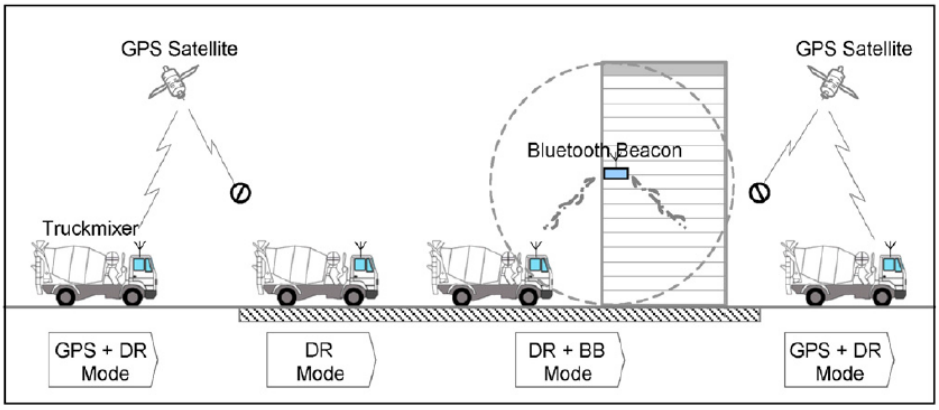

Figure 3: Positioning and course determination through a system that uses GPS, DR, and Bluetooth Beacon structure
Source: Lu et al. (2007:651)

They highlighted that it is more difficult to track and monitor equipment related to earthmoving and mine transport works in busy inner-city areas via GPS and that GPS performance is deeply affected in such areas. On the other hand, the existence of metal in near field makes positioning based on conventional radio frequency technology difficult. Thus, the authors addressed the pros and cons of positioning technologies based on radio frequency. It is reported that tracing is achieved without any interruption in positioning when GPS, DR, and BB are used (Lu et al., 2007).

According to Vo and Görg (2008), beacons have started to be preferred, within the scope of WSN, in various logistics scenarios and today's logistics information systems as they have a long life and are low-cost.

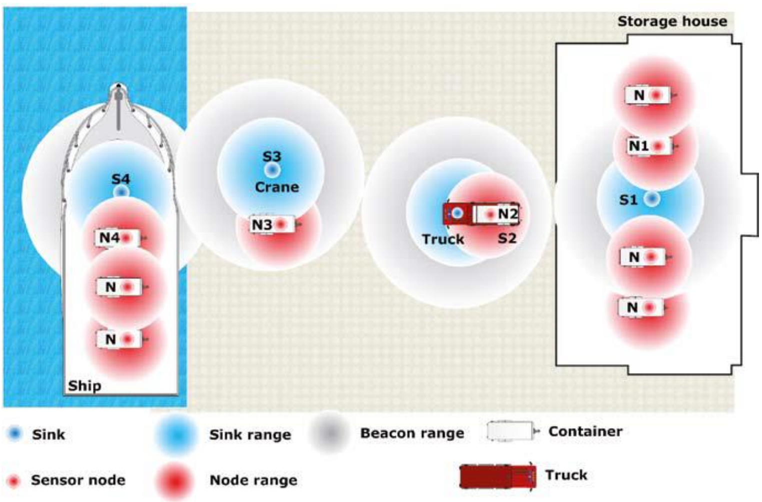

Figure 4: The Scenario for the Use of Wireless Receiver Sensors in Ports
Source: Vo and Görg (2008:58)

Figure 4 illustrates a system design involving information about mobility of containers in the port. In this system where beacon's sphere of influence is bigger, beacon devices capture information about containers, and information about points at which products will arrive are is sent to beacons during passage through sinks. In this regard, Vo and Görg (2008) mentioned that when they are used efficiently, wireless sensor networks function as a key technology allowing control and monitoring in logistics.

4. Hospitalar 2015 Fair "General Electric Healthcare" Application

International Fair of Products, Equipment, Services and Technology for Hospitals, Laboratories, Pharmacies, Health Clinics and Medical Offices 2015 (Hospitalar 2015) was held in Sao Paulo between the 19th and 22nd of May 2015 in order to introduce medical industry products, equipment, services, and technologies.

Being one of the most important medical industry fairs in Latin America, Hospitalar 2015 was held in an area of 82000 square meters with 1250 exhibitors and approximately 95,000 professional visitors arriving from every corner of the world. Among professional visitors were doctors, nurses, and managers working in hospitals, clinics, and laboratories, manufacturers of hospital products, distributors, representatives, students, health agents, and other organizations engaged in the field of health.

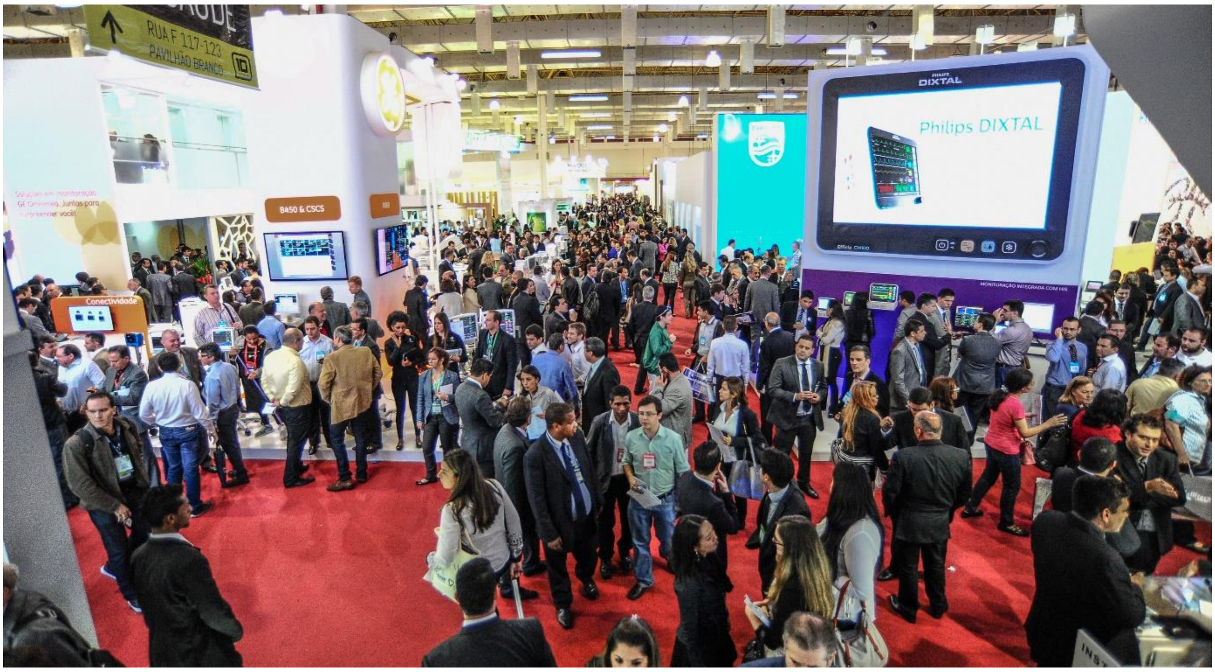

Figure 5: International Fair of Products, Equipment, Services and Technology for Hospitals, Laboratories, Pharmacies, Health Clinics and Medical Offices (Hospitalar 2015) - GE Healthcare Brazil

GE Healthcare Brazil attended Hospitalar 2015 with its selected 10 products in the fields of anesthesia, computed tomography, patient monitoring, ultrasound, interventional image guided systems, and magnetic resonance imaging in which it operates.

GE Healthcare Brazil wanted to use beacon technology in order to track the interests of the visitors who visited its booth at Hospitalar 2015 in its products. To this end, Sanitag Bilgi Teknolojileri A.Ş. (Sanitag Information Technology Corporation) created a mobile application called "GE NA Hospitalar" that fulfills wireless localization through beacon technology.

Sanitag Company uses real time locating systems in staff tracking and safety, patient tracking and safety, newborn safety and tracking and asset tracking (http://www.sanitag.com/about/, Erişim: 28/08/2015). Sanitag offers healthcare professionals with Real Time Location Systems and integrated solutions in order to increase patient safety, medical asset utilization, , staff safety, optimization of workflow, asset tracking such as ambulance, newborn baby protection, and environment monitoring at clinics and hospitals (http://www.sanitag.com/about/, Erişim: 28/082015).

The beacons needed for the developed application to do locating in the fairground were placed in the products in the booth. After the beacons were adhered to the products, each beacon and the product it belonged to were defined in the database. Whenever the application is turned on, it downloads the list of the beacons recorded in the system. When a new beacon is to be added, only a new ID number is defined in the application. Notifications are opened on the screen as signals arrive from the beacons. Figure 6 and Figure 7 illustrate the beacons placed on the products.

Figure 6: GE Healthcare LOGIQ S7 Pro Product and the Beacon Placed on It

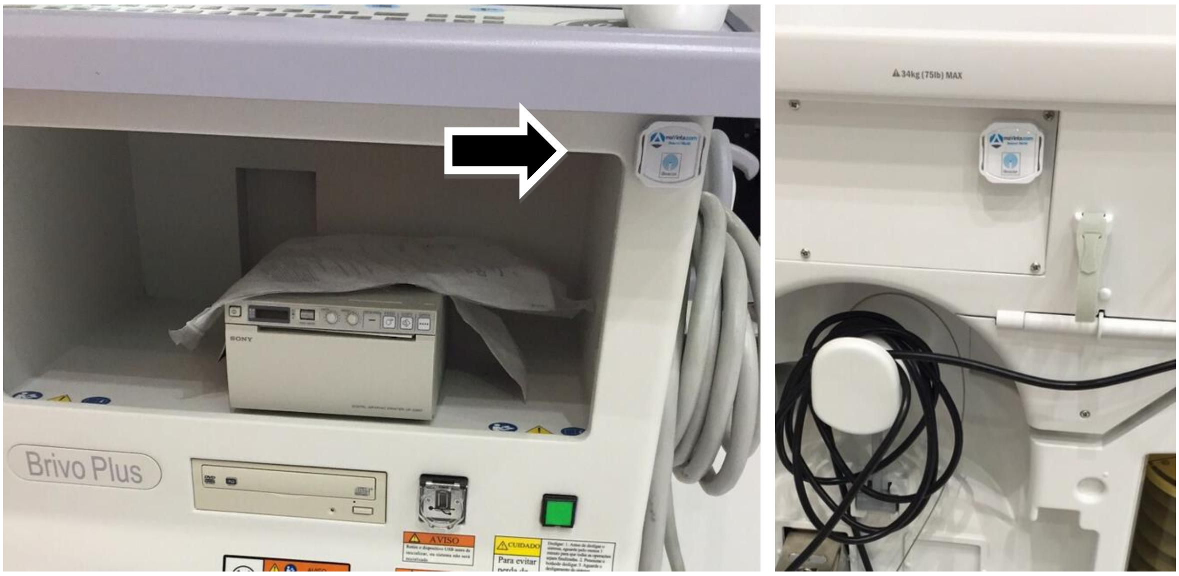

Figure 7: GE Healthcare Products and the Beacons Placed on Them

As an ibeacon standard, beacons can signal twice a second (once every 500 milliseconds). The quality of signal varies depending on the beacon used and environmental conditions and deviations occur in distance calculations. Therefore, signal calibration is made to ensure consistency between the strength of the received signal and distance and for the system to work efficiently. In this way, right distances can be calculated through the multiplication of the strength of signal by different coefficients. Figure 8 illustrates the layout of the booth of GE Healthcare Brazil. As explained above, signal calibration was made by measuring the coverage areas of the beacons positioned on the products in the booth of 15x16 meters one by one.

Figure 8: The layout of the booth of Hospitalar 2015 GE Healthcare Brazil

GE Na Hospitalar application had to work on common mobile operating systems. For that reason, Ionic platform was used to produce a mobile application that is compliant with both Android and iOS mobile operating systems. Ionic is a HTML5 local application development platform that helps create mobile applications that feel local in operating systems through web technologies such as HTML, CSS, and javascript. Ionic makes good and interactive mobile applications very easily by use of HTML5 and AngularJS. AngularJS is needed for Ionic platform to work with its full potential. Ionic focuses on creating native/hybrid mobile applications rather than mobile websites. Thus, in order to use the Ionıc Scanner in platforms trough local applications the Ionıc Scanner needs a Web view API. Accordingly, Ionic applications perfectly work on UIWebView in iOS operating system and on WebView in Android operating system (http://ionicframework.com).

Upon the request of GE Healthcare Brazil, statistical information was obtained in regard to the time spent by visitors examining the products, the number of visitors visiting the products, the number of the downloads of the introductory guides related to the products, and cross-correlations between the visited products. When one logs in the system over Facebook or by using e-mail, ID-based statistics can also be kept. If no user logs in the system, one can monitor by using ID details belonging to the Bluetooth adaptor.

GE NA Hospitalar application indicates in which product’s coverage area a user is. It is seen in Figure 9 that we are in the coverage area of no product on the left screen, but we are in the coverage areas of 2 products on the right screen. When a product’s name is clicked, the user manual belonging to is opened. The application also shows the products visited before. The mark “i” next to a product’s name indicates whether or not the user manual belonging to such product has been downloaded before. While the red mark shows that the user manual has not been downloaded before, the blue mark shows that it has been downloaded before.

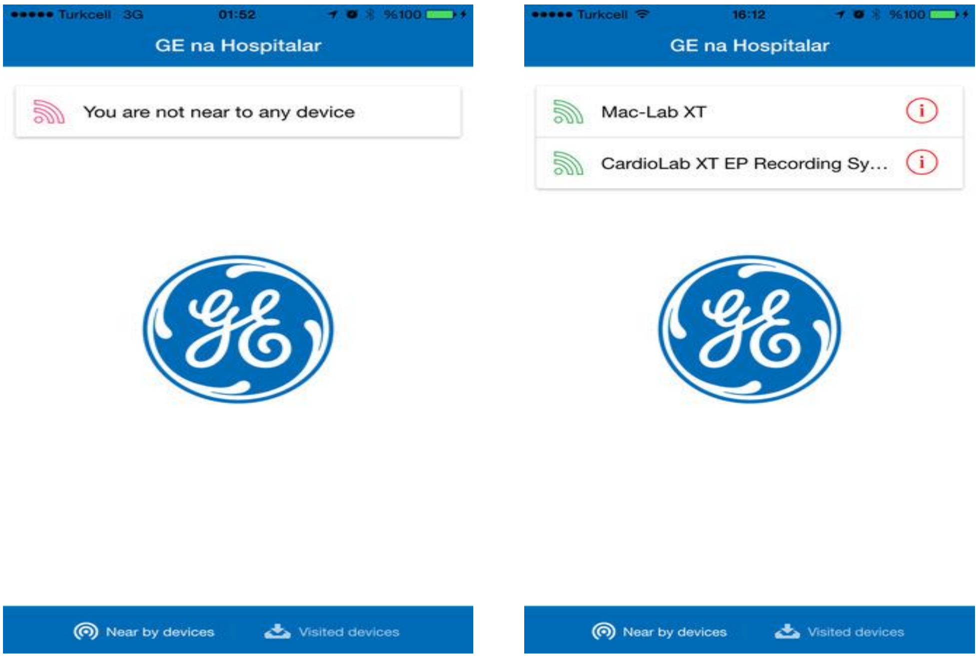

Figure 9: GE NA Hospitalar Application

The database of the application and documents related to the products are in Microsoft Azure, a cloud computing platform. Since the fair was in Brazil, they were loaded on Microsoft Azure Brazil server so that the application could work rapidly and productively. The database includes fields for product ID number, e-mail address, Facebook identity, Bluetooth adaptor mac address, and beacon signals.

The actions of visitors can be tracked by use of the data in the database. As an example, the actions of the visitor having the Bluetooth adaptor address 88-53-2E-F4-5A-1E are indicated in Table 1 and Table 2 Table 1 shows that the visitor received the Beacon1 signal on 19.05.2015 at 14:05:23.500 for the first time and stayed in the valid coverage area of Beacon1 for 3 minutes and 21 seconds. Table 2 indicates that the visitor having the Bluetooth adaptor address 88-53-2E-F4-5A-1E downloaded the introductory guides belonging to Machine 1 and Machine 2. It is seen that 4.8 product introductory guides were downloaded per visitor among 10 products in the booth.

The application operating system can also reach different data depending on permissions. Personal data were not accessed so as not to tarnish the trust of users. How interesting a user found a specific page in the downloaded introduction and how long s/he read it can be monitored.

Table 1– Beacon Signal Table

Bluetooth ID	Date	Time	Beacon No
88-53-2E-F4-5A-1E	19.05.2015	14:05:23.500	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:05:24.000	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:05:24.500	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:05:25.000	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:08:42.500	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:08:43.000	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:08:43.500	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:08:44.000	Beacon1
88-53-2E-F4-5A-1E	19.05.2015	14:08:44.500	Beacon1

Table 2 – Introduction Manual Loading Table

Bluetooth ID	Guide	Date	Time
88-53-2E-F4-5A-1E	Machine1	19.05.2015	14:06:13.475
C8-F7-33-AA-84-8E	Machine3	19.05.2015	14:06:25.333

88-53-2E-F4-5A-1E	Machine2	19.05.2015	14:11:24.275
00-10-60-AA-36-F8	Machine6	19.05.2015	14:12:05.917

The application is able to reach different data as the permissions given by the operating systems. It was not preferred to reach the personal data in order to not misuse of trust level of consumers. The read time of the manual by attendants and how it attracts the attention of attendants can be tracked by this system.

5. CONCLUSION

Increase in data needed to maintain the current customers and improve customer satisfaction forces enterprises to use information and communication technologies. Enterprises use wireless and mobile systems in order to increase customer traceability. Switch to wireless and mobile systems provides opportunities to access customer data and turn them into competitive advantage in the market. The use of beacon technology in the fairground was examined in the present study.

Visitors visiting the booth of an enterprise in a fair are considered potential customers. Various technologies can be used for tracking these visitors. Giving a tag to every customer to track them is quite difficult and costly. Given the common use of smart phones at the present time, beacon technology that does not require distributing tags is one of the most logical solutions.

Beacon will have a wider usage area in the future. In this regard, GE Healthcare aims to use beacon technology not only in fairgrounds but also in its products continuously. Accordingly, beacon is going to be put in every manufactured product. User manuals, updates, and details of products will be displayed on tablet or smart phone screens whenever users want. The useful life of beacon battery may be lengthened to 10 years if such battery is enlarged. Moreover, it can be used without any power-related problem if it is connected to the electrical circuit of the product.

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PRODUCTION PLANNING WITH PRICING AND DUE DATE CONSIDERATIONS

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Abstract − *In contrast to classical production planning models which mainly consider the capacity constraints, in recent years, there has been a growing interest in integrating demand management decisions in production planning through the use of pricing decisions. In this work, a mathematical programming approach is utilized to address the production planning problem in a real life make-to-order production system. Order acceptance and due date assignment decisions are given through the use of the model so that profit is maximized and the tradeoff between the customer due dates and order prices are also taken into consideration. Capacity expansion options such as subcontracting and overtime is also included. A case study in an* automotive *brake discs manufacturing company is presented to illustrate the proposed approach and the results.*

Keywords − *Capacity management, due date assignment, make-to-order production, order acceptance, pricing, production planning.*

INTRODUCTION

Integration of production planning and order acceptance decision has an important role in make-to order production system. Companies don't accept all orders in order to gain their goals in today's competitive environment. In addition to capacity decisions, the interest in decisions such as due date assignment, pricing and order acceptance has been increasing in production planning.

The short term capacity planning model for make-to-order production systems was studied in [1]. Their model depends on selection of orders in order to maximize the profit. Source options are regular time, overtime and outsourcing in their study. According to their model, tardy delivery was not allowed, so orders which were selected can't exceed their due dates.

Mixed-integer linear program was used for order selection and capacity allocation decisions in a make-to-order production system and branch and price algorithm was applied to solve the problem effectively in [2]. Although regular time, overtime and subcontracting were considered as source options in [1], only regular time and overtime were considered as source options in [2]. A heuristic model was proposed in [3] which were based on the model of [2]. The production planning problem which includes order acceptance decision and due date flexibility was studied in [4]. Mixed-integer linear programming formulation and a heuristic model were used for solving the problem in [4].

The mathematical model which was initially proposed in [1] was modified and considerably improved in the present study. We have identified some mistakes in the formulation of some constraints such as capacity constraints and precedence constraints of reference [1]. Therefore we have revised and reformulated the core mathematical model which was proposed in [1]. According to reformulation of the mathematical model, capacity constraint for outsourcing is transformed into a non-linear constraint and a linearization procedure is applied to this constraint. More importantly, “sales prices” and “due dates” are considered as decision variables with minimum and maximum bounds in contrast to model of [1], where they were considered as constant parameters. This practical enhancement has entirely changed the model and its functioning logic. After this modification objective function and due date constraints become non-linear in our revised and

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improved model. A linearization technique is applied to the objective function and due date constraints in order to linearization of the mathematical programming model to enable standard optimization software for its solution. Finally we have developed a multi-objective mixed-integer non-linear programming model for a capacity constrained production planning problem with pricing, order acceptance and due date decisions along with many other practical constraints. For solving the mathematical model with the objectives of profit maximization and due-date minimization ε-constraint method is utilized after linearization by using Lingo 14.0 software. A practical application of the proposed model is also presented in a real manufacturing company producing automotive brake discs in Manisa industrial zone.

PROBLEM DESCRIPTION

The multi-objective short-term production planning problem is considered in this study for a make-to-order production system. In contrast to classical production planning models, orders are accepted or rejected in order to maximize the total net profit and minimize the total due dates. The total net profit is considered as the difference between the total revenue and total processing cost. Tardy delivery is not allowed, so orders which are accepted can't exceed their due dates. Regular time, overtime and outsourcing are source options and unit processing cost per hour on resource *k* of source *r* increases from regular time to outsourcing. The problem includes more resources and each resource has one or more machines. All resources are available during regular time and overtime and the capacity of outsourcing is large enough. Each order has more than one job, so orders are processed according to their routes. The process route of each order and the processing times of jobs on different resources are known in the problem. The outputs obtained from the solution of the problem provide information about the total net profit, list of accepted orders and their schedule, price and due date values for each order.

MATHEMATICAL FORMULATION OF THE PROBLEM

Sets, parameters and decision variables which are formed by developing the mathematical model are defines as follows [1]:

Sets:

I items $\{i \in I\}$
J_i jobs (or operations) in item i $\{j \in J_i\}$
K resources $\{k \in K\}$
R sources $\{r \in R\}$
T time periods $\{t \in T\}$

Parameters:

p_{ijk} :processing time of job j of item i on resource k
c_{kr}: unit processing cost per hour on resource k of source r
b_{krt}: number of hours of resource k of source r available in time period t
l_{rt}: number of hours of source r available in time period t.

Decision Variables:

s_i :selling price of item i
d_i: due date for item i
X_{ijkrt} number of hours of resource k of source r assigned for processing job j of item i in time period t
Y_{ijkrt} 1, if job j of item i is processed on resource k of source r in time period t;
0, otherwise
Z_i 1, if the order for item i is accepted;
0, otherwise
O_{ij} 1, if the operation j of item i is outsourced;
0, otherwise

The complete multi-objective mixed-integer non-linear mathematical programming model is shown below:

Maximize $\sum_{i \in I} s_i * Z_i - \sum_{i \in I} \sum_{j \in J_i} \sum_{k \in K} \sum_{r \in R} \sum_{t \in T} c_{kr} * X_{ijkrt}$ (1.1)

Minimize $\sum_{i \in I} d_i * Z_i$ (1.2)

Subject to:

$\sum_{i \in I} \sum_{j \in J_i} X_{ijkrt} \leq b_{krt} \quad \forall\, k \in K, r \in R, t \in T$ (2)

$\sum_{r \in R \setminus \{|R|\}} \sum_{t \in T} X_{ijkrt} + \sum_{t \in T} X_{ijk|R|t} = p_{ijk} * Z_i \quad \forall\, i \in I, j \in J_i, k \in K$
(3)

$\sum_{t \in T} X_{ijk|R|t} = p_{ijk} * O_{ij} \quad \forall\, i \in I, j \in J_i, k \in K$ (4)

$\sum_{i \in I} \sum_{j \in J_i} \sum_{k \in K} X_{ijkrt} \leq l_{rt} \quad \forall\, r \in R \setminus \{|R|\}, t \in T$ (5)

$\sum_{i \in I} \sum_{j \in Ji} \sum_{k \in K} X_{ijk|R|t} * O_{ij} \leq l_{|R|t} \quad \forall\, r \in |R|, t \in T$ (6)

$\sum_{j \in J_i} \sum_{r \in R} \sum_{k \in K} X_{ijkrt} \leq 24 \quad \forall\, i \in I, t \in T$ (7)

$X_{ijkrt} \leq M * Y_{ijkrt} \quad \forall\, i \in I, j \in J_i, k \in K, r \in R, t \in T$
(8)

$X_{ijkrt} \geq p_{ijk} * Y_{ijkrt} \quad \forall\, i \in I, j \in J_i, k \in K, r \in R, t \in T$
(9)

$\sum_{k \in K} t * Y_{i|Ji|krt} \leq di * Z_i \quad \forall\, i \in I, r \in R, t \in T$ (10)

$\sum_{r' \in R} \sum_{t'=1}^{t-1} X_{i(j-1)kr't'} + \sum_{r'=1}^{r} X_{i(j-1)kr't} \geq p_{i(j-1)k} * \sum_{k' \in K} Y_{ijk'rt}$
(11)

$\forall\, i \in I, j \in J_i \setminus \{1\}, k \in K, r \in R \setminus \{|R|\}, t \in T$

$\sum_{r \in R} \sum_{t'=1}^{t} X_{i(j-1)krt'} \geq p_{i(j-1)k} * \sum_{k' \in K} Y_{ijk'|R|t}$ (12)

$\forall\, i \in I, j \in J_i \setminus \{1\}, k \in K, t \in T$

$\sum_{j \in J_i} \sum_{k \in K} X_{ijk|R|t} \leq 24 - \sum_{j \in J_i} \sum_{k \in K} \sum_{r \in R \setminus \{|R|\}} r * l_{rt} * Y_{i(j-1)krt}$ (13)

$\forall\, i \in I, t \in T$

$X_{ijkrt} \geq 0 \quad \forall\, i \in I, j \in J_i, k \in K, r \in R, t \in T$ (14)

Y_{ijkrt} Binary $\quad \forall\, i \in I, j \in J_i, k \in K, r \in R, t \in T$ (15)

Z_i Binary $\quad \forall\, i \in I$ (16)

O_{ij} Binary $\quad \forall\, i \in I, j \in J_i$ (17)

Equation (1.1) is to maximize the total net profit which is difference between total revenue and total processing cost. Equation (1.2) is to minimize due dates. The capacity of resource k of source r in time period t is not exceeded by Equation (2). Equation (3) ensures that the total number of hours which are allocated to processing of job j of item i must be equal to its processing time. Equation (4) ensures that if the job j of item i is assigned to outsourcing, it is completely outsourced and does not exceed its processing time. Equation (5) ensures that the total number of hours which are allocated to process of all items can't exceed the capacity of the number of hours of source r available in time period t. Equation (6) is the capacity constraint for outsourcing option in each time period.

Equation (7) ensures that each item can be processed less than or equal to 24 hours in each time period. Equation (8) and Equation (9) express the relation between the binary variable Y_{ijkrt} and the continuous variable X_{ijkrt}. If Yijkrt is 0, number of hours of resource k of source r assigned for processing job j of item i in time period t (X_{ijkrt}) takes the value of 0, otherwise X_{ijkrt} takes a value of 1. M is a big number in Equation (8). Equation (10) ensures that the completion time of last job of item i can't exceed the due date of item i. Equation (11) ensures that the processing of job j of item i can be started only after job (j-1) of item i is completed. Equation (12) ensures that job j of item i can be processed in outsourcing only after job (j-1) of item i is completed. Equation (13) ensures that processing of outsourced job can't be more than available hours. Equation (14) is ensures that X_{ijkrt} is not negative. Equations (15)-(17) are related with binary restrictions on the decision variables Y_{ijkrt}, Z_i and O_{ij}. Due to space limitations the linearized model along with linearization procedures are not presented in this paper.

CASE STUDY

The proposed mathematical programming model is applied in an automotive brake discs manufacturing company in order to analyze the model. Regular time, overtime and outsourcing are source options for each resource type. Regular time is 11 hours and overtime is 11 hours per day in the company. We assume that outsourcing runs 24 hours per day and the capacity of outsourcing is large enough. The numerical example includes 7 orders and each order has 7 jobs. Each order is processed in a flow-shop like process. There are 7 resources and each resource has one or more machines.

Table 1 shows that the unit processing cost per hour on resource k of source r. Order (item) related information such as minimum and maximum bounds of due date and sales price, operation sequence, resource ID and processing time are shown in Table 2.

The objectives of the model are; maximizing the total net profit which is difference between total revenue and total processing cost and minimizing the total due dates. The multi-objective mixed-integer non-linear model is solved with the ε-constraint method after linearization. When the model is solved according to the first objective (under 1 % tolerance of the objective value) the profit is found as 178697.6 TL. In this solution due dates and selling prices of orders take maximum values. Under ε-constraint method the second objective is selected for optimization and the first objective is thought as a constraint. In order to analyze the changes of due dates, the total net profit is decreased from 178697.6 TL to 140000 TL. The value of the first objective which is the constraint under ε-constraint method is considered as bigger than 140000 TL. Obtained results show that when we decrease the total net profit, the values of due dates decrease and the fourth and the sixth orders are rejected. Due date value of the first order is 2, second order is 3, third order is 4, fifth order is 2 and seventh order is 2. The schedule of the model under ε-constraint method is presented in Figure 1. One time period expresses one day in Figure 1.

Table 1. Processing Cost

Resource ID	Sources Type (TL/ hour)		
	1	2	3
1	48	50.4	52.8
2	36	37.8	39.6
3	36	37.8	39.6
4	15	15.75	16.5
5	10.5	11.025	11.55
6	3	3.15	3.3
7	1.5	1.575	1.65

Table 2. Order Related Data

Item (Order)	Minimum Due Date (Day)	Maximum Due Date (Day)	Minimum Sales Price (TL)	Maximum Sales Price (TL)	Operation Sequence	Resource ID.	Processing Time (hour)
1	2	5	22690.425	34910.475	1	1	4
					2	2	1
					3	3	7.5
					4	4	2
					5	5	2
					6	6	15.5
					7	7	2
2	2	5	29107.95	44781.225	1	1	4
					2	2	1
					3	3	7.5
					4	4	2
					5	5	2
					6	6	15.5
					7	7	2
3	2	5	16866.375	25946.85	1	1	2
					2	2	1
					3	3	7
					4	4	2.5
					5	5	2
					6	6	15.5
					7	7	2
4	2	5	12293.82	18914.28	1	1	2
					2	2	0.5
					3	3	5.5
					4	4	1.5
					5	5	1.5
					6	6	12
					7	7	1.5
5	2	5	9315.075	14329.7	1	1	2
					2	2	0.5
					3	3	4.5
					4	4	1
					5	5	1.5
					6	6	10
					7	7	1.5
6	2	5	13000.68	20002.29	1	1	2
					2	2	0.5
					3	3	5.5
					4	4	1.5
					5	5	2.5
					6	6	12
					7	7	1.5
7	2	5	14991.9	23064.58	1	1	2
					2	2	0.5
					3	3	4
					4	4	1
					5	5	2.5
					6	6	8
					7	7	1

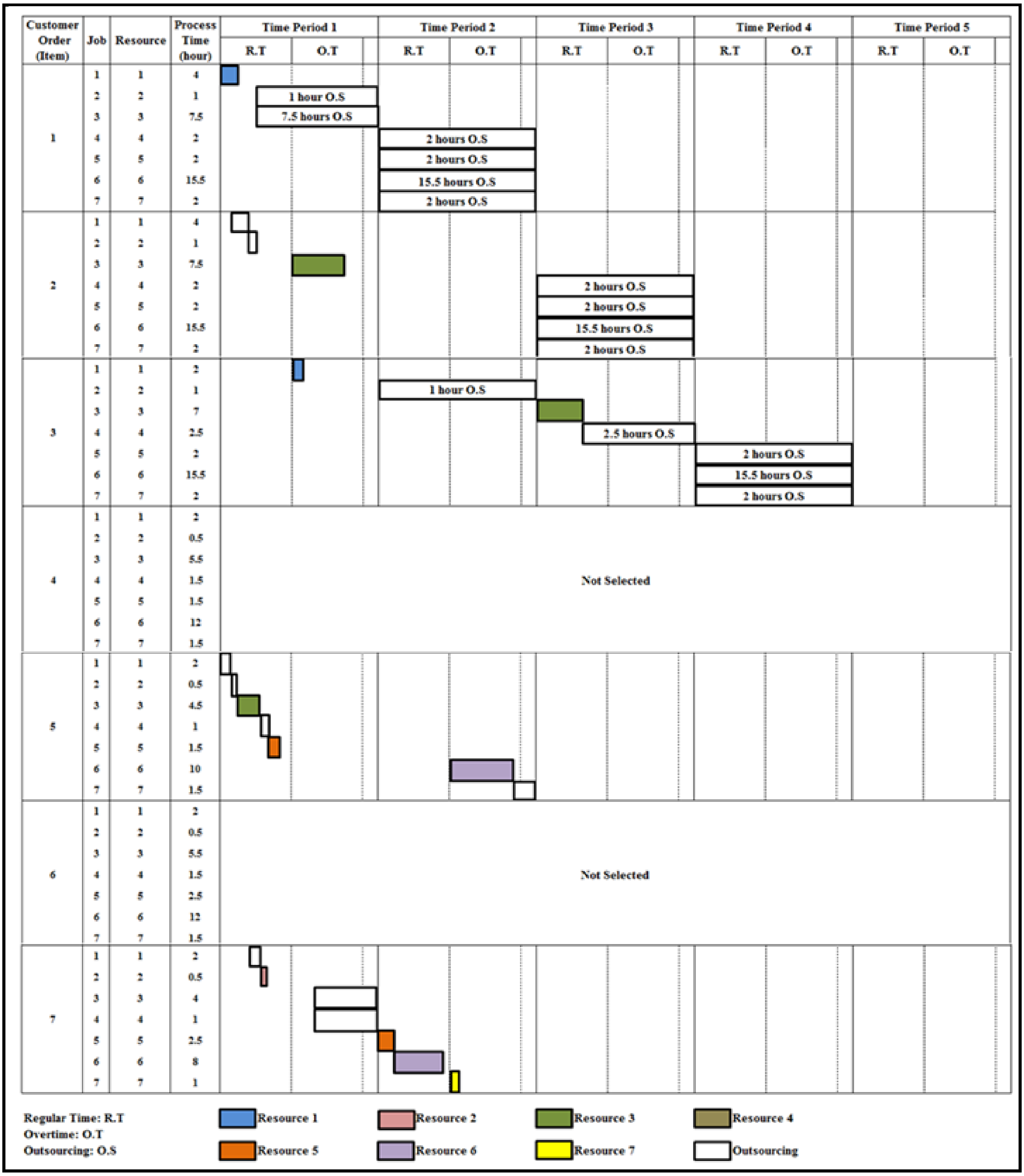

Figure 1. Optimal Schedule of Orders

CONCLUSIONS

In the present study a multi-objective mixed-integer non-linear model is developed for modeling and solving a capacity constrained production planning problem with pricing, order acceptance and due date decisions along with many other practical constraints. The model is solved by making use of ε-constraint method via Lingo 14.0 software. The proposed model is applied to a automotive brake discs manufacturing company in order to analyze the model. It is shown that the model is able to provide optimal schedules for the company.

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FROM SUPPLY CHAINS TO SUPPLY CHAIN ECOSYSTEMS: A SERVICE-DOMINANT LOGIC AND VALUE ECOLOGY PERSPECTIVE

Gül Denktaş Şakar[111]

Abstract – *Together with the increasing number of organizations connecting each other for various purposes within modern supply chain systems, more complex, globalized and interdependent mechanisms have been considered in today's business environment. These mechanisms that have recently been called as "supply chain ecosystems" are generally characterized as globally inter-weaved networks with many networks of related members of supply chains. Main triggers for such supply chain ecosystems are basically listed as; complexity, connectivity and interdependencies within various supply chains as well as global trade and logistics operations. As the main similarities between a biological ecosystem and a supply chain, the need for interaction and interdependency, having recognizable boundaries, sharing common adaptive challenges, pursuing dual goals, having common knowledge and skills can be mentioned. Contrary to traditional supply chain approaches focusing on network capability, collaboration-based approaches enriched with increased level of interdependencies with various stakeholders are viewed as the brand-new philosophy of supply chain systems and literature. In accordance with the changing philosophy in the supply chain systems, there is an increasing need for understanding and evaluating the emerging concepts related to the ecology and ecosystem based developments taking place in supply chain mechanisms. In the light of these, this study aims to provide an insight regarding the supply chain ecosystems concept by integrating service dominant logic paradigm and value ecology perspective. A conceptual model is also suggested in order to provide an overview regarding the approaches discussed in the study. Although there are many studies focusing on both business ecosystems and the collaborative functions and needs for supply chain actors, research on supply chain ecosystems and their relationship with service ecosystems and value systems is limited. Since both service dominant logic and value ecology perspectives focus on coproduction of service offerings, exchange and co-creation of value within an overall ecosytem perspective, the integration of these approaches is expected to bring out certain variables to be evaluated in further studies.*

Keywords – Ecosystems, Service-dominant Logic, Supply Chain, Value Ecology, Value Networks

INTRODUCTION

The current literature on supply chain systems mainly focuses on the various relationships within and across the supply chains and they mostly investigate dyadic relations such as buyer-supplier relationships [8, 9], service provider-focal firm relationships [4] etc. Research based on these relationships covers only a limited number of members within the supply chain since these studies are basically concentrated on identifying the relationships between the parties investigated. However, todays' supply chain systems highly demand a wider outlook to the environment, parties involved, resources utilized and exchange of information etc. Ecosystem-based approaches evolved as a result of this need so that a similar perspective can be taken for business supply chain systems as in the case of biological ecosystems. Although there is such a need to explore the supply chains from an ecosystem perspective, it is observed that the understanding and the investigation of ecosystem-wide supply chains are neglected in the current supply chain literature. Although business ecosystems, have been studied since the mid-1980s [51], the investigation of supply chains from an ecosystemic point of view is neglected in the literature. [32]'s study which mainly focused on service-dominant ecosystems developed a service dominant strategy built on ecosystem approach and it is considered as the first study which directly linked ecosystem approach to service dominant logic.

[24] dictated the strategic importance of such new evolution in supply chain systems by considering the sourcing function and they named this concept as supply ecosystems. Taking the perspective from supply

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function, [24] argued that there is a shift from some traditional supply chains to supply ecosystems, which represent a set of interdependent organizations that share common adaptive challenges as well as collectively shape the creation and nurturing of a sourcing base. Moreover, new ecosystemic methodologies and metrics to evaluate ecosystemic health (performance) are suggested [21, 60]. [7] investigated how the value-creation and –capture processes interplay and shape the ecosystem's lifecycle by applying lifecycle theory. It was clearly mentioned that it is challenging to shift from supply-chain logic (firm value creation) to ecosystem logic (ecosystemic value co-creation) and there is an increasing need for more partnership and cooperation within the ecosystem in order to leverage ecosystemic capabilities.

In the light of these approaches, increasing need for having shared value and co-creation of value within the supply chain ecosystems as well as the need for understanding the ecological value concept can be mentioned as the main triggers for this study. Since service-dominant logic and value ecology perspectives are considered as the complementary views that explain the ecosystem-based nature of supply chain systems, they are discussed as the main approaches in this paper. In this paper, several theoretical perspectives that hold promise for understanding supply chain ecosystems functioning and outcomes are offered.

LITERATURE REVIEW

Supply Chain Ecosystems

Originating from biological sciences, ecosystem is basically defined as an environment within which members interact and a set of interdependent activities occur among these members. The word "ecosystem" was coined in the 1930s by British botanist Arthur Tansley by referring to a localized community of living organisms interacting with each other and their particular environment of air, water, mineral soil, and other elements. These organisms influence each other, and their terrain; they compete and collaborate, share and create resources, and co-evolve; and they are inevitably subject to external disruptions, to which they adapt together. Business strategist James Moore adapted the concept to the business landscape. [35] compared biological and business ecosystems and mentioned that a community exists in business ecosystems as in biological ecosystems that works in specific environmental condition and relies on fair relationships between partners. In his Harvard Business Review article, Moore highlighted that: "*Successful businesses are those that evolve rapidly and effectively. Yet innovative businesses can't evolve in a vacuum. They must attract resources of all sorts, drawing in capital, partners, suppliers, and customers to create cooperative networks. . I suggest that a company be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries. In a business ecosystem, companies co-evolve capabilities around a new innovation: They work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations"* [35: 75-76].

According to [37: 26], business ecosystem is "*an economic community supported by a foundation of interacting organizations and individuals.... The member organizations also include suppliers, lead producers, competitors, and other stakeholders. Over time, they co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies."* By focusion on the value offering characteristics of business ecosystems, [20] defined ecosystems as: "*these loose networks—of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organizations—affect, and are affected by, the creation and delivery of a company's own offerings*". [24] mentioned that business ecosystem includes a set of organizations that are mainly interdependent, coordinate activities and share some adaptive challenges. [58: 10] also defined ecosystem as "*an environment consisting of the living organisms inhabited in an area, as well as the non-living physical and chemical components of the environments with which the organisms interact*. [58] argued that the interaction makes the ecosystem as a functional unit with all its components linked together through the flow of energy and nutrient cycles. According to [5], ecosystem is proposed as a metaphor to explain the need for business markets and non-business institutions to establish an ecologic equilibrium. Three core characteristics of ecosystems are highlighted as: (1) the participation of diverse range of organizations, who together can create, scale and service markets beyond capabilities of any single organization, (2) interaction and co-creation in increasingly sophisticated ways by deploying technologies and tools of connectivity and collaboration, (3) being connected by some combination of shared interests, purpose and values which motive the members to collectively nurture, sustain and protect the ecosystem [22]. [24] pointed out the basic difference between a network and a ecosystem by mentioning that there is an increased level of interdependencies across a broader array of stakeholders. Three main characteristics of ecosystems were emphasized by [39] as: co-opetition, dual goals for value creation and pooled knowledge and skills. Co-opetition mainly refers to competing for resources as within the ecosystem and also being connected to each other for the survival of the ecosystem. Having dual goals for value creation is another critical component which means that each member of the ecosystem must create value for itself. Thirdly, pooled knowledge and skills provide ecosystem-wide competences for the benefit of members.

Literature on business ecosystems can be considered as "developing" since there is limited number of studies in the field. Apart from [35], [20] and [44] are considered as the main pioneers of business ecosystem approach in the literature. Based on [35]'s approach and biological analogy, [20] suggested another model and pointed out three major players in an ecosystem as; dominators, niche players and networks by focusing on the business ecosystem's health. [44]'s model concentrates more on the digital and virtual organisations by focusing more on technological connectedness, technological changes and innovation. Additional efforts have been conducted to understand the mechanism of business ecosystems by [42, 43] based on suggested theoretical frameworks. Empirical studies by [12, 45] were also conducted by applying network techniques to analyze business ecosystems. These studies mainly shed light on the emergence of ecosystemic lens on business landscape through the use of different models and techniques. Although there is an emerging research on business ecosystems, the studies on supply chain ecosystems, which are basically a special form of business ecosystems, are limited. As seen from the definitions of an ecosystem, the existence of many members, their effort for survival and resource utilization and being connected to each other for various purposes can be listed as the main characteristics. These characteristics mainly resemble the network of companies connected to each other through the flow of materials, information, money and services, namely the supply chain systems. As [24] mentioned, a typical business ecosystem includes a set of organizations that are interdependent, coordinate activities and share some common adaptive challenges that are also the main capabilities of the supply chain systems. Moreover, there are remarkable similarities between supply chain systems and biological ecosystems in terms of the interactions and interdependencies among organizations. [58] provided the main components of supply chain ecosystem as seen in Figure 1.

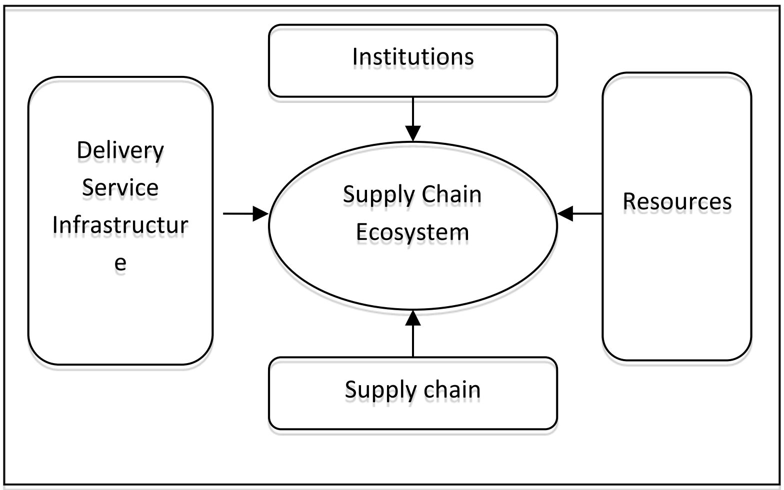

Figure 16. Supply Chain Ecosystem
Source: [58]

As seen from Figure 1, the supply chain ecosystem is categorized as; supply chain, institutions, resources and management and delivery mechanisms and infrastructure. From a wider point of view, networks of companies directly and indirectly part of the supply chain, countries of operations/presence and their governments; industrial, social and political organizations; logistics and information technology services infrastructure; the third party service providers that connect the companies and the countries to the external economic and social environment; resources including natural, financial and human resources with talent, connections and knowledge of the industrial environment; industry clusters, universities, etc. interacting together with the landscape (horizontal and vertical) and climate (economic and social) can be listed as the main components of supply chain ecosystem [58]. Similar to this view, [20, 36] agreed that the structure of the ecosystem should integrate the suppliers, distributors, creditors, technology providers, agency regulators and political entities, producers of complementary products, partners and outsourcing, competitors, media relations, employees and customers. Actors in the supply chain systems are getting more and more integrated in todays dynamic, hyper-connected and collaborative ecosystem designs. Since there are main concerns regarding cost reduction in supply chain systems, the members of the supply chains became widely dispersed and various functions of supply chains such as warehousing, production, order management, etc. took place in different parts of the world. This has led to complex supply chain systems together with many members sharing common goals, adaptive challenges and resources. Building upon the main discussions related to supply chain ecosystems and business networks, this paper provides an overview of supply chain ecosystem concept by linking the service-dominant logic and value ecology perspectives. The next section provides an overview of two basic perspectives utilized in the paper as; service-dominant logics and value creating ecology.

Service-Dominant Logic and Value Ecology Perspectives

Supply chain systems are studied and discussed in the light of various perspectives and theories such as transaction cost theory [17, 18], agency theory [13, 38], resource dependence theory [11], resource based view [19], institutional theory [47], social capital theory [26], game theory [33] etc. As [15] noted, it is practically impossible to rely on a single theoretical perspective to provide a comprehensive explanation of such phenomena. All related theories are basically dependent on the traditional definitions and components of supply chains. As seen from many definitions related to supply chain [27, 34], goods-dominant logic is mainly common due to the existence of linear set of firms connected to each other with materials moving forward. However, goods and other resources are considered as the main components that enable the transfer of other resources such as knowledge and skills so that supply chains are viewed as value co-creation networks [52]. According to [14], such networks enable knowledge growth and exchange among its members through resource deployment and coordination. Since todays ecosystem-based supply chain structures necessitate the use and implementation of such coordination and co-creation networks, a more detailed investigation of this concept within the body of supply chain ecosystems is needed. [52] highlighted that taking such a new paradigm so-called service-dominant logic may help to understand the co-creation of value by the entire network of supply chain members from raw material suppliers to end-users through dynamic, multi-party dialogue, knowledge exchange and utilization of various resources.

Service-dominant logic perspective has widely been researched by the scholars as a foundational premise for studying service innovations [40]. This approach has also been linked closely with relationship marketing, relationship marketing and knowledge management theory: resource-based view of the firm and interaction perspective in industrial marketing [25]. S-D logic perspective suggests that an organization should focus on considering the customer as a resource contributing to the creation of value that actually makes the customer a co-creator of value [55]. Since customers mobilize knowledge and other resources in the service process that also influence the outcome of value proposition [40], they are viewed as the main actors in the value creation process as well as the co-creators and producers. As an important contribution of service-dominant logic to the both marketing and SCM literatures is mentioned as the inclusion of end-users in the value co-creation process [52]. As dictated by [53: 6] *"a service-centered dominant logic implies that value is defined by and co-created with the consumer rather than embedded in output".* As a possible way to better understand the basic principles of service dominant logic, it may be suggested to overview the principles of goods dominant logic. As [53] argued, goods dominant logic is built on the assumption that economic value is added through industrial processes, embedded in goods and distributed. S-D logic redefines the role of supply chain as finding innovative ways to integrate the resources necessary for service provision [31]. Moreover, [31] define the value co-creation network as "value proposing social and economic actors interacting through institutions and technology, to: (1) co-produce service offerings, (2) exchange service offerings, and (3) co-create value."

Since ecosystems heavily rely on the use of mutual resources for their survival, the types of resources to be utilized within the ecosystems should also be discussed. Two main types of resources are highlighted in service dominant logic as operant and operand resources [53]. Operand resources such as all tangibles resources including the facilities and infrastructure-related properties are the ones on which an operation is performed to produce an effect. Operant resources including knowledge, skill, capabilities and all related intangible resources are employed to act on operand resources [10]. Integration of these resources enables the organizations to develop the service provision termed as "value-in use". As [52] pointed out, the exchange of knowledge and utilization of operant resources among members within the supply chain system enables co-created service offerings as well as value proposals for the end-users.

Apart from service-dominant logic, ***value ecology perspective*** is considered as a complementary approach for exploring the changing value dynamics in business environments. Ecology is a term, which is widely used in the understanding of the ecosystems and interconnected structure of the networks existing in ecosystems. By referring to ecology concept, [3: 108] highlighted that it is critical to understand the ecologies a company's products belong to. Performance is not just determined by the company but also by the performance of the ecology or web it belongs to. Similar to service-dominant logic, value ecology perspective mainly focuses on the value created through the integration of various actors within the specific ecosystem. According to the value creating ecology perspective, the firms are considered as constellations which are basically dynamic and where the value flow is multi-directional including many clusters of networks [16]. This perspective fits well with the service dominant logic and ecosystem approach since they both focus on the existence of many clusters, value flows and co-creation of value within different ecosystems. [16] discussed the shift from value chain to value creating ecology by highlighting the main limitations of a traditional value chain concept. These are mainly mentioned as: (1) value chain is isolated and ignores the environment of the businesses as well as the many other factors that are important catalysts for the chain [46], (2) value chain mainly focuses on the product neglecting the main externalities such as product value derived from the relationship of the product to a system or other products [59], (3) value chain is rather static rather than dynamic. By supporting this view, [23] identified value web concept by referring to the more complex systems of supply chains. They criticized the value chain concept since the value is created not only within firms but also in the rich interactions between many firms and linear sequences of activities are supplemented by more iterative and innovation-oriented collaborations. Such value webs are equipped with complex, connected, interdependent relationships and knowledge flows, learning and collaboration are as important as product flows, controls, and coordination.

Although many different concepts such as "value shop" or "value network" [50] or "value soup" [28] are discussed by various academicians, [16] suggested "value-creating ecology" perspective by focusing on the ecosystem-based nature of todays networks, namely the supply chains. They also discussed the main shift from traditional value chain to value ecology by highlighting the main components as: (1) from consumers to co-creators of value, (2) from product value to network value and (3) from simple co-operation or competition to complex co-opetition. According to the both approaches studied in this study, namely the service-dominant logic and value ecology, the shift from traditional supply chain systems to the evolving supply chain ecosystem structures is depicted in Table 1.

As seen from Table 1, the environment focus is mainly on the ecosystem rather than only the market or industry. While traditional systems mainly focus on the consumers, ecosystem-wide approach considers all stakeholders involved in the ecosystem. As an important component discussed in both approaches, value creation does not only occur in a step-by-step basis, but also emphasizes a holistic approach incorporating the needs and the requirements of the whole ecosystem. While strategic alliances and networks are mostly common in traditional systems, co-opetition is the new approach to be taken for the survival of the ecosystems. Although less transparent flow of information is mainly the basic form of information transfer between the parties, it is expected to have improved information sharing across the ecosystem so that related parties may be informed regarding any resources needed or common strategies to be followed. As the main resource approach, it is widely accepted that modern supply chain systems and the ecosystems need to share their both operant and operand resources rather than defending and guarding them. When the strategic vision of the system is considered, service-dominant logic perspective where the value in-use is shared and increased exchange of information is highly considered as the main approach as well as the well being of the whole ecosystem.

Table 1. Changing Terminology From Traditional Supply Chains to Supply Chain Ecosystems

Main elements	**Traditional supply chain**	**Value chain**	**Value ecology**	**Supply chain ecosystem**
Environment	Market/industry	Market/industry	Value creating ecology	Ecosystem
Environment status	Static/stable	Static/stable	Chaotic/uncertain	Chaotic/uncertain
Customers	Consumers	Consumers	Consumers, suppliers, competitors etc.	Ecosystem-aware stakeholders
Value creation	Limited emphasis on value creation	Emphasizes a value creation approach which adds value at every node	Emphasizes a holistic approach to value creation throughout the ecosystem	Co-created ecosystem value
Partnership	Strategic alliances/networks	Strategic alliances/networks	Co-opetition	Co-opetition and win-win
Risk	Low	Medium	High	High
Profit focus	Increase own profits	Increase own profits	Increase ecosystem profits	Increase ecosystem profits
Cost focus	Minimize own cost	Optimize own cost	Share costs	Share costs
Information leverage	Within the enterprise	Within the enterprise	Across the ecosystem	Across the ecosystem
Resource approach	Defending	Guarding	Sharing	Flow of shared operant and operand resources
Time orientation	Short term	Long term	Long term	Long term
Long term vision and performance	High performance of the supply chain	High performance of the enterprise	High value creating system	Service-dominant logic and ecosystem wide survival
Key driver	Cost	Revenue	Knowledge	Well being of the whole ecosystem

Source: adapted from [2, 5, 7, 46]

In the light of changing concepts, patterns and environment-related conditions, supply chains pass through an evolutionary process where it becomes almost impossible to conduct an operation on its own and the main actions and activities are performed in a collaborative manner. In addition to collaboration, becoming partners as well as competitors for the activities in supply chain ecosystem may change and affect the philosophy and the system of the members so that emphasis should also be given to the resource utilization and sharing mechanisms. Hence, service-dominant logic perspective, which focuses on the importance of value creation concept and exchange of main operant resources as well as the value ecology perspective, is employed as the main philosophy that fits well with the requirements of evolving supply chain ecosystems.

CONCEPTUAL FRAMEWORK FOR SUPPLY CHAIN ECOSYSTEMS

The theoretical and empirical implications of ecosystems for value creation and capture have mainly been studied by scholars from management [1, 6, 20, 21, 37], and marketing disciplines [55]. Since ecosystems are composed of many organizations with various relationships, the management and the dynamics of the overall ecosystem is of paramount importance for scientific research. In addition, understanding the main parameters to follow the main dynamics of the market and achieving close relationships with customers and other members of the ecosystem is the basic subject of marketing discipline. Service-dominant logic paradigm as well as value creating ecology is considered as the basic thoughts to explore the supply chain ecosystems due to their main principles regarding value creation, resource utilization and relationships within the ecosystem. Since there are loosely connected networks of organizations within ecosystems interacting with each other in various forms and ways, main enablers and motivators that create such structure as well as the main actors should be considered. In the light of these, a conceptual framework incorporating both approaches to explain the main dynamics of supply chain ecosystem is suggested. Since business ecosystems are analogous with biological ecosystems, and the use of biological metaphors are applicable, same approach is used in structuring the basic components of the model such as biotic and abiotic factors, organisms etc. Figure 2 shows the conceptual framework including the basic components of supply chain ecosystem together with additional factors to be considered in the successful operation of a supply chain ecosystem.

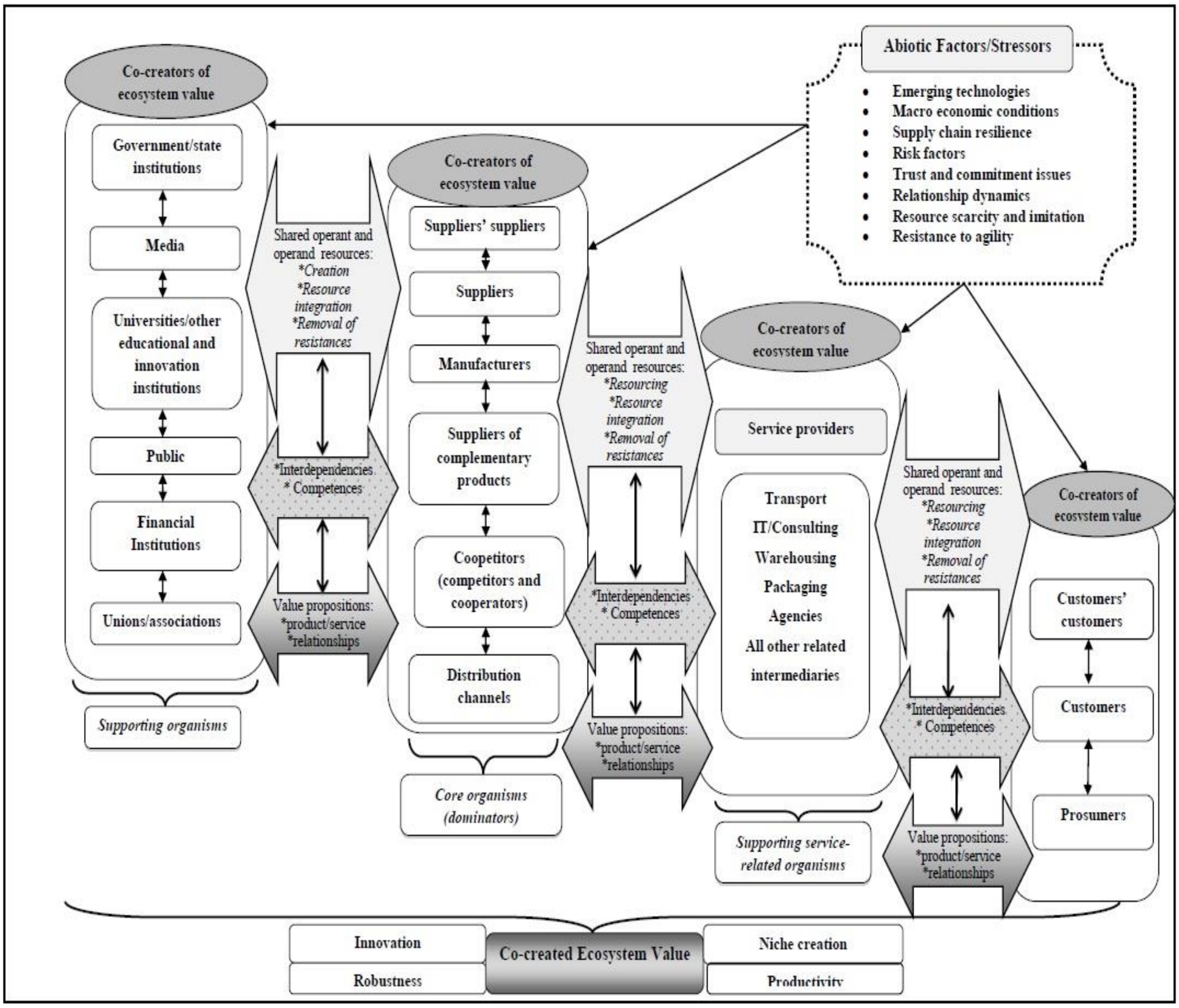

Figure 2. Conceptual Framework for Supply Chain Ecosystems

Biotic and Abiotic Factors

Taking a biological perspective, ecosystem is defined as any community where all living and non-living things that are existent and act together. These living and non-living things are classified as biotic and abiotic factors. Biotic factors are mainly the all-living organisms within an ecosystem such as plants, animals, fungi etc. On the other hand, abiotic factors (sunlight, salinity, nutrients etc.) are all of the non-living things within an ecosystem. Both factors are closely related to each other since any change in one of the factors can easily affect one of the organisms and the overall ecosystem as well. ***Biotic factors/actors*** in the conceptual framework of the study are the main organisms within the supply chain ecosystem and they are mainly divided into four groups as the supporting organisms (government/state institutions, media, universities and other educational institutions, public, financial institutions and related unions and associations), the core of the supply chain ecosystem (suppliers, manufacturers, suppliers of complementary products, coopetitors including partners and competitors and distribution channels), service providers/supporting organisms (transport, IT/consulting, warehousing, packaging, agencies and all related intermediaries) and lastly the customers including the end-customers and prosumers. Supporting organisms and the core of the supply chain ecosystem are also shown as the co-creators of ecosystem value since they are involved in the creation of ecosystem value by producing an output (service or product or both) mutually. Core of the supply chain ecosystem can also be viewed as dominators who strongly influence the development strategies within the ecosystem and orchestrate the activities related to the creation of ecosystem value as well as value propositions.

In addition to these actors, consumers and prosumers are included to the framework since service-dominant logic necessitates the consideration of end-users in the value co-creation process. Such co-creation may be considered in terms of co-production and customization, discontinuous innovation, brand co-creation, experience co-creation, consumer empowerment etc. [52]. Since four main groups of supply chain ecosystem are accepted as the main organisms existent in a typical supply chain ecosystem, they are classified as the biotic factors that are actually alive and have relations with each other. Abiotic factors (earthquakes, fires etc.) may vary among different ecosystems and they certainly have drastic effects on the related ecosystems. From a supply chain perspective, ***abiotic factors or stressors*** can be mainly mentioned as; emerging technologies, macroeconomic conditions, supply chain resilience, risk factors, trust and commitment issues, relationship dynamics, resource scarcity and imitation. More abiotic factors may also be considered depending on the dynamics of the supply chain ecosystem. Abiotic factors mainly influence organisms' ability to survive in the ecosystem. Since every organism can only survive within a certain range (tolerance range) of these factors, it is critical for organisms to understand their limits and interdependencies. Optimal range is the one where the organisms are connected to each other in a healthy ecosystem. Since each organism has a tolerance range for every abiotic factor, their resistance and durability play an important role in their survival. For instance, while manufacturing companies and suppliers cannot perform efficiently in the ecosystem where there is an increased level of resource scarcity (tolerance range for resource scarcity is low), this may not be that disruptive for some of the service providers. While some organisms have wide tolerance ranges, other organisms may have narrower ranges and organisms with broad tolerance ranges may occupy a greater space within the ecosystem. While big scale third party service providers may have broad tolerance ranges, small trucking or warehousing companies within the supply chain ecosystem may lack such high degrees of tolerance ranges.

Connectors

Some connectors depicting the need for mutual actions and activities link organisms in the supply chain ecosystem to each other. These connectors are basically ***shared operant and operand resources*** (creation, resource integration and removal of resistance), ***interdependencies and competences*** and ***value propositions.*** These components are also considered as the main pillars of service dominant logic and value creating ecology. As a very critical component that provides the mutual collaboration and cooperation between the related organisms in the supply chain is the ***shared operant and operand resource***. The main logic behind the use of "shared" is that not every organism in the ecosystem may prefer to dedicate all of its resources to another organism, however, they may prefer to share variety of the resources to some extent. Especially when the operand resources (plants, warehouses, vehicles etc.) are considered, it may not always be optimal and possible to share such resources with other organisms in the ecosystem. However, these operand resources can be shared especially when the organisms agree to share them to a certain extent. Service-dominant logic views operant resources as very critical resources to be utilized and shared with the related parties due to the increasing importance of skills, information exchange and effective relationships in todays supply chain systems and they are mostly dictated as more critical compared to operand resources. Moreover, it is emphasized that operand resources only become valuable through the use of operant resources. Both operant and operand resources are depicted as inputs in the value-creation process between the biotic actors in the supply chain ecosystem. In addition to the shared operand and operant resources, ***resource creation, resource integration and removal of resistance*** should also be discussed within the context of resources. Resourcing which includes creation, integration and removal of resistances takes place when a potential resource (mostly the operant resources) is applied and contributes to a specific benefit. Resource creation is related to the development of many resources, both operant and operand as a result of human ingenuity [30]. The second component, resource integration considers that organizations integrate various resources such as many competences, knowledge, skills and internal and external resources in order to perform better in the ecosystem wide operations. Thirdly, removal of resistances is about removing the main limitations that prevent resources from being useful. Not only organizations and service providers can strive to remove such resistances but also the customers and other stakeholders should put some effort to achieve According to [57], these resistances generally originate from negative attitudes that individuals or groups of individuals hold against a particular firm or industry that prevents businesses from making their resources available in the market.

The second connector is ***interdependencies and competences***. [1] dictated that ***interdependence*** is one of the main characteristics of ecosystems. Each ecosystem has a certain size as well as boundaries and the characteristics of each ecosystem have an important impact on the fates of the organisms within the ecosystems. As [20: 69] mentioned, "*each member of the ecosystem ultimately shares the fate of the network as a whole, regardless of that member's apparent strength''*. Since the interactions between the organisms in the ecosystem are bidirectional, many organisms actively participating in the activities are interdependent and also contribute to the value creation within the ecosystem. Such interdependencies may be achieved by flexible and transparent boundaries between the organizations. For instance ongoing projects for developing manufacturing systems or inventory programs between the supply chain department of a university and a manufacturing organization require interdependent relationships with continuous flow of information between the parties.

Apart from interdependencies, ***collaborative, absorptive and adaptive competences*** are the other components for achieving co-created ecosystem value. [29: 9] defined absorptive competence as; *"the ability of an organization to be able to comprehend from the external environment the important trends and know-how".* Then, the organization should be able to transform the main outcomes originating from the external environment to the critical resources. Collaborative competence helps the organizations in absorbing all related information and knowledge from the main sources as well as improving its absorptive competence. Adaptation is listed as one of the critical characteristics of ecosystems. Adaptive competence is basically adjusting itself to the changing circumstances. Through the development of collaborative competence, the organizations may consider partner firms as mechanisms for adapting to change brought about by complex and turbulent environments and improve their adaptive competence [29]. Application of such competences also determines the performance level of the ecosystem and every actor in the ecosystem must have the ability and the willingness to adapt and integrate resources and to co-create value [60].

The last connector that links the various organisms to each other with the aim of achieving co-created ecosystem value is the value proposition. It should be noted that the relevant organisms within the supply chain ecosystem should accept the value propositions. According to [53], organizations do not produce and/or deliver value; they can only propose value and in case the proposition is accepted, then the value is co-created together with the participation of related members, mainly the customers. Value proposition concept recognizes that the value includes benefits and costs that unfold as a service beneficiary such as a customer integrates the service-provider resources [53]. In accordance with service-dominant logic which views value propositions as value creation promises that are created by the firm alone or together with customers and other actors through resource integration [48] the resources, value propositions and the competences are connected to each other in the conceptual framework of the study.

According to [49], a service system is an arrangement of resources (including people, technology, information, etc.) connected to other systems by value propositions. Same approach can also be adapted to the supply chain ecosystems as suggested in the conceptual framework. Value propositions generated by different organisms within the supply chain ecosystem are basically dependent on the resources and the competences. Starting from the supporting organisms within the supply chain ecosystem to the end customers, value is proposed based on each organism's shared resources and competences. As shown in the framework, shared operant and operand resources, interdependencies, competences and the value propositions are mutually connected to each other from the very first organism to the last one in the supply chain ecosystem. Also, the framework suggests that value propositions occur in two basic forms as services and/or goods and relationships. While product-related value propositions depend on the characteristics of products (quality, customization, design etc.), service-related value propositions are mainly related to the characteristics of service (responsiveness, flexibility, reliability, courtesy, technical competence etc.). Although product and service related value propositions intensively take place between the core organisms, service providers and the end customers, they are also depicted between the supporting organisms and the core organisms. While service-related value propositions such as the financial support of financial institutions, know-how support of universities, marketing activities of media etc. gain more importance in terms of the value proposed to the core organisms, product-related value propositions can also be discussed between these parties to some extent. Apart from service and/or product related value propositions, relationship-related variables including image, trust, commitment, solidarity are critical in terms of achieving a successful fit between the organisms in the ecosystem. Moreover, competitive and cooperative relationships between the members of the ecosystem play a key role in the co-evolution of the overall ecosystem. As [35] argued, there are four stages in the development of business ecosystems as; birth, expansion, leadership, and self-renewal,or, if not self-renewal, death and although evolutionary stages blur over time, competitive and cooperative strategies and relations always remain valid and acceptable between the members of the supply chain ecosystem. It is suggested that only with the detailed investigation and understanding of these value propositions, the survival of the supply chain ecosystem without the negative impact of abiotic factors may be possible.

Co-created Ecosystem Value and Related Components

Since the organizations can offer their resources and collaboratively create value following acceptance but cannot create/deliver value alone [56], participation of many related organizations within the supply chain ecosystem is needed. As [20] discussed, it is compulsory to create value within the ecosystem to attract and retain customers as well as to provide growth potential for the ecosystem. In addition to the creation of value, ways of sharing the value within the ecosystem should be explored. As service-dominant logic view of value suggests; "*there is no value until an offering is used – experience and perception are essential to value determination*'' [54: 44]. This purports that any service or good offered by the supply chain ecosystem should be integrated with the resources of other organizations (mainly the core members of the supply chain such as manufacturers, suppliers, etc.) and other actor's resources (other members of the ecosystem such as universities, associations etc.). For instance, a personal computer can gain its value only through the integration of the manufacturer's production processes, raw materials supplier's processes, suppliers of complementary products, service providers' processes (innovative use of warehousing systems, application of JIT systems or on-time delivery systems) etc. as well as customers' own resources (special computer using skills) and the resources of other biotic actors within the supply chain ecosystem (government, state institutions, universities, public, financial institutions and related unions, associations). Following the main relationships between the organisms in the ecosystem as well as the main links and the components that connect them to each other, the main output of the ecosystem is suggested as the co-created ecosystem value. Each ecosystem has its own co-created ecosystem value and this value is the main trigger for achieving competitive advantage and differentiation in competition of various supply chain ecosystems. This view also supports the concept of "ecosystemic value" introduced by [7], which is multi-actor (individuals, firms, customers, and others) and multidimensional (social, cultural, and economic). Co-created ecosystem value should be in a form that provides favorable outcomes to the well being of the ecosystem and it needs to include some additional components and parameters to obtain an overall ecosystem value. Adapted from [7, 20, 37], these can be mainly mentioned as; productivity, robustness, niche creation and innovation generation. [20] tested the health of business ecosystems through the analysis of three dimensions as productivity, robustness, and niche creation. These dimensions are considered to accompany the co-created ecosystem value since they have a considerable share in the value created. While ***productivity*** is mainly about how innovations and raw materials are converted into products, lowered costs and functions with some parameters such as factor productivity (returns on invested capital) or delivery of innovations (time between the appearance of a technology and its distribution), ***robustness*** is defined as the ability to survive disruptions and unforeseen changes in the ecosystem. It can also be considered as the survival rates, predictability, agility can be categorized under the robustness concept. ***Niche creation*** is mainly the capability of the ecosystem to create new and valuable functions by fostering diversity and creating value. Main components of niche creation can be listed as growth in firm variety and growth in product and technical variety [20]. Since value is no longer considered as an economic equation, preferably views as a multilevel experience involving many actors in continuous interactions [41], niche creation requiring close relationships between the actors can be accepted as a very critical component of co-created value. ***Innovation*** is basically regarded as an important contribution to the co-created ecosystem value since successful innovations are key to an ecosystem's long-term survival. Business ecosystems are considered as the main triggers of innovation since strong and continuous interactions among the actors facilitate the generation of new opportunities through the exchange of mostly operant resources such as information, knowledge exchange, skills and competences. [37] argued that there are highly flexible producers and consumers who specialize in order to innovate so that when all members are truly dedicated to the generation of innovation, overall ecosystem gains strength by contributing enormously to its environment. [5] argued that the ecosystems adapt themselves in balancing life creation and innovation to the evolving conditions as nature does. Innovation diffusion is needed in supply chain ecosystems and this may include lowering the cost of producing, enabling the connection between the members and the new customers through novel ways of communication or increasing the value of output etc.

CONCLUSION

The relevant literature has largely ignored the investigation of supply chain ecosystems as a new phenomenon. This is mainly due to the fact that most studies have concentrated on individual organizations and their relations with other organizations rather than taking an ecosystemic view. In addition, literature review suggests that with the exception of a few studies, remarkably little attention has been given on exploring the creation of supply chain ecosystem value. Scholars specialized especially in marketing and management disciplines need to explore the value creation processes in supply chain ecosystems not only by focusing on the economic outcomes of the system but also through the investigation of the social issues such as cultural values, sustainability concerns, social relations etc.

The framework suggested according to service-dominant logic and value ecology perspectives encapsulates the main components of each perspective regarding how the supply chain ecosystems operate. Analogous to biological sciences, supply chain ecosystems consist of abiotic and biotic factors. As the living organisms in the ecosystems, biotic factors as "living organisms" play a key role in the survival of the ecosystem so that their activities, operations, facilities, relationships with other organisms, exchange of related resources should be integrated into the supply chain ecosystem model. Moreover, it would be myopic to evaluate the supply chain ecosystems without assessing the impacts of some stressors, namely the abiotic factors or stressors since they substantially influence the way the value propositions are conducted and ecosystem-wide strategies are established. Exchange of shared resources, value propositions and competences originate mainly from the service-dominant philosophy. Although it is mostly preferable and required to integrate all these components to any supply chain ecosystems, organization designs of each member of the supply chain ecosystem may differ and complicate such integration. Blurring edges between the members of the supply chain may ease such problems. Supply chain ecosystem mindset should be generated inside all the organisms that are habitant in that ecosystem to improve their level of commitment to value-creation as well as their desire for sharing the related resources between each other. The framework provides an output called “co-created ecosystem value” together with four components of robustness, productivity, innovation and niche creation. Apart from productivity, three components are related to becoming more proactive, strong and innovative in the operations of supply chain ecosystems. Focusing on productivity without considering these components would not reflect the actual outcome of co-created ecosystem value.

Only limitation for this study can be mentioned as the application of only two perspectives (service-dominant logic and value ecology) for the development of a conceptual framework. However, intersecting theories can also be employed for understanding the main dynamics of ecosystem value creation phenomena. There is room for further research that following the detailed understanding of the conceptual framework suggested in the study, various qualitative and quantitative studies can be conducted. In case of qualitative studies, one supply chain ecosystem can be selected and the main components in the framework can be explored through the use of qualitative interviews, focus groups or Delphi studies. Empirical research may also bring out considerable outcomes in order to reveal the relationships between the components of the framework. Supply chain ecosystems and members with different size and specialization can also be compared and similarities and the differences may be observed. In addition, further research should use an ecosystemic lens to understand how value is co-created through the existence of various biotic and abiotic factors within the ecosystem so that not only the individual organisms’ value propositions, value-creating activities or their contribution to the overall ecosystem value created is understood, but also the climate, way of acting together and value creating processes are discussed.

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INVESTIGATING SUPPLY CHAIN SUSTAINABILITY IN SOUTH AFRICAN ORGANISATIONS

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Abstract − The need for sustainable supply chain management has become a necessity given the growing impact of climate change and global warming. Given the limited literature on supply chain sustainability in South Africa, the main objective of this paper is to investigate the current sustainability reporting practices in supply chains of South African organisations. The focus is on the supply chain sustainability practices of organisations listed in selected sectors on the Johannesburg Stock Exchange (JSE). Data collected from sustainability and integrated annual reports of organisations in the sample are analysed using non-parametric statistical tests to compare sectors on the JSE and companies listed on the Socially Responsible Investment (SRI) Index with those that are not. The results show that there are differences in the supply chain and sustainability practices for the selected sectors and between SRI and non-SRI companies. South African organisations need to increase their focus on supply chain sustainability and further research is necessary to support and expand on the findings of this paper.

Keywords − Carbon Tax, Environmental Sustainability, Johannesburg Stock Exchange, Supply Chain Management, Sustainability Reporting.

INTRODUCTION

The trend towards sustainable practices is on the rise globally as governments, organisations and the public realise the increasingly negative environmental impact anthropogenic activities have on the environment [1]. Environmental issues have, therefore, become significant causes for concern around the world and the environmental dimension has become an integral aspect in organisational strategy, planning and operations. Supply chain members face increased environmental risk as a result of the effects of global warming and climate change, which have received escalating recognition and attention in recent years. Supply chains are under immense pressure from multiple stakeholder groups to seek solutions that positively impact both economic and environmental performance, and they are constantly developing, implementing and improving operations to ensure that they mitigate their negative environmental impact and are socially responsible [2]-[3].

Defining Sustainability

Sustainability is often implicitly defined with little international agreement on one concrete definition. Although the definitions for sustainability are often relatively vague, a number of themes emerge when defining sustainability that relate to maintaining economic prosperity and balanced population growth, meeting societal needs in addition to preserving natural resources and minimising negative environmental impacts [4]. From this, it can be deduced that sustainability relates to social well-being, financial success in meeting desired living standards and a healthy, balanced natural environment. For the purpose of this paper, sustainability is defined as the ability to meet current social, environmental and economic needs without negatively impacting the ability of future generations to meet their social, environmental and economic needs.

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Driving Forces for Sustainability in Supply Chains

Driving forces behind sustainable practices in organisations can either be because of individuals, groups or events inside the organisation; internal driving forces, or they can be due to individuals, groups or events outside of the organisation; external driving forces [5]. With regards to internal driving forces, there are a number of strategic drivers for sustainability including enhancing the reputation of the brand/ organisation, new market and product opportunities and aligning sustainable practices with overarching strategic objectives [6]. Forward thinking organisations see opportunities to create value and develop and maintain strategic competitive advantages through the development and implementation of supply chain sustainability [7].

Global warming and climate change are prominent external driving forces that make organisations address the negative impact their operations have on the natural environment. Rising fuel prices are driving sustainable practices in organisations as they find ways to minimise transport and utilise renewable energy in place of fossil fuels such as oil and coal [8]. The supply chain itself drives sustainable practices to develop efficiencies, minimise waste, and reduce costs and emissions in addition to supporting the sustainability objectives of other supply chain members including suppliers, distributors and sales agents such as retailers [9]-[10]. Higher levels of efficient and effective supply chain integration provide an additional incentive for organisations to implement environmentally conscious practices [7]. International and domestic regulation and legislation, such as the Kyoto Protocol and the carbon tax due for implementation in South Africa in 2016, force organisations to adopt sustainable practices to remain competitive, or in the case of the Johannesburg Stock Exchange, organisations must address environmental issues as part of the listing requirements [11].

South African Context

South Africa, as an economic leader on the African continent, is a member of the Kyoto Protocol and has planned to implement a carbon tax in 2016 [12]. This is a clear indication that the country is committed to making the transition from an energy-intensive economy to a low-carbon economy. Organisations should use the time remaining until the tax is in full effect, to develop and improve environmentally sustainable practices and begin emissions reduction programmes so that corrective adjustments can be made. The financial implications of the tax will place financial pressure on organisations as the tax rate will be R120 (equivalent to approximately US$9.23 or €8.00) per ton of carbon dioxide equivalent emissions [13]. It is imperative that companies focus on maximising the efficiency and effectiveness of their supply chain operations to minimise the future cost implications of the tax.

Johannesburg Stock Exchange

The Johannesburg Stock Exchange (JSE) was established in 1887 and is the largest stock exchange on the African continent. It is included in the top 20 largest stock exchanges globally based on market capitalisation. Listing requirements for the JSE stipulate that companies must follow the King III corporate governance code and should publish an annual integrated report. The integrated report represents a transformation of the separate annual financial and sustainability reports to provide a holistic overview of the companies' financial, social and environmental performance [14]. The Global Reporting Initiative (GRI) Sustainability Reporting Guidelines are the most used reporting guidelines in South Africa. The guidelines consist of 70 assessment criteria including both general indicators and sector specific indicators. The reason for the popularity of the GRI guidelines is because they can be used for any company, regardless of industry and size, and the assessment is comprehensive providing a standardised framework for companies to report their sustainability efforts and accomplishments to date [15].

Companies listed on the Main Board of the JSE have begun taking steps towards ensuring their operations are sustainable. The Main Board is responsible for most of the JSE's market capitalisation and consists of over 300 listed companies. Sectors on the Main Board include Basic Materials, Consumer Goods, Consumer

Services, Financials, Healthcare, Industrials, Oil & Gas, Technology and Telecommunications [11]. The sectors making up the majority of the JSE Main board include Financials, Basic Materials and Industrials, which is in line with the sectors driving the South African economy. Traditionally, the economy was driven by agriculture and mining operations, included in the Basic Materials sector; however, there has been a shift towards focusing on knowledge and service provision [16]. With the exception of the Financials sector, the sectors driving the economy are some of the most energy-intensive [17]. Organisations operating in these sectors need to ensure the efficiency and sustainability of their supply chains to ensure social, environmental and financial costs are minimised.

Moving Toward Sustainable Development

The JSE Socially Responsible Investment (SRI) Index, currently consisting of 82 constituents, was launched in 2004 to facilitate the management of listed companies' triple bottom line performance. The index provides a benchmark for organisations to compare and improve their current sustainability performance, and allows investors to base their analyses on a broader set of criteria [18]. According to a report compiled by the Carbon Disclosure Project (CDP), South African companies included in the JSE Top 100 are performing well with regards to sustainability reporting given that the CDP response rate for 2013 was 83%; the second highest response rate in the world. Roughly 70% of the JSE Top 100 companies are listed on the SRI Index. Disclosure in sustainability reports has improved in general, and there has also been an increase in the number of companies that have voluntarily set emissions reductions targets [19].

Sustainability reports are easily accessible and valuable sources of information when wanting to examine the supply chain and sustainability practices of organisations [20]. Although it appears that sustainability reporting efforts have improved, a study undertaken by KPMG found that the level of reporting on the impact of supply chains on sustainability is relatively low. It is imperative that organisations realise the potential of supply chains to do damage to the social and natural environment and also the potential to create and maintain sustainable business operations. By including supply chain issues and opportunities in transparent integrated reports companies will allow investors, consumers, the government and the general public to know how they are managing the complex challenges associated with adapting to global warming, increasing regulations and rising consumer pressure [21].

It is clear that the topic of supply chain sustainability has been researched thoroughly across the globe; however, less research has been done on the disclosure of sustainable supply chain management practices in sustainability reports, in particular for developing countries such as South Africa [22]. This paper aims to address this issue by investigating the current supply chain sustainability reporting practices of organisations listed on the Mainboard of the JSE. A comparison was done between sectors and between companies listed on the SRI Index and those that are not. The remainder of this paper is organised as follows. Section 2 is a detailed description of the research methodology that was used, followed by a discussion of the results and findings of the study. The final section presents the conclusions and implications for future research on this topic.

METHOD

As mentioned in the introduction, the primary purpose of this paper is to investigate the current supply chain sustainability reporting practices of organisations listed on the Mainboard of the JSE. As a result of the investigation into these practices, it is possible to determine the current level of awareness of and commitment to supply chain sustainability in South African organisations. The sustainability and integrated annual reports, available online on company websites, were content analysed providing the necessary data to investigate differences between sectors and SRI Index versus non-SRI Index companies.

Sampling Procedure & Data Collection

This study focused on South African organisations due to the fact that there is little previous research on supply chain sustainability in South Africa. The organisations listed on the Main Board of the JSE are some of the largest companies in South Africa and can be classified as market leaders in their sectors.

The sampling procedure that was utilised for this study began with the selection of all organisations listed on the Main Board of the JSE due to the online availability of their sustainability and integrated annual reports. The latest available reports for these organisations were downloaded from company websites during February 2015. For the majority of the reports (64%), the reporting year of 2014 was used as this was the most recent reporting period where complete reports were available. However, the most recent reporting period for 32% of the companies included was 2013, and the most recent reporting period for the remaining 4% of companies was 2012. Companies whose operations are based overseas were excluded from the study in addition to companies that did not have reports available from 2012 to 2014. After performing initial statistical analyses, five of the sectors were found to have insufficient data producing insignificant results. To ensure the reliability of the results, it was decided that only energy intensive sectors with sufficient data to produce significant results would be included in the final analyses. The total sample size for the final analyses was 155 companies. Table 1 presents the sectors, their inclusion/ exclusion from the study and the reason for their inclusion/ exclusion.

Table 11: Sector Inclusion/ Exclusion

Sector	Number of companies	Included/ Excluded	Reason
Basic Materials	52	Included	Significant data, energy intensive
Industrials	59	Included	Significant data, energy intensive
Retailers	24	Included	Significant data, energy intensive
Consumer Goods	20	Included	Significant data, energy intensive
Financials	79	Excluded	Significant data, non-energy intensive
Other Consumer Services	13	Excluded	Insignificant data
Technology	8	Excluded	Insignificant data
Healthcare	8	Excluded	Insignificant data
Oil &Gas	3	Excluded	Insignificant data
Telecommunications	3	Excluded	Insignificant data

Data Analysis Techniques

There were two phases of analysis for this study. The first phase was content analysis using NVivo 10 Software and the second phase consisted of non-parametric statistical analyses using Statistica. To perform the content analysis, a total of 32 keywords were identified relating to supply chain management and sustainability as shown in Table 2.

Table 12: Key Words Relating to Supply Chain Management & Sustainability

Supply Chain Key Words	Sustainability Key Words
Inventory	Carbon Emissions
Logistics	Carbon Footprint
Packaging	Carbon Tax
Procurement	Energy
Recycling	Energy Conservation
Refurbishment	Energy Efficiency

Remanufacturing	Environmental Management
Reverse Logistics	Environmental Performance Indicators
Sourcing	Global Reporting Initiative
Supply Chain	GRI
Supply Chain Management	International Organisation for Standardisation
Transportation	ISO
Warehousing	ISO 14001
	ISO 14001 Certification
	Renewable Energy
	Sustainability
	Sustainability Framework
	Sustainability Metrics
	Triple Bottom Line

The NVivo 10 software located the keywords in the reports and counted how many times each word/ phrase was mentioned, in addition to highlighting the sentences containing the keywords to provide context. The keyword frequencies obtained in the content analysis were utilised as the data inputs for the statistical analyses performed using Statistica. Key words with less than 10 observations were excluded from the statistical analyses. Due to the fact that the data had a skewed distribution, non-parametric statistical tests were utilised to determine the significance of the data at a 5% level of significance. The Mann-Whitney U test was used to compare the differences in reporting between companies that are part of the SRI Index and companies that are not. The Kruskal-Wallis test was used to compare the differences in reporting between the different sectors.

RESULTS DISCUSSION

Descriptive Statistics

As shown in Table 3, it is clear that supply chain related key words are included in most of the sustainability and integrated annual reports. The concepts of inventory, procurement, supply chain and logistics are mentioned by at least 68% of the companies included in the study. The concepts logistics, procurement, supply chain, inventory and packaging are the supply-chain related terms mentioned most frequently in the study. Remanufacturing and reverse logistics were the concepts with the lowest observations and the smallest frequencies. They were excluded from further analyses for having less than 10 observations.

Table 13: Supply Chain Descriptive Statistics

Supply Chain Key Words	Number of Companies	Frequency
Inventory	124	941
Logistics	106	1078
Packaging	69	887
Procurement	123	1077
Recycling	93	551
Refurbishment	25	76
Remanufacturing	3	11
Reverse Logistics	3	7
Sourcing	78	307
Supply Chain	107	1001
Supply Chain Management	39	89
Transportation	57	170
Warehousing	44	124

It appears that there is a larger range in the number of observations for sustainability related key words when compared with supply chain related key words. As shown in Table 4, the concepts of energy and sustainability have the highest number of observations and the highest frequencies by a large margin. Sustainability is discussed by 97% of companies included in the study and is mentioned over 5000 times, whilst energy is discussed by 90% of companies and is mentioned over 3000 times. Other concepts mentioned frequently include GRI, ISO, environmental management, carbon footprint and renewable energy. International Organisation for Standardisation, sustainability framework, sustainability metrics and ISO 14001 certification were the sustainability related concepts with the lowest observations and the smallest frequencies. They were excluded from further analyses for having less than 10 observations.

Table 14: Sustainability Descriptive Statistics

Sustainability Key Words	**Number of Companies**	**Frequency**
Carbon Emissions	61	176
Carbon Footprint	83	285
Carbon Tax	34	115
Energy	139	3144
Energy Conservation	10	13
Energy Efficiency	30	79
Environmental Management	90	400
Sustainability Key Words (continued)	**Number of Companies**	**Frequency**
Environmental Performance Indicators	10	11
Global Reporting Initiative	75	165
GRI	77	466
International Organisation for Standardisation	9	10
ISO	86	453
ISO 14001	47	151
ISO 14001 Certification	3	6
Renewable Energy	45	240
Sustainability	150	5044
Sustainability Framework	7	10
Sustainability Metrics	2	9
Triple Bottom Line	14	24

Kruskal-Wallis Test: Sector Comparison

Table 5 displays the results of the Kruskal-Wallis test to determine whether there is a significant difference between the mean frequencies of the selected sectors. When there were fewer than five observations, no mean frequency was calculated resulting in the display of not applicable (NA). The results show that the mean frequencies for the majority of the key words did not have significant differences between the sectors. Procurement, sourcing and supply chain were the supply chain related key words with significant differences in the mean frequencies of the sectors, and energy, Global Reporting Initiative and ISO were the sustainability related key words with significant differences in the mean frequencies of the sectors. All of these key words had p-values of less than 0.01 except for Global Reporting Initiative, which had a p-value of 0.04.

Table 15. Sector Comparison: Kruskal-Wallis Test Results

Variable	Kruskal-Wallis: p-value	Sector Mean Frequencies			
		Basic Materials	Industrials	Consumer Goods	Retailers
Inventory	0.0501	8.842	5.408	7.188	10.714
Logistics	0.1000	3.966	16.317	11.588	5.105
Packaging	0.2500	17.357	15.815	9.375	5.583
Procurement	0.0000	8.795	6.978	14.947	6.789
Recycling	0.6000	6.000	6.657	4.800	4.714
Refurbishment	0.6600	3.000	1.500	2.400	4.250
Sourcing	0.0000	1.909	2.000	6.857	6.250
Supply Chain	0.0000	7.414	6.857	12.438	14.950
Supply Chain Management	0.8000	2.818	2.308	2.000	1.714
Transportation	0.2800	2.700	4.087	1.200	1.778
Warehousing	0.2300	1.875	3.000	1.375	4.750
Carbon Emissions	0.9200	3.056	2.850	2.786	2.778
Carbon Footprint	0.2200	2.560	3.138	4.857	4.133
Carbon Tax	0.3800	NA	NA	NA	NA
Energy	0.0000	36.630	15.760	21.053	11.292
Energy Conservation	0.4100	1.600	1.000	NA	1.000
Energy Efficiency	0.7200	3.182	1.667	1.800	4.000
Environmental Management	0.1600	5.500	3.536	3.467	2.333
Environmental Performance Indicators	0.4700	1.000	NA	1.250	1.000
Global Reporting Initiative	0.0400	2.680	2.143	1.833	1.600
GRI	0.4800	7.500	5.393	5.500	4.000
ISO	0.0000	4.586	6.057	6.600	1.286
ISO 14001	0.6100	3.000	3.632	2.778	NA
Variable (continued)	**Kruskal-Wallis: p-value**	**Sector Mean Frequencies**			
		Basic Materials	**Industrials**	**Consumer Goods**	**Retailers**
Renewable Energy	0.4700	3.571	6.455	6.429	1.500
Sustainability	0.3500	35.388	32.561	37.150	29.625
Triple Bottom Line	0.4700	1.833	2.000	1.000	NA

With regards to the significant supply chain related concepts consumer goods and retailers were the sectors with the highest mean frequencies. The Consumer Goods sector had the highest mean frequency for procurement at 14.947 and for sourcing at 6.857, whilst Retailers had the highest mean frequency for supply chain at 14.950. With regards to the significant sustainability related concepts the basic materials sector had the highest mean frequencies on average. Basic Materials had the highest mean frequency for energy at 36.630 and also for Global Reporting Initiative at 2.680. For the concept ISO, Consumer Goods had the highest mean frequency at 6.600.

Table 6 shows the only significant differences in the mean frequencies of key words between sectors. For the key word supply chain, the Industrials sector has a lower mean frequency at 6.857 compared to the Consumer Goods sector at 12.438 and Retailers at 14.950. The Industrials sector also has a significantly lower mean frequency at 5.408 compared to the Retail sector at 10.714 for inventory. The Consumer Goods sector has a significantly higher mean frequency at 14.947 for procurement compared with the Industrials sector at 6.978

and the Retail sector at 6.789. With regards to sourcing, the Retail sector has a significantly higher mean frequency at 6.250 compared to Basic Materials at 1.909 and Industrials at 2.000. Energy and ISO were the only sustainability related key words to have significant differences between some of the sectors. Basic Materials had a significantly higher mean frequency for energy at 36.630 when compared with the Industrials sector at 15.760. For the key word ISO, there were significant differences in mean frequencies between all of the sectors. The Retail sector had the lowest mean frequency at 1.286 compared with Basic Materials at 4.586, Industrials at 6.057 and Consumer Goods at 6.600.

Table 16: Significant Differences Between Sectors

Variable	Sector 1	Sector 2	Kruskal-Wallis p-value
Supply Chain	Industrials	Consumer Goods	0.016696
Supply Chain	Industrials	Retailers	0.000319
Inventory	Industrials	Retailers	0.042842
Procurement	Industrials	Consumer Goods	0.007883
Procurement	Retailers	Consumer Goods	0.024183
Sourcing	Basic Materials	Retailers	0.003282
Sourcing	Industrials	Retailers	0.003403
Energy	Industrials	Basic Materials	0.023456
ISO	Retailers	Basic Materials	0.032956
ISO	Retailers	Industrials	0.004645
ISO	Retailers	Consumer Goods	0.010786

These results show that consumer goods manufacturers and retailers are giving critical consideration to their sourcing/ procurement activities to minimise input costs and are considering the impact of the supply chain on their operations. It is logical that the Basic Materials sector would have the highest focus on energy due to the energy intensive nature of their operations and the extensive listing requirements for mining companies included in the sector. These results also show that the Retail sector is less concerned with energy and international standards such as ISO when compared with the other sectors.

Mann-Whitney U Test: SRI Index vs Non-SRI Index

Table 6 displays the results of the Mann-Whitney U Test to determine whether there is a significant difference between the mean frequencies of SRI Index companies and Non-SRI Index companies. When there were fewer than five observations, no mean frequency was calculated resulting in the display of NA. The results show that the mean frequencies for the majority of the key words did not have significant differences between SRI Index and Non-SRI Index companies. Procurement, recycling and supply chain were the supply chain related key words with significant differences in the mean frequencies between SRI Index and Non-SRI Index companies, and energy, environmental management and sustainability are the sustainability related key words with significant differences in the mean frequencies between SRI Index and Non-SRI Index companies. Recycling, supply chain, energy and sustainability all had p-values of less than 0.01, procurement had a p-value of 0.0219 and environmental management had a p-value of 0.0121.

Table 17: SRI Index Comparison: Mann-Whitney U Test Results

Variable	Mann-Whitney U Test: p-value	SRI Index Mean Frequency	Non-SRI Index Mean Frequency
Inventory	0.3429	7.744	7.506
Logistics	0.1058	14.769	7.493
Packaging	0.8872	18.793	8.550
Procurement	0.0219	10.894	7.434
Recycling	0.0013	7.000	5.246

Refurbishment	0.6120	2.667	3.385
Sourcing	0.1843	5.788	2.578
Supply Chain	0.0000	14.581	5.844
Supply Chain Management	0.6345	2.313	2.261
Transportation	0.8007	3.167	2.849
Warehousing	0.6346	3.000	2.680
Carbon Emissions	0.5332	2.839	2.933
Carbon Footprint	0.9208	3.314	3.521
Carbon Tax	0.2543	3.950	2.571
Energy	0.0000	32.140	17.270
Energy Conservation	0.4161	NA	NA
Energy Efficiency	0.8858	2.474	2.909
Environmental Management	0.0121	6.194	3.525
Environmental Performance Indicators	0.4237	1.000	1.200
Global Reporting Initiative	0.3897	2.242	2.167
GRI	0.2357	7.469	5.044
ISO	0.9042	5.088	5.385
ISO 14001	0.6036	3.417	3.000
Renewable Energy	0.1669	6.750	4.200
Sustainability	0.0000	50.820	25.030
Triple Bottom Line	0.3354	NA	NA

SRI Index companies had significantly higher mean frequencies than Non-SRI Index companies for all of the significant key words. The mean frequency for procurement for SRI Index companies is 10.894 compared with 7.434 for Non-SRI Index companies, and for recycling for SRI Index companies the mean frequency is 7 compared with 5.246 for Non-SRI Index companies. The difference in mean frequency for supply is large at 14.581 for SRI Index companies compared with 5.844 for Non-SRI Index companies. For the significant sustainability related key words, the mean frequencies for Non-SRI Index companies are roughly half of those for the SRI Index companies. This is in line with the fact that SRI Index companies have an obligation to ensure that they maintain a high level of social and environmental performance. To illustrate this, the mean frequency for energy for SRI Index companies is 32.140 compared with 17.270 for Non-SRI Index companies. The mean frequency for environmental management for SRI Index companies is 6.194 compared with 3.525 for Non-SRI Index companies. The greatest difference in mean frequencies is for sustainability with SRI Index companies at 50.820 and Non-SRI Index companies at 25.030. From the results, it is clear that SRI Index companies discuss supply chain and sustainability related concepts more than Non-SRI Index companies.

CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

It is evident from the results of this study that the majority of the companies included in the sample mention supply chain and sustainability concepts; however, there were no significant differences between sectors for the majority of the key words. The most frequently mentioned supply chain concepts were logistics, procurement and supply chain, which is a positive indication that organisations are considering the impact of their supply chain operations with a particular focus on sourcing and procurement practices. The Consumer Goods and Retail sectors had significantly higher mean frequencies than the Industrials and Basic Materials sectors for supply chain related concepts including supply chain, inventory, procurement and sourcing. Energy and sustainability were mentioned most frequently of all of the concepts; however, there was no significant difference in the mention of sustainability between sectors. Basic Materials and the Industrials sector had significantly higher mean frequencies for the sustainability related terms energy and ISO. When comparing

SRI Index companies and Non-SRI Index companies, it is clear that there were no significant differences for the majority of the key words. The concepts that produced significant results include procurement, recycling, supply chain, energy, environmental management and sustainability, and the SRI Index companies had significantly higher mean frequencies for all of these concepts.

It is important to note that although supply chain and sustainability concepts are discussed in sustainability and integrated annual reports, there is limited discussion on important sustainable supply chain concepts such as reverse logistics, refurbishment and remanufacturing. These practices can facilitate organisations in reducing emissions, mitigating negative environmental impacts and minimising costs. There was also limited discussion on carbon emissions, carbon footprints and the impending carbon tax. This is a cause for concern as organisations need to begin managing and reducing their carbon footprints and greenhouse gas emissions to mitigate the financial impact of the carbon tax. South African organisations need to increase their focus on sustainable supply chain practices particularly given the current economic climate and the global shift towards sustainable development.

Further research on this topic is warranted to support the findings of this paper. It would be beneficial to include all sectors of the economy to produce more generalizable results and the cooperation of privately owned companies is necessary to gather enough data to achieve a significant number of observations. Performing qualitative research in the form of in-depth interviews and focus groups with relevant industry members would provide detailed information on the exact nature of supply chain operations and the extent to which sustainable practices are implemented. Gaining further industry support in the form of participation in online questionnaires would provide further details from a larger sample thus producing more generalizable results. Given the relatively low level of discussion on concepts relating to carbon emissions and the impending implementation of the carbon tax in South Africa, further investigation into the preparation efforts of companies to reduce their emissions/ footprint and mitigate the impact of the tax is necessary.

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A STUDY ON SUPPLY CHAIN MANAGEMENT AND FREIGHT VILLAGE PRACTICES IN TIRE CLUSTERING FORMATION IN KOCAELİ REGION

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Abstract – Since the turn of century, the concept of clustering has become a central theme for analysing the competitiveness of nations, industries and spesific locations. Because, there are strong indications in Europe that, with clustering relationships both region's economy develops and wages of employed people increase more to the otherwise cases. Therefore, the cluster concept can also be usefully applied to study of clustering of tire manufacturing environment activities. Due to ongoing internationalization in these industries, the concentration of tire manufacturing activities in clustering type formations is likely to increase in near future for many valid reasons. Tire manufacturing processes, such as procurement of raw materials via seaport, transferring to firms through road and train services, manufacturing and distributing the finished goods to dealers and distributers, are clearly geographically concentrated in Kocaeli region of the country. With this paper, our aim is, also, to demonstrate whether Kocaeli tire manufacturing location which is the hearth of Turkish tire sector, is a sub-clustering sector of Turkish automotive sector. Hence, this purpose leads to two important research questions that complement each other: Is Kocaeli, geographically a tire manufacturing cluster environment? And what factors influence the development of "Supply chain management", "Logistics activities development" and "Additional value development" in such a potential cluster?. Therefore, this research study aims to identify joint economics or characteristics that regional competitiveness can be constructed on further policy decisions. In relation to this goal, a conceptual framework for the tire industry was proposed. Being the first generic model, it also allows the empirical application as a clustering case study in Kocaeli. In this part of the study, both qualitative and quantitative studies were employed in finding out the implications of three important orientations' on industry performance with a clustering perspective. Based on research findings, it is shown that cluster structure features exist in the region and it is beneficial for the regions's additional competitiveness. This paper's main contributions to the literature could be presented as being the first study in Turkish tire sector with a clustering perspective, in addition to the novelty that it brought to a tire clustering study with a multitude of parameters' perspectives.

Keywords *– Clustering, Freight Village, Supply Chain Management, Tire Sector*

1. INTRODUCTION

The idea of regional competitiveness that can be provided with the acceptance of notion of networks has been accepted with the Porter's (1990) insight. Since then, it entered into the agenda of all nations. In the

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same article, author claims that, cluster concept represents a new way of thinking about the economy and emphasizes the importance of enhancing formal and informal ties across companies, governments and related institutions. This approach is gaining new dimensions with increasing importance, with new additions in terms of main purpose and mechanisms. Clusters are defined by the co-location of producers, suppliers, services providers, educational and research institutions, financial institutions and other private and government institutions related through linkages of different types. Throughout the years, the concept of cluster has gained various meanings in terms of content and mechanisms. A brief history of the cluster transformation is given in Table.1. Therefore, there is a considerable diversity among clusters. They differ in terms of their stage of development, also, along the cluster life cycle; some are networks of SMEs, some are organized around key anchor firms, and yet others have developed around universities. In the new economy, regions that do not specialize may be in danger of falling behind in competition. Clusters can be part of what makes a region prosperous but, they are not the only explanation for competitive advantages. The presence and depth of clusters in a regional economy is one aspect of the overall business environments that companies face in the location. In addition to that, factor conditions, the context for rivalry, and demand conditions are other aspects that have to be considered. Clusters are more likely to emerge, prosper, and survive where these conditions support high productivity and innovation. Although the cluster model is seen as a tool for promoting competitiveness, innovation and growth, there are concerns regarding difficulties in conceptualizing the definition of the cluster concept, theorization, empirics, benefits, advantages and its use in policymaking (Martin & Sunley, 2003).

Table.1 Grouping and Summarizing of Cluster Definitions

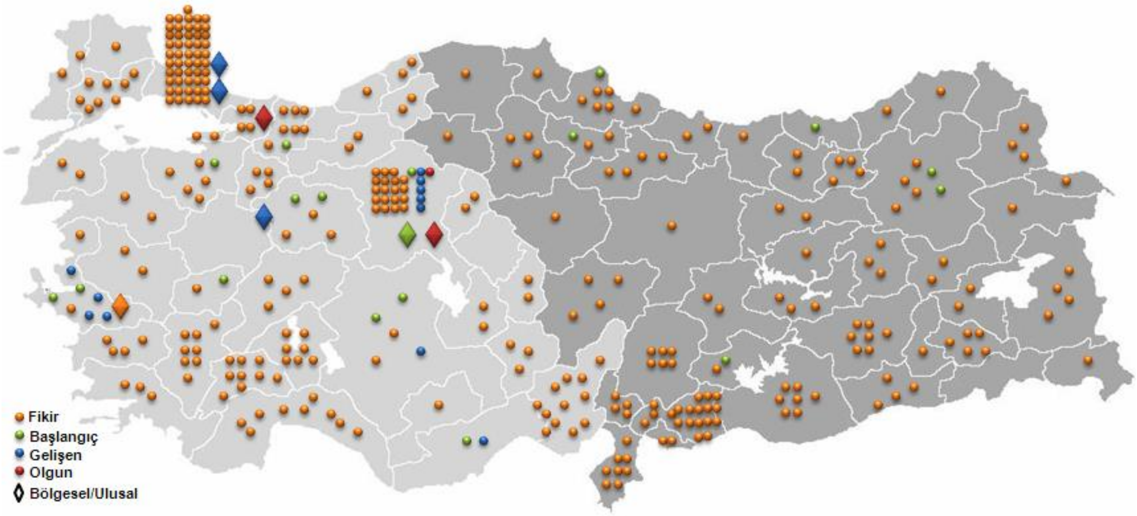
Approaches	Definitions	Authors
Geographical Approach	"Clusters are groups of companies and institutions co-located in a specific geographic region and linked by interdependencies in providing a related group of products and/or services […]"	Ketels (2003a)
	The more general concept of 'cluster' suggests […] a tendency for firms in similar types of business to locate close together."	Crouch and Farrell (2001)
	"Geographic concentration of competitive firms or establishments in the same industry that either have close buy-sell relationships with other industries in the region, use common technologies or share a specialized labour pool […]."	Hill and Brennan (2000)
	"Clusters are geographic concentrations of interconnected companies and institutions in a particular field […]."	Porter (1998)
	"A cluster means a large group of firms in related industries at a particular location."	Swann and Prevezer (1998)
	"A regional cluster is an industrial cluster in which member firms are in close proximity to each other."	Enright (1996)
	"Clusters are defined as groups of firms within one industry based in one geographical area."	Swann and Prevezer (1996)
	"Geographical concentrations of industries that gain performance advantages through co-location."	Doeringer and Terkla (1995)
Social Networks Approach	"In its broadest sense, a cluster is defined by systemic relationships among firms and organizations in a general region based on common needs for nearby goods and knowledge".	Rosenfeld (2005)
	"The popular term cluster is most closely related to local or regional dimension of networks [...]. Most definitions share the notion of clusters as localised networks of specialised organisations, whose production processes are closely linked through the exchange of goods, services and/ or knowledge."	van den Berg, Braun and van Winden (2001)
	Industry Cluster: may be defined very generally as a group of business enterprises and non-business organizations for whom membership within the group is an important element of each member firm's individual competitiveness."	Bergman and Feser (1999)
	"Clusters can be characterized as networks of producers of strongly interdependent firms (including specialized suppliers) linked each other in a value-adding production chain."	Roelandt and den Hertog (1999)
	"We define an innovative cluster as a large number of interconnected industrial and/ or service companies having a high degree of collaboration, typically through a supply chain, and operating under the same market conditions."	Simmie and Sennett (1999)
	"Clusters encompass an array of linked industries and other entities	Porter (1998)

	important to competition. […] Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. Finally, many clusters include governmental and other institutions […].”	
	An ‘innovative milieu’ is a “complex which is capable of initiating a synergetic process […] an organization, a complex system made up of economic and technological interdependencies […] a coherent whole in which a territorial production system, a technical culture, and protagonists are linked.”	Maillat (1991)

Related studies, especially, gained a strong momentum with the entry of 2000’s. In line with this goal, various studies have been started in Europe and in Turkey, almost, concurrently. With the publication of a Green Paper on future perspectives for the European Research Area (http://ec.europa.eu/research/era), the Commission has launched a complementary debate on the fragmentation of research activities in Europe. Since then, clusters have become an important part of the European economic reality. It can be assumed that roughly 38% of all European employees work in enterprises that are part of the cluster sector. In some regions, this share goes up to over 50% while in others it drops to 25%. About one fifth (21%) of these employees are employed in regions that are more than twice as specialized in a particular cluster category as the average region (www.clusterobservatory.eu.). To date, the “European Cluster Observatory” has identified more than 2000 regional clusters in Europe. Automotive sector is an example of a cluster category in which Europe shows clear regional specialization. Automotive clusters, including cars, buses and truck assembly, engines and other components, are an area where Europe is among the strongest regions in the world economy. This success builds on a network of 39 regional clusters (out of a total of 259 regions) that account for more than 50% of all European employment in the category. East and south Marmara region of Turkey is also among the most important regional automotive clusters of Europe.

In considering the progress of clusters in Turkey, also, as mentioned earlier, various studies have been realized by researching of various aspects of the clustering formation since 2000. Early studies that focus on manufacturing clusters in Turkey reveal that firms are localized in four metropolitan areas (Istanbul, Izmir, Ankara and Adana) and that these four regions make up nearly 73% of the total manufacturing labour force (Eraydın, 2002). Eraydın showed, in addition to these four main geographic dispersions of the industry centres in Turkey, emerging industrial localities around Ankara (Yozgat, Çankırı, Çorum, Niğde, Nevşehir, and Kırşehir) and regional industry centres as Kayseri, Gaziantep, Konya, Samsun and Eskişehir. Akgüngör (2006), using a meso-level application, a term adopted by the Organization for Economic Cooperation and Development (OECD), investigated the manufacturing sectors in Turkey, such that offers tools to identify key industries mostly using input/output-based methodologies. Study shows the identified clusters in Turkey’s manufacturing industry, by using the number of establishments and employment with percentage change during the period of 1996-2000 (Akgüngör, 2006). It is noteworthy to mention that, analysis does not show any clustering of automobile and related supplying industries’ results, probably, due to the period of data utilized and/or absence of investments to the sector, during the time of study.

In 2011, with a joint collaboration of Development and Economy Ministries, a general survey has been conducted countrywise in order to determine clusters/potential clusters via 26 Regional development agencies. The main purpose was to provide input to the URGE (Uluslararası Rekabetçiliğin Geliştirilmesi) project for increasing the competitiveness of SMEs. According to the analyses of survey results, 356 clusters/potential clusters have been obtained. While 331 of them are in idea stage, the remainning 35 were rated as being in the starting, developing ang maturation phases. Three cluster were spesifically rated as in maturing state. These three clusters were belong to “software, defense industry and vehicle spare parts industry”. During the preparation of survey questions, SWOT and Porter’s Diamand analyses have been utilised (T.C. Ekonomi Bakanlığı, 2012). Figure 1. shows the distribution of all of those clusters/potential clusters. There has not been seen any tire related cluster study among the 356 clusters/potential clusters.



Source: T.C. Ekonomi Bakanlığı, 2012**.**
Figure.1 Turkish General Clustering Identification Map

This paper will adress a range of spesific processes and topics including; tire clustering formation, cluster type of supply chain relations, logistical activities with an approach of freight village and some tire industry- spesific value-adding activities that may not be covered by previously mentioned themes. Naturally, it intends to build up upon what we already know with respect to industry clusters in Turkey, by adding new contributions to them. There are three empirical contributions of the research in addition to developing a theoretical framework for the industry;

- Tire sector, to best of our literature knowledge has not been studied as an industrial cluster including above mentioned orientations, so far. Therefore, this constitutes a novel attempt to shed light to Kocaeli tire location as a potential clustering formation. If results proves this hypothesis, clearly, more developed mechanisms for approaching to the economic competitiveness of the area would be needed though it is not subject of this study. For this reason, cluster assesment will take place to understand if existing tire firms are, already, embedded in a local cluster. This will also set out the main goal of the study.
- Adapazarı, Kocaeli, Bursa and eastern part of İstanbul is, already, an important location of clustering for Turkish automotive industry. With this research we, also, aim to support the hypothesis that; the most successful regions tend to have a portfolio of clusters related through linkages to each other. Thereby, Kocaeli tire clustering formation is the most potential one for such a structure in the mentioned automobile clustering location, namely, being a potential sub-clustering of automobile sector.
- The third contribution of the study is that, the identification and measurement of "relationship level" which is essential for hidden cluster networks including three orientations. They also facilitate information and knowledge transfer which is a pre-condition of a successful and competitive cluster. So, willingness and ability to create such cluster formation that allows for information and knowledge transfer across firms and institutions, in addition to the formal business relationships, will be searched. The assumed linkages among the tire clustering formation will be searched with respect to a mix of "supply chain development", "logistics village existence" and "additional value development" perspectives. To our best literature knowledge, again, such a rich combination of perspectives in researching of a cluster of tire manufacturing type, is a new attempt. From this point of view, the study is a candidate to portray a baseline for the tire industry and contribute to the literature.

Automotive industry is one of the most important sectors in Turkey's economic development with a positive trend of production, in general. In conjunction with it, as a supplying industry, tire sector is also following similar trends that supply tires to both OEM and the replacement market. Kocaeli is one of the highly developed regions of the country. In this district, main Turkish tire producing companies are located. They are; Brisa, Good Year and Pirelli. Özka and Kolsan which have a kind of SEM type firms, will also be included in the analyses. These five firms, almost, produce 86 percent of tire production yield of the whole country which is nearly, thirty two million tires in 2012. Table.2 summarizes the production figures of automotive and tire production figures for Turkey, for the year of 2012. In the same table, World and European production figures were, also, given for comparative purposes.

One of the mostly utilized methods for identifying the clustering formations is Location Quotient. A localisation quotient equal to 1 means that the given region is not specialized in the given industry. (A localisation quotient equal to 1.5 means that the given industry is represented by a 50% bigger share of employment in the given region than the industry's share of employment on the level of all regions. This indicates that the region is specialized in the industry). As used by the early researchers of manufacturing clustering in Europe and Turkey, Location Quotient was also investigated for the area. Therefore, Location quotient is a measurement of the industry's concentration in an area relative to the rest of the nation.

$$\mathbf{LQ} = \frac{[(\text{Industry's local employment}) / (\text{Total local employment})]}{[(\text{Industry's national employment}) / (\text{Total national employment})]}$$

Using the data in Table.3, LQ for Kocaeli region was calculated as 21.1. A location quotient greater than 1 means that the cluster employs a greater share of the local work force than it does nationally. LQ value greater than 1.25 is considered to be an initial evidence of regional specialization. Kocaeli tire location's calculated LQ was found to be 21.1 which is bigger than an accepted minimum value of 1.25 by a 19.95. This finding also strongly suggests that tire clustering formation of the region is a high possibility. However, specialization measures such as Location Quotient results should be used as complementary tools in cluster analysis. Because one of our main aims is to find out the existing relationships which are crucial in terms of inner strength and relational bases of a sustaining cluster. Therefore, such methods that specifically focus on identifying regional key industries through use of employment data, say little about intra-industry "relationship patterns" such that make it difficult to reach conclusive decisions.

Table.2 Comparative Vehicle and Tire Manufacturing Figures, 2012

Vehicle and Tire Production Figures	Vehicle Production , unit	Tire Production, unit (Million)
Kocaeli Region	302,500 [2] (**28**)	27 [5] (**86**)
Turkey	1,072,339 [1] (**100**)	31.5 [4] (**100**)
AB-28	16,238,031 [1]	265 [3]
World (Total)	84,141,000 [1]	1,800 [3]

Sources: [1] OICA, 2012 (OICA; International Organization of Motor Vehicle Manufacturers))

[2] Başbakanlık Yatırım Ajansı, 2012

[3] LASID, 2012

[4] Turkish Statistical Organization, 2012

(Light Commercial Tire Production is not given. It was expected to be 5 million units)

[5] KSO, (Kocaeli Industrial Chamber, 2012

Table.3 Kocaeli Tire Industry Location Quotient (LQ) Components, 2012

Local Quotient Calculation Parameters	Employment, person
Tire industry's Kocaeli employment	5,300 [1]
Total manufacturing industry's Kocaeli employment	179,000 [2]
Tire industry's national employment	6,200 [1]
Total manufacturing industry's national employment	4,420,000 [3]

Sources: [1] Turkish Tire Workers Association, 2012

[2] İSKUR (Regional Business Office, 2012)

[3] Turkish Statistical Organization, 2012

Following orientations have been chosen in investigating the existing "relationships" of related parameters in relation to Kocaeli tire clustering formation;

Supply chain development perspective: A supply chain is defined as a network of organizations performing various processes and activities to produce value in the forms of products and services for the end customers (Christopher, 1992). Various authors have focused on the different aspects of it. Bowersox and Closs (1996) and Gianno Coccoro and Batrandolfo (2002) have mentioned that SCM is being a process based mechanism, gives the opportunity to decrease the manufacturing costs by concentrating to customer services. Li et all. (2005, 2006) identified strategic supplier partnership, customer relationship and information sharing as being the prime SCM practices. Different interests and opportunistic behavior of supply chain partners and informational asymmetries across supply chain affect the quality of information (Feldman and Müller, 2009). During the recent years, the focus has shifted from factory level management of supply chains to enterprise level management of supply chains (Gunasekaran et al. 2005). In the same article of author, differences between "traditional" and "networked" organizations are well discussed by emphasizing the importance of strategic alliances, global outsourcing, shorter product life cycles, partnership formation and collaboration, agility, responsiveness, flexibility, reverse logistics and extended enterprise integration (integration beyond enterprise resources planning (ERP), covering both internal and external integration). Therefore, supply chain relation of a cluster is even more complex phenomenon than individual firms' supply chains. In this article, one of our main targets was to investigate these interrelationships that could be effective in the competition of tire sector in Kocaeli location, as a whole.

Freight village development perspective: Logistics (freight) villages are connection points of local and long distance transport as well as interface of the transport carriers. Today, logistics assumes a function of stabilizer and coordination in a constantly changing supply and distribution groups within the framework of Global Supply Chain Management. Therefore, globalization is a strong impulse for increased attention for logistics management. As a facilitator of global logistics activities, logistics villages were among the earlier solutions. The first initiatives for the development of Logistics Centers in Europe, started in sixties and seventies, particularly in France, Italy and Spain. Logistics villages, with their differing partners, can be seen as synergy producing entities. Bentzen and at al. (2007) have given samples from logistics villages in Europe, with differing characteristics. Jordan (2006), has developed assessment criterion depending upon the purpose, location, transport mixes etc. He has classified 19 different criteria in five dimensions. Meidute (2005) takes geographical coverage differences as basis when differentiating existing logistics centers. She suggests three types of centers which are concrete, virtual and network (sometime referred to as regional) logistics centers. In Turkey, however, there are continuing efforts to establish logistics villages with similar functions as existing in Europe. Kocaeli region has a unique location in terms of having a capable port such as Derince port which is servicing to mainly exporting purposes via sea. Köseköy train logistics village is, mainly, servicing to the logistics purposes for inland logistics and transportation activities, in addition to the two state roads that pass through the region. Connection between train logistic village and the port has been, also, established. Having the opportunity of three different transportation modes in the same area with close distances to each other, a virtual logistics village concept can be visualized and developed. With such a holistic view of logistic village, additional synergies are expected to be provided to the area's economic growth, also for tire industry. In the study, this perspective will be sought in terms of their formation and effective contribution to tire clustering study. As being one of the purposes of clustering study, this can be foreseen to show how important it is for the region's future economic growth.

Add value development perspective: As explained earlier, economic clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, and associated institutions in a particular field that are present in a region. As a result of strengthening of formal and informal interdependencies, further collaborations are expected to increase. Therefore, in the study, as a third perspective of research mix, additional activities' existence between potentially clustering firms will be sought. Because, it is acknowledged from previous clustering studies that such value adding joint activities contribute to the whole sector's output and competitiveness.

2. RESEARCH FRAMEWORK AND PROPOSED MODEL

Three main components that were chosen as the main research approaching areas of the study, as explained in previous section are;

-Supply chain development for tire clustering

-Logistic village development for tire clustering

-Joint value development operations for tire clustering

During the study, we will investigate the effects of these three main areas to the tire business partners' behavior in terms of their business decisions. These results are expected to yield explanatory clues for the reached level of regional clustering in terms of qualitative aspects. Therefore, proposed model was consisted of inclusion of these main components.

In order to include and integrate the industry-specific requirements, necessities, and peculiarities to our main model, a "focus group" study was planned. Focus groups are used to generate and collect data in exploratory research especially for previously unexamined topics. By bringing people who share similar backgrounds or interests together, focus groups create opportunity to produce new ideas or determine some dimensions in the subjects that the researchers wish to understand (Morgan, 2008). Using focus group analysis in logistics and supply chain research has its examples in the related literature especially for exploring practitioner perspectives. Christopher and Jüttner (2000) use focus group analysis in order to explore the strategic supply chain partnership practices in the industry combines the method with specific case analysis. Inputs derived from this session are used to design the technical descriptors of logistics center services in the survey research.

Such a study was believed to improve the selected standard parameters that will be used during the research study. One of the main motivations of the "focus group study" would be to evaluate the validity of concepts that developed for the individual firm based "supply chain and logistics" models' application to cluster type of formations of firm concentrations and its applicability to the tire industry. Because there was not a previous guide in this respect, focus group study gained more importance for the model improvement. Participants were selected to represent the research subject content. Therefore, participants were determined on a judgmental bases so that mostly based on the researcher's expertise. The focus group study took place on the 26th of June, in Commercial Chamber of Kocaeli at 16.00 O'clock. Although, it was planned to last for one hour, the session took two hours with the approval of all four participants. Eight participants were contacted on phone and then official invitation letter were sent. In spite of, all eight representatives' prior confirmation to participate in the study, four of them could not attend to the session due to the last minute changes on their programs. The representative demographics are listed on Table 4.

Table.4 Focus Group Research Demographic Properties

	Participant.1	Participant.2	Participant.3	Participant.4
Sector	Tire Manufacturing	Automobile Manufacturing	International Logistics (train)	Tire Component Supplier (steel wire)
Duty	Logistics and Distribution Manager	Senior Buyer	Railway Manager	Sales & Customer Services Coordinator
Tenure at current company	15 years	7 years	3 years	5 years
Tenure at the sector	22 years	7 years	15 years	9 years
Education	Bachelor’s	Master’s	Master’s	Bachelor’s
Age	51	33	36	33

Focus group study was constructed from two sections. In the first section, each participant was asked to answer the following questions. Interactions among the participants were actively encouraged as being the one of the main aim of the study.

1. *By focusing at Kocaeli tire industry location only; what are the main problems in the sector, in terms of your main duty’s view?*
2. *By focusing at Kocaeli tire industry location only; what would you like to happen in future in the sector, in terms of your main duty’s view?*
3. *What would you say about the “competitiveness” of Kocaeli tire industry location, both domestically & internationally?*
4. *If your competitiveness evaluation is positive, how much of this success can be attributed to the “local suppliers, supply chain management and/or logistics activities”?*

Considering the answers of participants to the above questions; major problems were mentioned as; self-dictating of behavior of local transportation companies, higher supplier prices compared to nearby cities, shortage of sufficient products required by OE companies, weakness of train transportation and tiring customs practices. Almost, all of the participants agreed upon that, their collaboration with each other contribute to the competitiveness of the tire sector in the area, in different respects. Logistics and closeness of the firms to each other in the region were mentioned as being the two main areas that are most influential in the competitiveness process. Some of the important statements of focus group participants are, also, evaluated in the “Results and Expectations” section.

At the second part of the study, analytical model’s content was discussed. As a starting and reference point, as given in Table.5 descriptive “standard terms” that were borrowed from SCOR (Supply Chain Operations Reference Model) and LPI (Logistics Performance Index) models were used and discussed. Moderator explained the literal meaning of each “term” in terms of official sources’ definitions.

Table.5 Original components of HDI and LPI that were used in Focus Group study

Logistics Performance Index (LPI) **Components**	**Supply Chain Operations Reference Model (SCOR) Components**
• Customs • Infrastructure • International shipments • Logistics competence • Tracking & tracing • Timeliness	• Reliability • Responsiveness • Agility • Cost • Asset Management Effectiveness

The latest releases of data that used in the focus group have been taken from the official World Bank (http://rru.worldbank.org) as well as from the APICS's (http://www.supplychain.org/) sources. These original constructs were applied to individual firms' studies in Supply chain and Logistics studies in various sectors. However, as a novel application of these models in a tire clustering study, as is the case in our study, they had to be fine-tuned and adjusted for sector properties. Because of the fact that, these basic models would be addressing to the characteristics of an accumulation of firms, rather than individual firms' evaluations. In the first evaluation session, participants were asked to prioritize the given terms in view of their importance level, in tire sector, by looking through their current duties. For the final analytical model study, first three terms that were prioritized at the end of session were chosen. Considering all these contributing factors that were derived from Focus group study findings, targeted clustering research model of conceptualization was formed as shown in Figure.2.

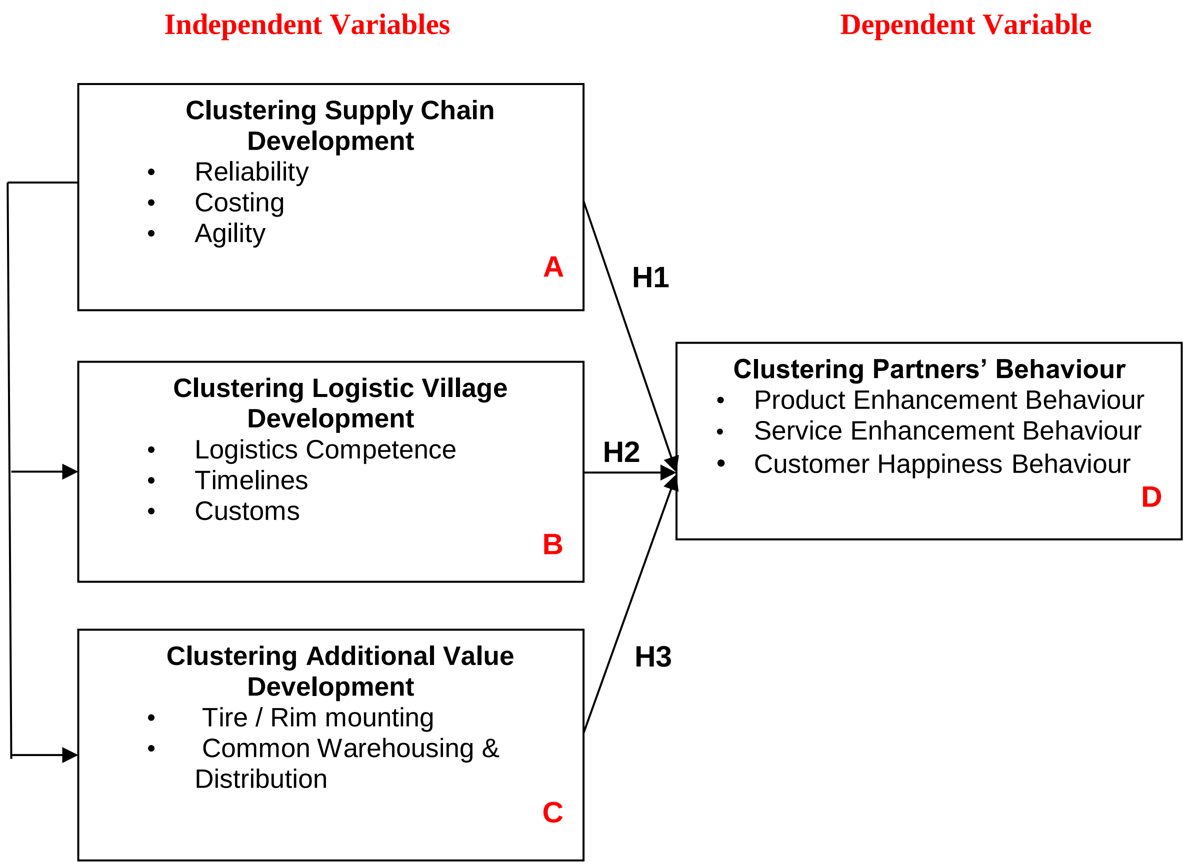


Figure.2 Proposed General Model for Tire Clustering Interactions

- **Research Question**: In compliance with above updated conceptual model, does the Kocaeli tire manufacturing location possess clustering location properties?

As mentioned in introduction, Adapazarı, Kocaeli, Bursa and eastern part of İstanbul is, already, an important location of clustering for European automotive industry. With the below hypotheses we aim to support the argument that; the most successful regions tend to have a portfolio of clusters related through linkages to each other. Thereby, Kocaeli tire clustering formation is the most potential one for such a structure in the mentioned automobile clustering location, namely, being a potential sub-clustering of automobile sector.

- **Research Hypotheses**: In compliance with above explanation and conceptual model, following hypotheses have been determined to be tested under the perspectives of selected orientations;

H1: Supply chain structures of tire companies in Kocaeli region have a significant impact on their business partners' behavior.

H2: Logistics village service structures of tire companies in Kocaeli region have a significant impact on their business partners' behavior.

H3: Collaborative structures between tire companies in Kocaeli region have significant impact on their business partners' behavior.

Afterwards the basic model was finalized, question forms which are consisted of 45 questions were prepared and they were sent to three practitioners for first evaluation. They were working in different departments like supply management, logistics management and sales departments. Their comments were utilized by revising some questions. The 5 point Likert scale measures were used as a scale type in the survey. The scale was chosen to measure the impact in the real life.

3. METHODOLOGY AND APPLICATION

Finalized questionnaire have been sent to chosen forty representatives whom are currently active in the sector and have close relations with the tire manufacturing process itself as manufacturers, suppliers, service providers, transporters, forwarders, OEM customers, sectorial associations and academicians. They were expected to contribute to the qualitative evaluation of the proposed model. Sample size will not be restricted at this stage. After obtaining the answers of respondents, "factor/principal component analysis" will be conducted to consolidate the prior established variables' final status. In a factor analysis, in order to get reliable factor solutions the sample size should be adequate and the factor loadings should be high (Field, 2000). In order to test the sample size adequacy Kaiser-Meyer-Olkin test will be applied. Values above 50 % are considered to be appropriate for exploratory factor analysis (Hair et al., 2006). The internal consistency of the scale items will be measured with Cronbach's Alpha. In addition to these measures, inter-item correlations will be analyzed within the factor items and these values should be all above the threshold value of 50 % (Hair et al., 2006). This analysis is expected to be applied in SPSS software. Mean values of independent and dependent variables will be checked after all testing criterions are satisfied. After this initial analysis is confirmed, related hypothesizes and sub-hypothesis will be tested by applying regression analysis. It was also realised by using SMSS 18.0 software. Linear multivariate regression methodology was utilised to see the relationships of independent variables' effects on dependent variables. This way, we will obtain the "explanation power" of single or combined independent variables' on the main partners' decisions. A detailed analysis of the total explanation power of respective variables are, then, expected to give us a good indication of the tire clustering network relationship formation. Table.6 and Table.7, below, summarize both analyses results.

Table.6 Validity, Reliability and Composite Reliability Coefficient Results of Factor Analysis

Main Orientations and Finalized Sub-dimensions Number	Factor Analysis Validity Coefficient (KMO)	Factor Analysis Significance Value (Bartlett)*	Factor Analysis Reliability Coefficient (Cronbach's Alpha**)	Composite Reliability Coefficient *** (Werts, Linn ve Jorseskog)	Remarks
Supply Chain Development (2 sub-dimensions)	0.734	P=0.000	1st dimension: 0.877 2nd dimension: 0.770	Pc= 0.959	For the original 4 sub-dimensions, composite validity coefficient was found as Pc= 0.966
Logistics Activities Development (3 sub-dimansions)	0.785	P=0.000	1st dimension: 0.904 2nd dimension: 0.830 3rd dimension: 0.788	Pc= 0.977	
Additional Value Development (2 sub-dimensions)	0.760	P=0.000	1st dimension: 0.917 2nd dimension: 0.739	Pc= 0.957	
Outputs and partners' Behaviour (3 sub-dimensions)	0.762	P=0.000	1st dimension: 0.901 2nd dimension: 0.805 3rd dimension: 0.885	Pc= 0.972	

***** Bartlett's significance value $p < 0.05$ was taken as valid. Significance value p is the main factor that validates whether the related variable is suitable to our main research model. In our research study, p significance value was taken as meaningful below the 0.05 value level of the first type error.

** Cronbach's Alpha > 0.60 was taken as valid during analysis

***Composite Reliability Coefficient (Pc) = (∑factor load)2) / (∑factor load)2) + (∑error load) . Pc >0.70 was taken as valid.

Table.7 Regression Analysis Results

					Regression analyses and their relationships with sub-hypotheses				
Main Hypotheses	Main Orientation	Existing sub-dimensions prior to Factor Analysis (number of questions)	Resulting sub-dimensions after the Factor Analysis (number of questions)	Finalised sub-dimensions after the Reliability Analysis (number of questions)	Regression variables (Last one is dependent variable)	ANOVA *P*(independent variables-general significance)*	Coefficients *P*(constant and independent variables' individual significance)*	Explained variance ratio (R^2):%	Decision in regard to proposed sub-hypotheses
H1	Supply Chain Development (Independent Variable)	Reliability (6) Agility (6) Costing (5)	Reliabili. (5) Agility(3) Costing(3) New di. (2)	Reliab. (5) Agility (3)	Reliability Agility Customer h.	*p*: 0.000 (2nd trial result)	Cons(*p*):0.670 A(*p*):0.000	0.357	Confirmed
					Reliability Agility Product en.	*p*:0.000 (2nd trial result)	Cons(*p*):0.208 A(*p*):0.000	0.433	Confirmed
					Reliability Agility Service en.	*p*:0.011 (2nd trial result)	Cons(*p*):0.449 A(*p*):0.011	0.170	Confirmed
H2	Logistics Activities Development (Independent Variable)	Logistics competence(5) Customs (4) Timeliness (4)	Log. co. (5) Customs (4) Timeline.(4)	Log.co.(4) Cust.(4) Timeli.(3)	Logistic co. Customs Timeliness Customer h.	*p*:0.001 (3rd trial result)	Cons(*p*):0.037 L(*p*):0.001	0.290	Confirmed
					Logistic co. Customs Timeliness Product en.	*p*:0.002 (2nd trial result)	Cons(*p*):0.009 CS(*p*):0.002	0.247	Confirmed
					Logistic co. Customs Timeliness Service en.	*p*:0.574 (1rd trial result)	Cons(*p*):0.058 L(*p*):0.896 CS(*p*):0.770 T(*p*):0.316	0.058	Not Confirmed
H3	Additional Value Development (Independent Variable)	Tire & rim mounting (4) Common warehousing & distribution (4)	Ti. rim. (2) Wa.dist.(4)	Ti.rim.(2) Wa.dis.(4)	Tire-rim Ware.-dist. Customer h.	*p*:0.004 (2nd trial result)	Cons(*p*):0.000 W(*p*):0.004	0.209	Confirmed
					Tire-rim Ware.-dist.. Product en.	*p*:0.004 (2nd trial result)	Cons(*p*):0.000 W(*p*):0.004	0.209	Confirmed
					Tire-rim Ware.-dist. Service enh.	*p*:0.276 (1rd trial result)	Cons(*p*):0.000 TR(*p*):0.579 W(*p*):0.312	0.073	Not Confirmed
H1 H2 H3	Outputs and Partners' Behaviour (Dependent Variable)	Product enhancement (3) Service enhancement(3) Customer happiness(6)	Pro. enc. (4) Ser.enc. (3) Cus.hap.(5)	Pro.en.(2) Ser.en.(3) Cus.ha.(5)					

***** If *p* (significance) is less than 0.05 for ANOVA and individual independent variables; sub-hypothesis relevant with main H1, H2 ,H3 hypotheses will be confirmed. In similar manner, if *p* value is less than 0.05 for a constant, it will be used in regression equation.

4. RESULTS AND DISCUSSION

In order to test and validate our main concerns that were explained in three hypotheses and with the research question, various studies that linked and complemented each other were conducted. For the application of the proposed framework to the tire location in focus, both, quantitative and qualitative methods have been used. As a quantitative method application, the first one was the calculation of Location Quotient for Kocaeli tire area. It was useful because, if LQ value was greater than 1.25, it is normally considered to be an initial evidence of regional specialization in a spesific product manufacturing process. In light of this valuable information, for the year of 2012, Kocaeli tire location's calculated LQ was found to be 21.1 which is bigger than an acepted minimum value of 1.25 by a 19.95. Because Kocaeli's LQ is considerably bigger than the value of 1.25, this finding strongly suggests that tire clustering formation of the region is a high possibility from a quantitative point. This can be considered as a good starting point with an encouragement to continue further in our study, considering the fact that employment figures of the region do not change radically from year to year. As shown in Introduction section, according to the mathematical calculation for the same year of 2012, tire firms in the area had produced 86 percent of tire production yield of the whole country. This is nearly, amounts to thirty two million tires for 2012. By looking at both calculated figures together, Kocaeli region, clearly distinguish itself as a dense location in tire manufacturing that contributes to economy in terms of specialization of a specific product kind which is tire.

To approach to the qualitative side of the study, a representative generic framework for the industry was develeoped. For this aim, initially, a “focus group” study was realised for obtaining the ideas of selective partners that resemble Kocaeli tire environment, in large. In addition to adapting of the main research perpectives, such as LPI and SCOR models, to tire manufacturing environment, additonal questions were directed to participants to get better insight to the industry. In the “Focus group” study, four different questions were directed to four participants representing different areas of tire industry. With the first question, “current problems” in Kocaeli tire industry was aimed to be learned. Seven problems were predominantly mentioned by the particitipants. Four of the problems were related with logistics area; existing transport cooperatives’ one sided decisions, not full appreciation of train transportation’s value in the region, TCDD’s high price policy and inspection problems at customs during exporting activities. In addition to these mentionings, two of the remaining problems were related with supply chain management; local suppliers’ high pricing policy and shortage of tires in urgent demanding situations of OEM companies. The last problem mentioned was directly related with industrial relations; noticable variations in workers wages even within the same firm. With second question, it was aimed to learn their “future possible improvement plans” in the tire industry that were, at least, expected to occur in coming years. One participant did not answer. Six concerns were mentioned that were expected to be improved, in future. Three of them were related with supply chain management; more close interaction with local tire manufacturers, improving of cost situation of tire products and improving the agility during the changing of plans upon OEM customers’ requests. Two of the future expectations involved logistics management area; better appreciation of logistics’s overall positive contribution to sector by upper management and better commitment of upper management to the co-modality transportation activity between Derince port and Köseköy train logistics village.

Qualitative study is, also, an important part of the research study in understanding how the tire industry can utilize supply chain and logistics in a potential clustering framework. As stated in the conceptual framework development part, SCOR and LPI approaches were the main drivers of the research subject. In conjunction with the refined research model and related Research question and Research hypotheses derived, it was aimed to distinguish the significant effects of cluster supply chain and cluster logistics variables’ on the cluster partners’ behaviour/performance results. Author defined a third components of “additional value” variable was also included in the study, with the expectation of covering other industry-spesific items that could not be included in two models. As shown in Table.6, resulting regression analysis results yielded seven confirmed sub-hypotheses. In all of the three confirmed sub-hypotheses regarding “supply chain management” construct, “agility” variable was the only robust and most effective one having significant effect on the results. When a total evaluation is attempted to be made, it would be consistent to say that independent variable of “agility” attribute for the supply chain management has a significant effect on all outputs. However, the other variables of “reliability” and “costing” haven’t showed the similar effect on results. “Agility” variable had the most pronounced effect on “product enhancement behaviour” compared to other two behavioural output categories, by looking at the explained variance ratios.

In regard to “logistics activities development” construct and “outputs and partners’ behaviour” variables relationship analyses via correlations, three sub-hypotheses were tested. “Logistics competence” and “customs” were the most effective variables on the results. While, two sub-hypothesis are confirmed, on was rejected.

The last regression analysis performed was related with “additional value development” and “output and partners’ behaviour” relationships. Independent variable construct was consisted of “tire & rim mounting, common warehousing & distribution” attributes. Regression analysis results showed that, “common warehousing & distribution” variable had a significant effect on “customer happiness” with an explained variance ratio of 0.209. Therefore, this sub-hypothesis was confirmed. Similarly, “common warehousing & distribution” was the effective independent variable in the regression for “product enhancement behaviour”. Therefore, the second sub-hypothesis was also, confirmed.

After completing the hypotheses validation tests, we can say that Kocaeli tire agglomeration is showing proven clustering characteristics in terms of proposed cluster-dependent frameworks’ constructs. Namely, “agility” feature of Supply chain development, “logistics competence and customs” components of

Logistics activities development and “common warehousing and distribution” features of Additional value development constructs are shared as existing and significantly effective features on cluster-dependent results. Because the proposed framework model and related hypotheses were designed and applied with an approach of a “clustering mind”, proven characteristics are also, strongly, expected to be cluster dependent. Taken together, the tire clustering validation study started with eight features and seven of the sub-hypotheses were validated with four sustaining variables throughout whole the analyses. Clearly, sustaining of these four features out of eight variables are proven to be as real clustering dependent robust characteristics. As yet, remaining four independent variables could not be qualified as cluster dependent characteristics according to the analyses results.

As known well, freight villages are natural locations for manufacturing locations because of their cost effective and frequent multinational transportation offerings. Such services allow manufacturers to move raw materials and parts inbound and to distribute the finished products efficiently. Köseköy train logistics village (called as pocket village) and Derince port being in the same vicinity of tire manufacturers’ cluster, are presenting good opportunities for multi -modal usage of both transportation modes. Köseköy train village and Derince port is connected to each other. There is a limited usage of this infrastructure by tire manufacturers as a joint usage. As it has been clearly mentioned of the participant (international logistics firm representative) in the “focus group” study, the usage of the both modes requires a “freight village mind” rather than the individual usages. So, there exist some obstacles that have to be solved. The first one is the still higher pricing of train transportation in comparison to highway transportation. He also mentioned that another important problem is “not a proper appreciation of strategic position of train carriage by the upper management of tire manufacturers, yet”. Similar views were expressed by Köseköy train village and Derince port authorities during the survey study conversations. Köseköy logistics village managers mentioned that if the higher management demanded to use the train mode more to Derince port and inland operations, they would feel more responsibility for better price adjustments and proper designing of respective routes. One manager also added that they expanded the storage area capacity of the train logistic village to 77 he. from a 18 he. for preparing themselves for the future requests of the tire manufacturing customers. It is expected that, by improving the above mentioned joint activities further, Kocaeli tire location can reach to a bigger collective capacity and enriched capability for already existing firms such that may position them more strongly in the tire market to compete.

5. CONCLUSION

Finally, this study is an important first step in understanding how supply chain management, logistics activities and additional value-adds can make more contribution in a tire production location that has a potential to increase its competitiveness further. By utilising the models of SCOR and LPI in a unique framework in order to explain the supply chain and logistics relations predominantly; supporting, confirming and encouraging results were reached. One of the most important findings was that “agility” is an effective attribute in tire clustering formation regarding supply chain management. Similarly, “logistics competence” and “customs” were among the significant features that were effective for the function of the logistics activities in the clustering formation. Similarly, “common warehousing and distribution” feature is being paid more attention in joint activities. The major finding of this study is that there exist solid indications of an industrial cluster in tire industry by following the important characteristics of Supply Chain and Logistics Activities areas that are defined in novel ways.

The contribution of this research is unique as it takes a combined quantitative and qualitative approach when studying cluster performance of industrial location such as Kocaeli. However, it should be born in mind that clusters are constructs with essentially no self-defining boundaries, whether in terms of inter-sectoral, inter-firm linkages, information networks. Clearly, further studies are needed in the tire industry to find out the different dimensions of the complex relationships.

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INTELLECTUAL STRUCTURE OF LOGISTICS AND SUPPLY CHAIN IN TURKEY

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Abstract-Supply chain management (SCM) is a well-known management strategy which attempts to add value to customer service, to enhance competitive advantage through integrating the main business process in supply chain. Even, in early stage, SCM has once been recognized as a synonym for logistics the studies after 2000s showed that they can be divided and specialized. Therefore, logistics and SCM individually has been developing fields since 1940s. There are many researches and researchers in this field however, few studies explore intellectual structure of logistics and SCM. The purpose of this study is to examine the intellectual structure of SCM through scientometric methods for Turkey. Data was collected from Web of Science online database. Author collaborations, country collaborations will be analyzed by using social network analysis and the maturity of the fields regarding internationally published articles will be traced retrospectively.

Keywords: *logistics, supply chain management, scientometrics, bibliometrics, collaboration, co-authorship*

Related Topics: Strategic Logistics Management, Logistic Sector, Logistics and Supply Chain Management: New Directions

INTRODUCTION

Evaluating academic scholarship is a common activity in many disciplines. Publication trends give insight for further studies and future collaboration opportunities. Analyzing these trends may guide scholars to see the big picture for their field and provide them to further their studies to the emerging subjects in the field.

Bibliometrics is the application of mathematics and statistical methods to books and other media of communication [1]. Bibliometrics and scientometrics are two closely related approaches to measure scientific publications and science in general, respectively. Both of them are applied many disciplines for finding out relationships and visualizing the intellectual structure of scientific fields. There are some bibliometric and scientometric analysis examples for logistics and supply chain management field. Fahimnia et al. [2] analyzed the green supply chain management field by reviewing the literature. They began with over 1000 published studies and by using bibliometric tools established emerging research clusters for topological analysis. Their systematic mapping of the field helps graphically illustrate the publications evolution over time and identify areas of current research interest and potential directions for future research.

Any other study is about authorship collaboration in logistics research [3]. They applied network analysis to understand the collaboration trends of logistics scholars and found that the logistics landscape is undergoing tremendous change and this change force scholars to collaborate individually across the border of their institutions even internationally. Based on their findings logistics scholars value collaborative research. In addition, collaboration impact the article citation numbers also. Finally they proposed that thought leader institutions are important and focusing special subjects is important for further qualified publications.

Shiau and Tsai [4] analyzed the intellectual structure of supply chain management field. They tried to contribute by providing core knowledge for both researchers and practitioners to understand the aspects of supply chain management. They downloaded 4033 journal articles and 117984 references from the Web of Science database and used citation and document co-citation to extract the 41 highly cited articles and generated these articles into correlation matrix. They found that sustainable supply chain management is an emerging issue and they propose to further these analysis by enlarging the time period.

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Any other study is social network analysis of business logistics and transportation [5]. Authors handled the issue with evolutionary perspective and used network analysis to find out collaborative structure of logistics field.
Even there are several studies regarding extracting out the intellectual structure of logistics and supply chain management field, there is not a study prepared for Turkey and Turkish scholars in the same field. Because of this gap in literature, in this study it is aimed to demonstrate intellectual structure of logistics and supply chain management field in Turkey. Publication analysis, in other words scientometrics, was performed for identifying the co-authorship, co-organizational, and co-term relationships. Publications were downloaded from Web of Science database and the data is prepared and analyzed by using Citespace [6].

ANALYSIS AND FINDINGS

The analysis is performed by using Citespace for visualizing co-authorship network, co-organization network and co-term network. By doing this it is aimed to understand the intellectual structure of logistic and supply chain management field with author, organization and sub-field levels retrospectively. The query is searched by using TI=("logistics" OR "supply chain management") Boolean set in publication titles in Web of Science database. This search retrieved 3000000 publications. For Turkey CU=(Turkey OR Turkiye OR Türkiye) Boolean set is used to retrieve the publications of Turkey and by doing the search 324679 publications are reached. Time interval is set for 1980-2015. Then by crossing two sets 768 publications found. First of all the data analyzed to clean and exclude the duplicate data and nothing is found as duplicated. Then, analysis is performed without pruning because of the limited number of publications and top 100 publications are selected for each slice, which is determined for one-year period. First analysis is co-authorship network and this network is demonstrated in Figure 1.

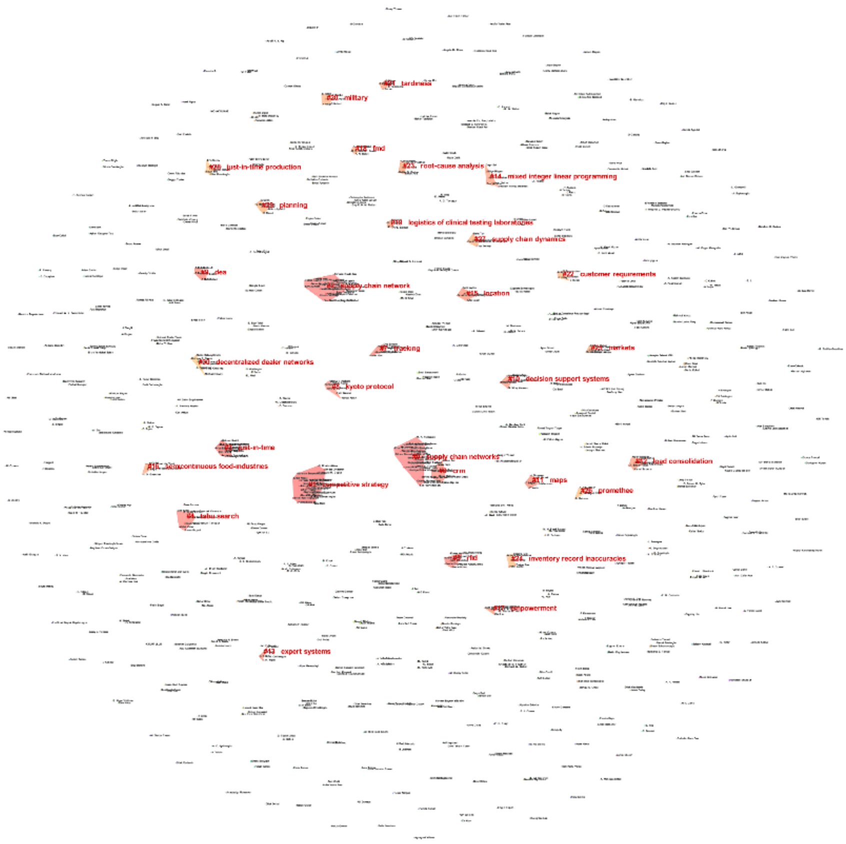

Figure 1 Co-authorship Network

The network is not easily understood because of contributing many authors and the complex visual representation. By performing network analysis the network is divided into 31 co-citation clusters. These clusters are labeled by index terms from their own citers. The largest 12 clusters are summarized in Table 1

Table 1. Summary of the largest 12 clusters.

Cluster ID	Size	Silhouette	Label (TFIDF)	Label (LLR)	Label (MI)	mean(Cited Year)
0	28	0,966	(16,33) supply chaın networks	end-of-life	...	2010
1	26	1	(19,11) competitive strategy	logistics	supply chain management; economic sustainability; turkey; logıstıcs provıder; ınıtıatıves; framework; ınsıghts; ındustry; drıvers	2009
2	23	1	(18,11) supply chain network	logistics	genetic algorithms; reverse logistics; vehicle routing problem with simultaneous pick-up and deliveries	2010
3	14	1	(20,16) just-ın-tıme	data envelopment analysis	...	2009
4	10	1	(16,04) tabu search	multi-item dynamic lot-sizing	supply chain management; economic sustainability; turkey; logıstıcs provıder; ınıtıatıves; framework; ınsıghts; ındustry; drıvers	2008
5	8	1	(13,63) rfıd	fuzzy rule-based system	...	2006
6	8	0,991	(16,33) crm	outsourcing	...	2010
7	8	1	(16,04) trackıng	trackıng (49,82, 1.0E-4)	...	2007
8	7	1	(16,33) kyoto protocol	mixed-integer programming	...	2006
9	7	1	(17,16) dea	supply chain strategy	...	2002
10	6	1	(17,86) decision support systems	disasters	...	2010
11	6	1	(17,16) maps	combinatorial optimization	...	2000

When table 1 analyzed it can be said that the largest cluster is cluster #0 and has 28 members. Silhouette number is bigger than 0.5 and it can be interpreted that the clusters are homogenous. The label of this network is supply chain networks and the average year of the publications is 2010. It is attracting attention that the nearest average year of publication to present is 2010 for all clusters. This can be interpreted that with the limitation of web of science database the scientific production trend for logistics and supply chain management is not increasing for Turkey. Labels used most in the clusters may give information for the authors' focus for that time period.

When the citation measures analyzed it can be seen that the top ranked item by citation counts is Turan Paksoy (2006) in Cluster #2, with citation counts of **23**. The second one is Gulcin Buyukozkan (2006) in Cluster #1, with citation counts of **20**. The third is Eren Ozceylan (2010) in Cluster #2, with citation counts of **18**. The 4th is Adil Baykasoglu (2008) in Cluster #12, with citation counts of **10**. The 5th is Ekrem Tatoglu (2007) in Cluster #3, with citation counts of **10**. The 6th is Alp Ustundag (2006) in Cluster #5, with citation counts of **9**. The 7th is Onur Kaya (2008) in Cluster #45, with citation counts of **9**. The 8th is Surendra M. Gupta (2010) in Cluster #1, with citation counts of **9**. The 9th is Erkan Bayraktar (2007) in Cluster #3, with citation counts of **8**. The 10th is Ozalp Vayvay (2008) in Cluster #10, with citation counts of **8**. These frequencies gave information about the leaders of the scientific production in Turkey for logistics and supply chain management. However, frequency is not adequate to understand the intellectual structure, centrality measure is important for interpreting the collaboration intensity. The collaboration statistics can be seen in Table 2.

Table 2 Centrality Measures of Selected Authors

centrality	References	cluster #
0,00	Turan Paksoy, 2006, SO, V, P	2
0,00	Gulcin Buyukozkan, 2006, SO, V, P	1
0,00	Eren Ozceylan, 2010, SO, V, P	2
0,00	Adil Baykasoglu, 2008, SO, V, P	12
0,00	Ekrem Tatoglu, 2007, SO, V, P	3

0,00	Alp Ustundag, 2006, SO, V, P	5
0,00	Onur Kaya, 2008, SO, V, P	45
0,00	Surendra M. Gupta, 2010, SO, V, P	1
0,00	Erkan Bayraktar, 2007, SO, V, P	3
0,00	Ozalp Vayvay, 2008, SO, V, P	10

As can be seen in Table 2, in-between centrality measures are 0 and this means that these authors with their higher scientific production their collaboration intensity is lower to be central figures. Co-organization network is demonstrated in Figure 2.

Figure 2 Co-Organization Network

When the network in figure 2 analyzed it can be seen that it is more central than author network. The network is divided into **10** co-citation clusters. These clusters are labeled by index terms from their own citers. The largest **4** clusters are summarized in Table 3.

Table 3. Summary of the largest 4 clusters.

ClusterID	Size	Silhouette	Label (TFIDF)	Label (LLR)	Label (MI)	mean(Citee Year)
0	30	0,917	(12,99) cooperative games	Inventory	pricing theory; operations management; operations planning; supply chain management; inventory control; inventory management; supply chain dynamics; logistics; lot sizing; style-goods; buyers perspective; chain; information; contracts; capacity; demand; commitment; decisions; opportunities	2010
1	26	0,834	(13,62) management	multi-echelon inventory management	outsourcing; fuzzy; decision making; ahp; erp; information-systems; vendor selection; model; technology; management; firm; ahp; perspective; logistics; business	2006
2	22	0,909	(12,99) cost management	multiclass finite-source populations	inventory; joint replenishment; economic order; quantity model; non-cooperative game theory; information asymmetry; cost allocation; supply chain; inventory games; cooperation; systems	2007
3	20	0,944	(11,23) mode	batch sizing	supply chain; information; policies; models	2010

As can be seen in Table 3 the largest cluster (#0) has 30 members and a silhouette value of 0,917. It is labeled as *inventory* by LLR, *cooperative games* by TFIDF, and *pricing theory; operations management; operations*

planning; supply chain management; inventory control; inventory management; supply chain dynamics; logistics; lot sizing; style-goods; buyers perspectıve; chaın; ınformatıon; contracts; capacıty; demand; commıtment; decısıons; opportunıtıes by MI. The second largest cluster (#1) has 26 members and a silhouette value of 0,834. It is labeled as *multi-echelon inventory management* by LLR, *management* by TFIDF, and *outsourcing; fuzzy; decision making; ahp; erp; ınformatıon-systems; vendor selectıon; model; technology; management; firm; ahp; perspectıve; logıstıcs; busıness* by MI. The third largest cluster (#2) has 22 members and a silhouette value of 0,909. It is labeled as *multiclass finite-source populations* by LLR, *cost management* by TFIDF, and *ınventory; joint replenishment; economic order; quantity model; non-cooperative game theory; ınformation asymmetry; cost allocatıon; supply chaın; ınventory games; cooperatıon; systems* by MI. The 4th largest cluster (#3) has 20 members and a silhouette value of 0,944. It is labeled as *batch sizing* by LLR, *mode* by TFIDF, and *supply chaın; ınformatıon; polıcıes; models* by MI.
The top ranked item by citation counts is Istanbul Tech Univ (2000) in Cluster #8, with citation counts of **68**. The second one is Middle E Tech Univ (2001) in Cluster #0, with citation counts of **55**. The third is Dokuz Eylul Univ (2004) in Cluster #4, with citation counts of **47**. The 4th is Bilkent Univ (2001) in Cluster #3, with citation counts of **44**. The 5th is Koc Univ (2002) in Cluster #9, with citation counts of **39**. The 6th is Bogazici Univ (1998) in Cluster #1, with citation counts of **38**. The 7th is Galatasaray Univ (2004) in Cluster #6, with citation counts of **35**. The 8th is Sabanci Univ (2001) in Cluster #2, with citation counts of **33**. The 9th is Yildiz Tekn Univ (2008) in Cluster #4, with citation counts of **30**. The 10th is Selcuk Univ (2010) in Cluster #5, with citation counts of **29**.
The centrality figures of organizations can be seen in Table 4.

Table 4 Centrality Statistics of Organizations

centrality	References	cluster #
0,29	Bilkent Univ, 2001, SO, V, P	3
0,24	Middle E Tech Univ, 2001, SO, V, P	0
0,16	Sabanci Univ, 2001, SO, V, P	2
0,11	Dokuz Eylul Univ, 2004, SO, V, P	4
0,10	Istanbul Tech Univ, 2000, SO, V, P	8
0,10	Bogazici Univ, 1998, SO, V, P	1
0,08	Koc Univ, 2002, SO, V, P	9
0,08	Yildiz Tekn Univ, 2008, SO, V, P	4
0,08	Marmara Univ, 2008, SO, V, P	1
0,07	Bahcesehir Univ, 2006, SO, V, P	1

The top ranked item by centrality is Bilkent Univ (2001) in Cluster #3, with centrality of **0,29**. The second one is Middle E Tech Univ (2001) in Cluster #0, with centrality of **0,24**. The third is Sabanci Univ (2001) in Cluster #2, with centrality of **0,16**. The 4th is Dokuz Eylul Univ (2004) in Cluster #4, with centrality of **0,11**. The 5th is Istanbul Tech Univ (2000) in Cluster #8, with centrality of **0,10**. The 6th is Bogazici Univ (1998) in Cluster #1, with centrality of **0,10**. The 7th is Koc Univ (2002) in Cluster #9, with centrality of **0,08**. The 8th is Yildiz Tekn Univ (2008) in Cluster #4, with centrality of **0,08**. The 9th is Marmara Univ (2008) in Cluster #1, with centrality of **0,08**. The 10th is Bahcesehir Univ (2006) in Cluster #1, with centrality of **0,07**. Against their centrality mean average publication years are not recent. However it can be said that organizational structures more compatible and create networks within and between them in contrast to author networks. At last the co-term network is demonstrated in figure 3.

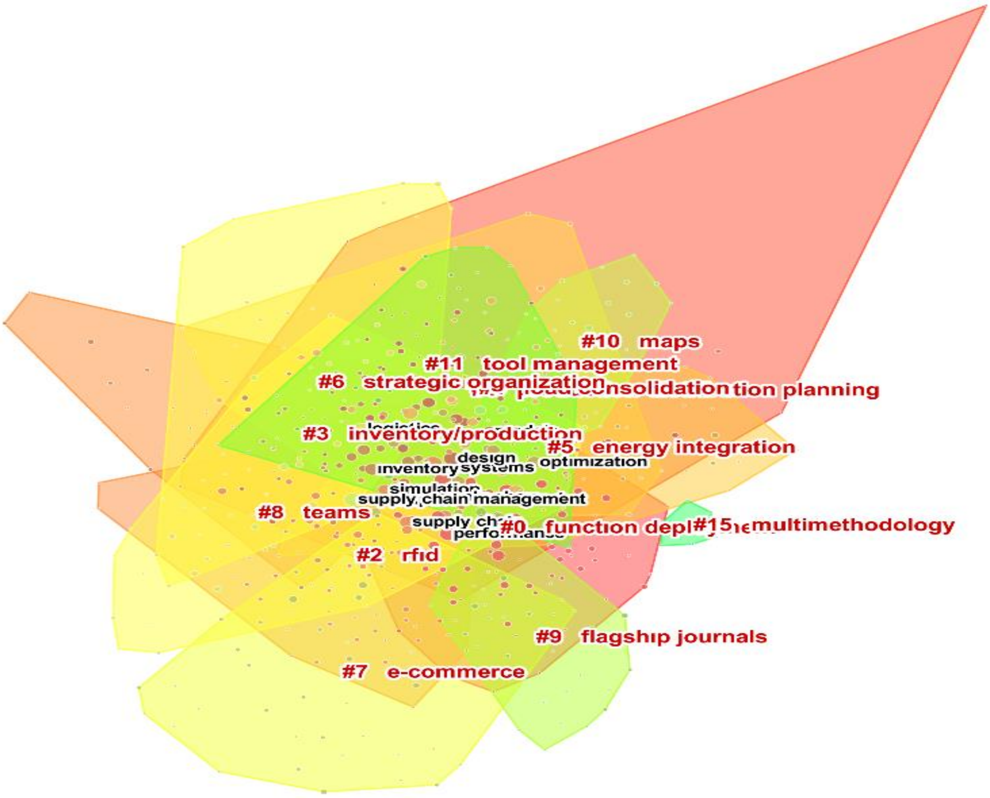

Figure 3 Co-term network

When the figure 3 analyzed it can be seen that the network is divided into **17** co-citation clusters. These clusters are labeled by index terms from their own citers. The largest **6** clusters are summarized in Table 5.

Table 5. Summary of the largest 6 clusters.

ClusterID	Size	Silhouette	Label (TFIDF)	Label (LLR)	Label (MI)	mean(Cited Year)
0	117	0,52	(15,77) functıon deployment	strategic management	consumer; perception; risk; supermarket; turkey	2007
1	87	0,618	(14,47) production-distribution planning	production-distribution models	supply chain management; inventory-routing problem; branch-and-cut; integer programming; heuristics; systems; vendor; allocatıon; polıcıes; costs	2008
2	67	0,666	(13,78) rfıd	ınventory control	consumer; perception; risk; supermarket; turkey	2008
3	58	0,767	(14,95) inventory/production	inventory/production	genetic algorithm; ıntegrated supply chain; multi-item; multi-supplier; supplier selection; stochastıc demand; chaın management; ınventory system; buyer; coordınatıon; vendor; order; tıme; envıronment; decısıons	2006
4	55	0,745	(14,47) load consolidation	multi-agent systems	military application; logistics; location routing problem; network design; locatıon-routıng problem; dıstrıbutıon-system desıgn; travelıng salesman; depot locatıon; facılıty locatıon; hazardous materıals; tabu search; vehıcle; model; wastes	2008
5	44	0,789	(12,64) energy integration	media modeling	supply chain; brand management; brand elevation in supply chains; managerıal ımplıcatıons; ındustrıal-products; market orıentatıon	2009

As can be seen in Table 5 the largest cluster (#0) has 117 members and a silhouette value of 0,52. It is labeled as *strategic management* by LLR, *functıon deployment* by TFIDF, and *consumer; perception; risk;*

supermarket; turkey by MI. All silhouette values are above 0.5 and it means that the groups in these networks are homogenous.
The top ranked item by citation counts is model (2006) in Cluster #2, with citation counts of **141**. The second one is management (2006) in Cluster #2, with citation counts of **110**. The third is supply chain management (2001) in Cluster #8, with citation counts of **80**. The 4th is supply chaın (2001) in Cluster #0, with citation counts of **71**. The 5th is desıgn (2004) in Cluster #1, with citation counts of **67**. The 6th is systems (2003) in Cluster #4, with citation counts of **64**. The 7th is performance (2004) in Cluster #0, with citation counts of **63**. The 8th is system (2004) in Cluster #0, with citation counts of **56**. The 9th is logıstıcs (1994) in Cluster #4, with citation counts of **50**. The 10th is optımızatıon (2004) in Cluster #5, with citation counts of **48**. The centrality figures can be seen in table 6.

Table 6 Centrality statistics

centrality	References	cluster #
0,13	supply chain management, 2001, SO, V, P	8
0,12	performance, 2004, SO, V, P	0
0,09	ınventory, 2002, SO, V, P	3
0,08	desıgn, 2004, SO, V, P	1
0,08	supply chain, 2000, SO, V, P	2
0,08	logistics, 2001, SO, V, P	6
0,08	simulation, 2002, SO, V, P	2
0,08	network, 1998, SO, V, P	1
0,07	systems, 2003, SO, V, P	4
0,07	ımpact, 2007, SO, V, P	2

Based on findings in Table 6, the top ranked item by centrality is supply chain management (2001) in Cluster #8, with centrality of **0,13**. The second one is performance (2004) in Cluster #0, with centrality of **0,12**. The third is ınventory (2002) in Cluster #3, with centrality of **0,09**. The 4th is desıgn (2004) in Cluster #1, with centrality of **0,08**. The 5th is supply chain (2000) in Cluster #2, with centrality of **0,08**. The 6th is logistics (2001) in Cluster #6, with centrality of **0,08**. The 7th is simulation (2002) in Cluster #2, with centrality of **0,08**. The 8th is network (1998) in Cluster #1, with centrality of **0,08**. The 9th is systems (2003) in Cluster #4, with centrality of **0,07**. The 10th is ımpact (2007) in Cluster #2, with centrality of **0,07**.

CONCLUSION

Logistics and supply chain management issues are interdisciplinary fields and need more teamwork for creating more value-added works. For Turkey, it can be asserted that mean citation year is 2005 and later for years between 1984 and 2014. This means that studies in logistics became popular after 2005. In addition there is not an author coming forward and connect two different clusters together based on centrality measures.
Author-based analysis demonstrates that authors cannot be assembled under common sub-terms because the impact areas are not located centrally in visual map.
Co-organization network demonstrates that universities can assemble on some sub-fields. In addition based on centrality measures the mean citation year is before 2005 and it can be interpreted as organizations' adding value is decreasing.
In the co-term map some of the stacks as flagship journal and multimethodology goes away from the main cluster and this means that their relation to logistics is decreasing.
Finally it can be said that logistics and supply chain management studies in Turkey have become popular since 2005 based on the network map. However even author network has no statistically meaningful centrality values, organization network have some clues to demonstrate clustering around some sub-fields. For future studies these networks should be compared with world intellectual networks for last decade by accepting last decade as a reference point.

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FOOD RETAILING LOGISTICS: A MONOGRAPHIC ANALYSIS OF A LOCAL SUPERMARKET CHAIN

Aylin Çalışkan[121], Ömer Baybars Tek[122]

Abstract_*The supermarket phenomenon started to gain momentum during 1990s at which time Turkey entered the modern retailing era. Today food retailing could be classified into increasingly competitive formats such as; Hypermarkets, Convenience stores, Warehouse clubs, Superets, Discount supermarkets, and Supermarkets etc. The number of local supermarket chains in Turkey, some of which are called Anatolian Tigers, is increasing each year. Since most of these local supermarket chains are in the category of small and medium enterprises (SMEs), they need to be analyzed for the purpose of efficiency and effectiveness of their operations. This descriptive and exploratory study tries to find out the present state of supermarket logistics in order to understand the application of contemporary information technologies and logistics instruments. In the context of this study, local food retail chain that owns 24 number supermarket stores in Aegean region is investigated through monographic approach, particularly based on personal interviews and observations.*

Keywords: Food retailing, retail logistics, food logistics, chill food, local supermarket

INTRODUCTION

One of the most important dynamics for the quality and well-being of any food stuff is cold chain logistics. Pivotal in this process, is the key role played by retailers, with their role of bringing the foods to the consumers. It therefore follows that such food retailers make an invaluable contribution towards the maintaining quality of food. Consumers expect food in retail stores to be of good quality and freshness, to have a decent shelf-life and to be fit for purpose. If a retailer can present products attractively and provide good shelf-life, then there is more chance of increase in sales and customer satisfaction [1].

Managing the logistics operations to maintain quality and fitness of food products therefore has direct cost and service implications. In the retail industry, customer product preferences are becoming increasingly diverse. Since most supermarket inventory is comprised of food products and since an important part of those products need to be kept cold, the management of cold chain is crucial in supermarkets. The term 'food chain' refers to the total supply process from agricultural production, harvest or slaughter, through primary production and/or manufacturing, to storage and distribution, to retail sale or use in catering and consumers practice [2]. The management of cold chain in supermarkets should prevent loss, improve sales and reduce inventory by minimizing the lead times [3], while maintaining the foods' safety and freshness. Jackson, Blair, McDowell, Kennedy, and Bolton [4] indicated that on average the shopping basket of European consumer mostly (say more than 60%) consists of chilled and frozen food, and food which can be consumed without heat treatment. Consumer awareness of food safety and government food safety regulations are the major driving forces behind cold chain development [5]. Food products begin to deteriorate the moment they are harvested or slaughtered, so it is primordial for cold chain logistics to insure that the cargo is kept in optimum storage, selling area and transport conditions so that shelf life, and therefore commercial potential, is maximized.

Timely distribution and interstore transfers in local areas is an important dynamic while operating in crowded urban areas. As local supermarkets are mainly located near the living area of households, it is more difficult to build cold transfer areas behind the stores for the cold chain food products. The aim of this study with the interest of how local supermarket chains manage cold chain logistics operations is to examine monographically cold chain logistics applications for chill products of a local supermarket chain which operates in Aegean region.

FOOD RETAILING AND DEDICATED LOGISTICS ACTIVITIES

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A retailer is a business that sells products or services or both, to consumers for their personal or family use. A distribution channel is a set of firms that facilitate the movement of products and services from the point of production to the point of sale to the final customer. Retailers are the final business in a distribution channel that links manufacturers to consumers [6].

Manufacturer → Wholesaler → Retailer → Consumer

Figure 1.

Distribution Chain and the Place of Retailer

The main purpose of retail logistics is to provide product availability. Retailers essentially serve several purposes: providing assortments of products and services, offering products in smaller quantities (breaking bulk), providing products available when consumers want them (holding inventory) and providing service (i.e. offering credits, displaying products, salesperson's help, buying time flexibility, etc.) that increase the value of the products and services they sell to consumers and facilitate the distribution of those products and services for those who produce them [6]. Retailers are divided mainly into two categories, (1) food retailers and (2) non food retailers [7]. The topic of this study that is food retailer the category have different types mainly which can be seen in the Table 1.

Table 1. Types of Food Retailers

FOOD RETAILERS		**Explanation**	**Example**
Conventional Supermarkets		400 m^2-2500 m^2 Wide variety of food (30-40 percent) and nonfood merchandise (60-70 percent) Self-service	Migros (M,MM) Pehlivanoğlu
Big Box food retailers	***Hypermarkets***	>2500 m^2 Wide variety of food (30-40 percent) and general merchandise (60-70 percent)	Wal-Mart CarrefourSa Migros (MMM) Tesco-Kipa
	Warehouse Club	10.000-15.000 m^2 Limited assortment of food (60 percent) and general merchandise with little service at low price (20-40%)	Price Club Metro
	Superstores	Two times bigger than supermarkets (2000-5000m^2). Wide variety of food and nonfood merchandise. Value added services like pet care, oto cleaning, etc. Higher prices.	Safeway's Pak'N Pay
	Combination (Combo) store	Two times bigger than superstores. Food, nonfood and medical merchandise. ¼ of the store space is allocated for food.	Family Mart Kroger-Sav-On

	Convenience store	200-300 m2 Limited variety and assortment of merchandise at a convenient location with speedy check-out. Long service hours	7-Eleven Stop N Go Alberthein
	Superets (Discount supermartkets)	Limited variety and assortment of merchandise. 20-65% cheaper prices.	BİM Şok market

Source: Adapted from [6] and [7].

The methodological part of this study focuses on conventional supermarket which is in service locally in the Aegean Region. The best starting point in analysis of supermarket for the purpose retail logistics is taking product categories in scrutiny.

Category Management and the Need for Special Logistical Treatments for Categories

The main aim of category management is to determine the optimal assortment of products that will maximize sales and eliminate unnecessary product duplication [8]. It arranges groupings of products into strategic business units, so as to better meet consumer needs and achieve sales and profit goals [8], at the same time paying attention the optimal compromise among competitor products in the same category.

Category management has become cornerstone of perishables (meat, produce-Harvested agricultural goods, especially fruit and vegetables, bakery and deli departments-cooked or prepared food ready for serving) strategy for supermarkets [8]. Each category needs special logistical treatment. That's why it is important to distinguish foods as vegetables and fruits, meat and meat products (i.e. salami, sausage, etc.), grains, canned foods, animal products (i.e. egg, milk, yoghurt, etc.), and industrial food products (i.e. chocolate, sweeties, biscuits, etc.) [9]. Different types of products need several temperature levels. Failure to maintain appropriate temperature can shorten the life of that product or may affect its quality or fitness for consumption, also increases wastage, complicates the supply dynamics, and adds costs. Kuo and Chen [5] divided the temperature scope into three kinds including fresh goods (18 C constant), chilled goods (2 C to +7 C) and frozen goods (below 18 C). United Kingdom regulated these temperatures as follow [10]:

- Frozen: -25 degrees for ice cream; -18 degrees for other foods and food ingredients.
- Cold chill: 0 to +1 degree for fresh meat and poultry, most dairy and meat based provisions, most vegetables and some fruit.
- Medium chill: +5 degrees for some pastry-based products, butters, fats and cheeses.
- Exotic chill: +10 to +15 for potatoes, eggs, exotic fruit and bananas.

Rodrigue and Notteboom [11] indicated that four temperature standards are among the most prevalent:

- Deep freeze (-28 to -30 Celsius): The coldest temperature range that can be maintained by conventional refrigerated units. This temperature range is used mostly for transporting seafood (particularly shrimp, which is the world's most consumed seafood) and ice cream.
- Frozen (-16 to -20 Celsius): Used for transporting frozen meat, including beef, poultry and pork. Frozen bakery (cakes, bread) also falls within this temperature range.
- Chill (2 to 4 Celsius): This range comprises the standard temperatures in a refrigerator and is commonly used to transport fruit, vegetables and fresh meat as it confers optimal shelf life without freeze damage.
- Banana (12 to 14 Celsius): This is temperature range is chosen for one of the world's most produced fruit that usually has its ripening controlled during shipping. It is also used for most tropical fruits (oranges and pineapples) and vegetables (tubers such as potatoes).

Because of the lack of standards of temperature based category distinctions, one of the questions that should be inquired in food product categories in the local supermarket chain is how they do manage the different food products with respect to temperature.

Logistical Operations in Food Retailing

Retail logistics involves activities such as giving orders to suppliers, receiving orders in warehouses, distribution centers and in stores, delivering the retail products to final consumers, transferring the products between stores [12]. Most of the instruments (handling, shelf placing and replacing, inventory control, packaging, cold storage, disposing return merchandise-reverse logistics, etc.) of logistics subfunctions are equally applicable in the supermarket store from the opening time to the closing time. The Distribution Center is the measure player for these activities as seen in the figure 2.

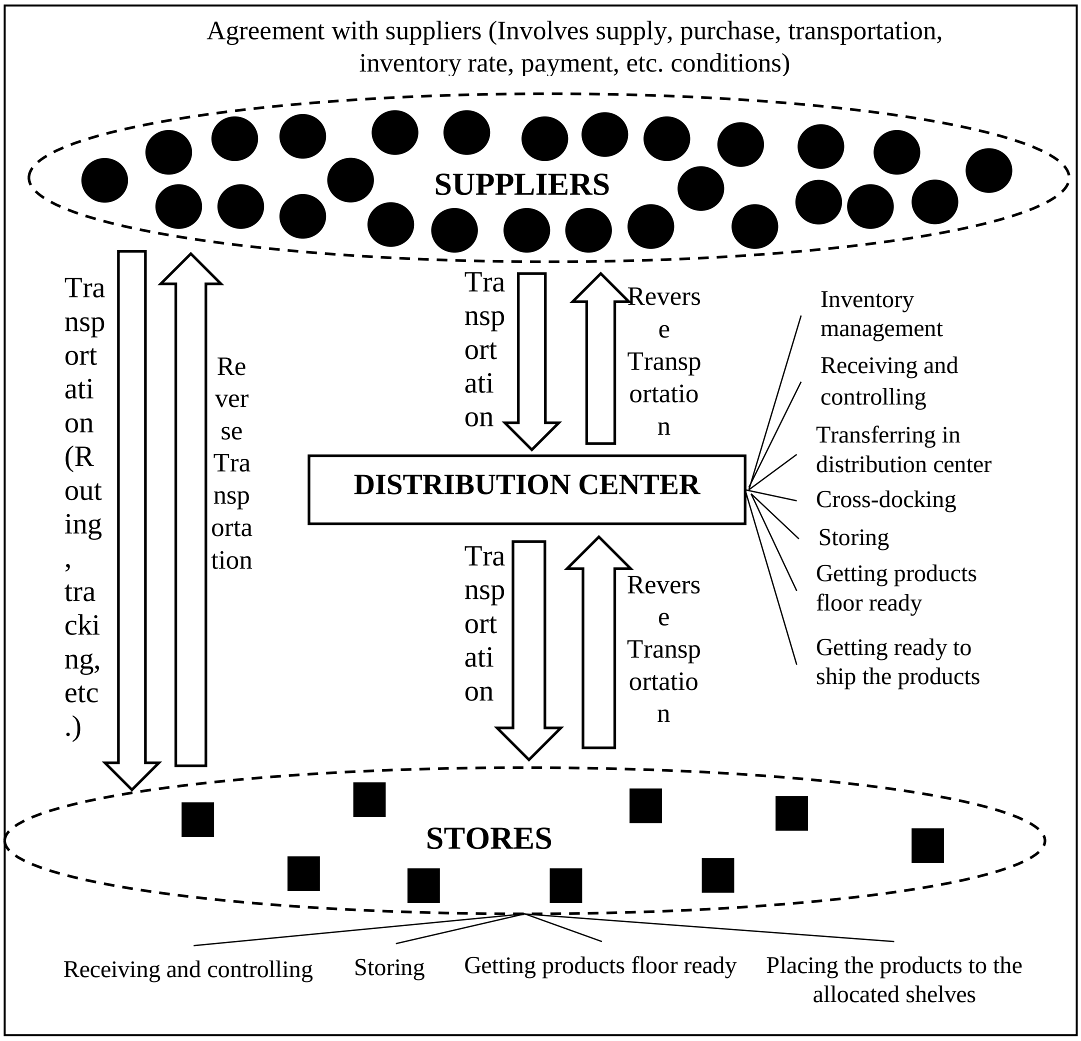
In the literature foods are handled as perishable goods while canned foods can last longer than those. Accordingly, some special logistics processes have to be carried out such as transportation, stocking, and packaging for food products. But it is vital here not to forget that special logistics activity requirements differ with the type of food products. Especially temperature controlled food products require specialized transportation equipment and storage facilities and closer monitoring of product integrity while in the logistics system. The food cold chain attempts to make sure that all kinds of perishable products with different temperature requirements can be maintained at the best quality condition, from the point of supply to the point of consumption, throughout the processes of storage and distribution [5]. To maintain food safety and quality, temperature monitoring and control are important activities in cold chain management [5]. According to Montanari [14] cold chain is referred to the equipment, processes and information management used to protect chilled and frozen foods. The integrity of the cold chain must be achieved from the point of production to the point of consumption. The phases of the logistics subfunction play a fundamental rule in order to achieve this goal. Thermal protection for perishable and temperature sensitive products, smaller shipments and timely deliveries are costly and challenging for retailers while operating the cold chains.

One of the most important activities in food retailing is *inventory management*. Inventory management has a critical importance due to the safety concerns, shelf life constraints and perishability of foods. Various activities that are undertaken by retailers in inventory management can be listed as follow [13]; (1) forecasting accurately the sales and needed inventory levels for each category, (3) placing accurate and timely orders with vendors and distribution centers. Analyzing sales transaction data with the help of sophisticated statistical methods helps food retailers to carry out tailored assortments on the basis of the characteristics of customers in each store's local market [13].

In food retailing because of the changing needs of food products which differ in terms of temperature requirement, packaging requirement, durability time requirement, etc. the warehousing activities in depots or in distribution centers differ with regard to the type of product. In the past single temperature warehouses dedicated to narrow product ranges of food, eg butters, fats and cheese at +5 degrees. With the development of retail supply chains especially with pioneering of Tesco, multi-temperature 'composite' warehouses that store, handle and deliver full range of product sets were built [1]. Mainly the processes ran in a distribution center and warehouse for foods, namely inbound logistics, can be listed as below [12], [7], [13]:

- Receiving: Recording the receipt of foods which arrives at distribution center.
- Checking: Making sure that the foods arrived are the right product, right quantity and without damage. Checking process is time consuming, if the retailer develop trustable and sustainable relationships with vendors there would be no need for the checking.
- Storing: The foods that are stocked are transferred to the cold cabinets.
- Cross-docking: The food products are prepackaged by retailer for multiple stores. Each package is labeled with the address of store.

Figure 2. Logistics Operations in Retailing



Source: Adapted from [13]; [1], [12]; [7]

- Getting foods floor-ready: This process consists of ticketing and marking which refer to affixing price and identification labels to the food products. It is more efficient for a retailer to perform these activities at a distribution center than in its stores. Getting merchandise floor ready in stores can block aisles and divert salespeople's attention from their customers. Eliminating the expensive, time consuming ticketing and marking process is important.
- Preparing to ship foods to a store: At the beginning of the day, the computer system in the distribution center generates a list of items to be shipped to each store on that day. For each item, a pick ticket and shipping label are generated. The pick ticket is a document or display on a screen in a forklift truck that indicates how much of each item to get from specific storage areas. The forklift driver goes to the storage area, picks up the number of cartons indicated on the pick ticket, places shipping labels on the cartons that indicate the stores to which the items are to be shipped and the cartons are directed to the loading dock for the truck going to the stores. Pick tickets and labels are also generated for the break pack area. Cartons with too many items to be shipped to a single store are packaged for the store. Employees, using the pick ticket select items from open cartons and put them into a new carton. When all the items have been picked, a shipping label indicating the store's destination is attached to the carton and then the carton is routed to the loading dock. So the loading dock is fed by three sources: (1)cross-docked cartons directly from the vendor's delivery trucks, (2) cartons stored in the distribution center, and (3) cartons from the break pack area.

Temperature controlled and temperature modified refrigerated vehicles are used in cold chain transportation. Temperature controlled refrigerated vehicles include vans, rigid trucks and semi-trailers that have an insulated thermostatically controlled cargo compartment and a dedicated refrigeration unit capable of maintaining the labelled temperature range of the products being transported (World Health Organization, 2014:10). Temperature modified refrigerated vehicles are similar to temperature-controlled refrigerated vehicles, except that the vehicle itself simply moderates the ambient temperature, either by heating or cooling [15]. The transported product is generally packed in a qualified passive shipping system designed to keep it within the labelled temperature range. The centers use sophisticated routing and scheduling computer systems that consider the locations of the stores, road conditions, and transportation operating constraints to develop the most efficient routes possible. As a result, stores are provided with an accurate estimated time of arrival, and vehicle utilization is maximized [13].

Information Systems' Role in Food Retailing

The sine qua non of retail logistics is efficient information systems. If the information system is not well settled, the physical flow of goods, especially in food products, can never run smoothly. Temperature tracking is prerequisite for food logistics and it can solely be achieved with the help of information systems. Armed by contemporary logistical softwares such as EDI, QR, CPFR, VMI, etc., efficient information system can improve food retailer's sales by offering more effective inventory management which results in product availability, more attractive and tailored assortments to the customers. Retailers also can lower their operating expenses by coordinating deliveries with the help of information systems, thus reducing transportation expenses. Receiving timely and accurate information from stores is the first step to arrange other logistics activities. What customers are buying and not buying and what they are asking for but not finding. The JCPenney department store chain in America downloads almost one telabayt information through a satellite system from its 1500 stores daily in order to find immediate solutions to the problems occurred in the stores [7]. The information about the transaction is captured at the point of sale (POS) terminal and sent to the retailer's information system, where it can be accessed by the planner for the product category. The planner uses this information to monitor and analyze sales and decide when to reorder or reduce the prices if sales are below expectations. By electronic communication between stores and other partners in supply chain, retailers successfully reduce lead time. Retailer-vendor information flow is achieved with help of electronic data interchange (EDI) and other methods.

MONOGRAPHIC ANALYSIS OF FOOD RETAIL LOGISTICS IN A LOCAL SUPERMARKET CHAIN

In this study it is aimed to explore how local food retailers deal with logistics management operations. This research consists of a single monographic case study of a local supermarket chain named Gürmar. This methodology was selected because a case study strategy has the ability to answer the 'how' questions and to put existing theory into a new light, which again can generate new hypotheses as well as provide in-depth insight into previously insufficiently-explored phenomenon [16]. Gürmar supermarket chains today operate with 24 stores throughout the Aegean region, one distribution center and cold storage with 8000m² in Sarnıç precinct, one warehouse in İzdep precinct and with 675 personnel in retail sector. The research method used in this research process is in-depth interview technique that allows conducting intensive individual interviews with a small number of respondents to explore the details in food retailing logistics. This qualitative method was preferred because its usefulness in the desire of gaining detailed information and exploring new issues in depth. Out of the local supermarket chain stores universe only one supermarket chain is chosen in accordance with judgment sampling. Judgment sampling, also known as purposive sampling, which is a kind of nonprobability sampling method was applied because the exploratory stages of the research are needed to be put forward. So the specialty of the researchers could select more representative retailer that operates in local market. Unstructured interviews with subject matter experts (1 veterinary, 1 purchase manager, 1 warehouse manager, 1 cold storage manager, 1 store manager) were conducted to gain general insight into how local food retailers operates logistics activities.

Food Categories in Gürmar

As could be seen the classification below Gürmar supermarket chain has classified the food categories in a logical order.

1) Frozen: Used for frozen meat, ice cream and frozen ready to cook foods like pizza, vegetables, potatoes, bakery products, meat and fish products. These category includes foods which were quick freezed at -40 degree and have been stocked at -18 degree to prevent bacterial growth and the release of microorganisms.

2) Chill: This category includes non-frozen foods like fresh chicken, meat, turkey, salami, etc., which need maximum +4 degree for storage and transportation. Here the basic point is to confer optimal shelf life without freeze damage.

3) Medium chill: The food products like milk, cheese, and yoghurt which have to be kept between +4 and +6 degrees.

4) Packed foods: The foods which can be transported with detergents in a single vehicle such as bottled and canned foods, pasta, rice, dry legumes, industrial food products like biscuits, etc.

5) Raw vegetables and fruits: In this category the fruits and vegetables do not need any cold treatment in short distance.

Monographic Analysis in Logistics Activities for Chill Foods

In this section all logistics processes are investigated in Gürmar for carcass meats and meat products.

Supplier management: Gürmar told that they purchase the meats from suppliers which are processed in accordance with the ISO2200 and HACCP system to maintain the required quality. They select the suppliers according to their core production to obtain the highest quality of the meat product. The examples of meat products and the suppliers' locations can be seen below;

- Veal carcass: Çorum, Aydın and Burdur
- Lamb carcass: İzmir and Balıkesir
- Calf's liver: Burdur and İzmir
- Tallow: Burdur and İzmir
- Tripe: Burdur, İzmir and İstanbul
- Lamb's liver: İzmir and Balıkesir
- Soudjouk: Torbalı

Before doing business together Gürmar prepare a contract with the suppliers which includes the terms about method of payment, period of payment, promotions, targeted revenue, special conditions, inventory turnover rate, etc.

Inventory management: In contrast, to the pervasive writings in the literature Gürmar doesn't use sophisticated statistical methods to analyze sales transaction data that helps food retailers to carry out tailored assortments on the basis of the characteristics of customers in each store's local market. Gürmar still trust intuition and experience of the store managers. But they use information system for more effective inventory management to prevent inventory stockout.

Receiving and controlling: The frigorific vehicle approaches to the cold receiving area and the doors of the vehicle are opened into the building and the buildings special tarpaulins cover the vehicle to prevent the ambience temperature affects the products. The carcasses arrives to the multi-temperature 'composite' distribution center in which full range of product categories can be handled. In an input form, critical control points were determined to control the carcass meats arrived are the right product, right quantity and without damage before accepting them. This form includes the followings;

- The look, smell and taste

- The quantity
- Hygiene conditions of the driver
- The cleanliness of equipment that touches on the meat
- Whether the meats touch to the floor of the vehicle
- Cleanliness of the vehicle (vehicle disinfection document)
- Veterinary stamp
- The production and expiration date
- The package of the meat
- Slaughtering and health certificates (These certificates are signed by both the veterinary of the supplier and veterinary of the government which show that the animals were slaughtered according to the hygienic and Islamic conditions)
- Vehicle temperature
- Product temperature

The carcass meats which are not fit the above conditions are sent back to the supplier with the same vehicle.

Processing: The received carcass meats are transferred in to the processing areas in cold storage apart of the distribution center and broken down into smaller parts. Although the receipt was a carcass meat, succeeding process the meats are divided into different meat products like fillet steak, beefsteak, spare rib, leg, lung, etc. The meat is in general is a category but meat products taken separately are also treated as different subcategories. The invoices of these subcategories are generated accordingly. Split meats are firstly subjected to the organoleptic, Ph and microbiological analysis lik e E.Coli, Salmonelia and mazofilic. Before storing the meat products each of them including bones are weighed. According to the weights of each piece all the inventory, profit and loss are calculated. For example in a standard carcass meat (164 kg) there would be %20 bones. So 32,8 kg bones and 131,2 kg meat are obtained. 131,2 kg meat gives wastage and after slaughtering these wastages are also calculated. After this process daily production report is prepared which includes the following items; Received product, The supplier, The quantity, Processing, Production quantity, Wastage quantity, Meat without bones quantity, Cold storage product quantity, Outgoing quantity, The quantity of the new stored meats.

Storing: The meat products that purged from bones and wastages are transferred into the storage areas in which all products have special cold rooms (lamb room, chicken room, bone room, soudjouk room, etc.) differ from 0 to +4 degrees. Machine to machine (M2M) technology and equipment is used to control the temperature and moisture levels in the cold rooms also in meat preparation room, meat receiving and outgoing corridors. If temperature falls below or rises above the standards alarms are sent automatically both to the computers and mobile phones of the employees in charge. With the help of this technology the temperature control in storage areas can be remote managed.

Order processing: In Gürmar the point-of-sale system is available. The sale quantity and the stock level can be seen in the system but top management prefers to take into account the store managers' ideas and demands about the orders because they want to keep pace with the local conditions, changing demands and promotion times. That's why generally the orders are taken via e-mail and the required meats are prepared according to the order.

Preparing to ship foods to a store: The packaging and ticketing activities are performed according to the regulations of the Ministry of Food, Agriculture and Livestock and Ministry of Health. Before sending the orders the meats are checked and controlled in terms of appearance, smell, package, quantity and label. All these controlled information is entered into final product control form. Before loading the vehicles meat warehouse outgoing form which involves product name and the quantity, the store name, the driver name is filled.

Transportation: The load rate of the vehicle depends on the order size on that day. Since the meats can't carried together with other products, transportation cost of meats is high if the order size is small. Between 08:30 and 10:30 am all the vehicles depart from the distribution center and within the day the delivery operations to the stores are achieved. With the help of tracking systems, the temperature, the route, the stopping places can be traced. By checking the temperature graphic the unloading duration can be seen as the temperature increases in the vehicle. Especially in the summer time it is important to avoid the doors of the vehicle open long time. That’s why routing and time window planning is important as the local stores are located in the crowded city centers.

Logistics activities at the point of destination: As soon as the vehicle arrives at the store the meats are transferred into the store as quickly as possible to avoid hot ambiance weather especially in the summer season. All the received meats are weighed with the weighing machine in the store or the hanging weight in the vehicle. Thereby the meat weights are cross checked by both veterinary and driver or store personnel and if the quantity is right, the dispatch list is approved. The same technology as in the distribution center, machine to machine (M2M) technology and equipment is used to control the temperature and moisture levels in the cold storage cabinets.

Reverse logistics: From the distribution center the bones as the source of protein are sent to a chicken factory in Izmir and the wastages are sent to the animal shelters or a rendering institution for destroying. In dedicated days and hours vehicles are sent to the stores for the returned meats as they expired. The stores send back the expired meats to the distribution center with dispatch note to reduce store’s inventory so the distribution center’s inventory increases as it receives the returned meats. Dispose report is prepared for returned meats to decrease the inventory level. If the meats are still valuable they are evaluated as animal feed, if they are not they are sent to the rendering institution for disposing.

Logistics Activities Performed for Other Food Product Categories

Frozen: Although they have frozen food products category they don’t operate any logistics process for these due to the special refrigerated vehicles need. The suppliers of these products deliver directly to each store according to the orders of Gürmar.

Medium chill: Here the logistics processes are a bit confusing. Gürmar has its own dairy factory in Menemen which produces milk and milk products like yoghurt, butter and cheese under the brand name of Gürsüt. These food products are produced, stored in this factory and distributed directly to the stores. Other brands’ medium chill food products come to the distribution center in Sarnıç and stored in special rooms with +4 degrees. They are prepared for the shipment according to the orders of stores and distributed with the frigorific vehicles.

Packed foods: Stores give orders to the distribution center and if there is not sufficient stock the distribution center purchasing department gives orders to the suppliers. Based on the agreements with the suppliers they have to send the orders in maximum 3 days. To control the stock levels and to give orders to the suppliers they use an information system called OBASE which involves modules like accounting, sale, and supply. The wrapped pallets with packages which are came from the suppliers are prepackaged and separated in terms of boxes or pieces. They are placed onto the allocated shelves. In the distribution center FIFO principle is applied due to the expiration dates of food products. For fast moving food products they do not avoid from stocking to prevent stock out but they try to keep the stock turnover rate at 10 days. Packed foods except chocolates are stored with other non-food products in the warehouse. According to the orders that logged into the system order picking list which involves all the food products in this category and other non-food products is printed. This list involves the information about store that gives the order, barcode, location of the products, product code, product name, order quantity, stock level, picking quantity, etc. The employees in the warehouse pick the orders from the shelves by scanning the product’s or box’s barcode with the RF handset and gather them in the loading dock. Dry foods are prepared for the shipment by wrapping them with the 22 micron stretch and putting on to the standard euro pallets. After the outgoing form is filled and the shipping labels are placed the products shipped to the stores early in the morning to avoid rush hours in traffic. In the stores placing the products on the shelves are done according to the desolate hours of the stores mostly in the mornings.

For packed foods, Gürmar’s distribution center operations are generally the same as indicated in the literature.

Raw vegetables and fruits: There is a dedicated distribution center of Gürmar in Kaynaklar precinct for fruits and vegetables which is close to the wholesale fruit and vegetable market. The products are taken to this distribution center and cross-docked immediately then distributed to the stores. In short distances (in the city) this food category do not need any cold treatment. Because the shelf life of fruits and vegetables is limited, showing special treatment in terms of both storage and distribution is important.

CONCLUSION

The cold chain food logistics system of the supermarket under analysis, which is subjected to monographic analysis, cold chain food logistics system has been found running effectively without any significant setbacks. Increasing consumer awareness of food safety, government regulations, competition with international supermarket chains, desire for obtaining loyal customers and increasing customer satisfaction are the main drivers of operating in a good order to manage cold chain logistics even in the medium sized local supermarket chains. This study highlights that although food retailing logistics structure is the same as retail logistics, every operation in the total process is more detailed, and needs diligent effort. The main contribution of this monographic analysis is showing that different food categories need different processes as can be seen in the examples of frozen, chill, medium chill, packed foods, fruits and vegetables. So it can be said conveniently that food logistics in retailing cannot be taken as a whole as it breaks into food categories with different logistics needs. However more studies need to be conducted to develop key performance indicators and best success factors. For the future studies differences and similarities in cold chain logistics applications can be researched between different food retailers. The difficulties can be identified and solution proposals can be developed.

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AN INVESTIGATION OF THE EFFECTS OF BASIC ECONOMICAL INDICATORS ON CASH TO CASH CYCLE AND WORKING CAPITAL IN RETAIL FIRMS WHICH ARE LISTED IN STOCK EXCHANGE IN FINANCIAL SUPPLY CHAIN MANAGEMENT BETWEEN 2000-2014

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Abstract_ *Beside physical goods flow also cash flow SCM exists. By applying a healthy cash flow, no shortage of cash in company occurs and value of firm increases in an efficiently financial supply chain. The aim of this study is to constitute a succesful cash flow planing by determining the basic economical values (BEV) effecting FSCM. In our analysis, retail industry is selected as target sector because SCM plays an important role in industry. As research method, linear regression analysis is applied. BEV were selected as independent variables and cash flow constituting financial ratios as dependent variables. After analysis results it is concluded that inventory keeping time is affected by €/TL, CHF/TL, export-import. DSO is not affected by anything economic indicators. Activity period is affected by €/TL, CHF/TL, export -import. WC turnover is not affected by anything economic indicators. If firms are constituting their FSCM planing considering economical values affected by cash flow, an effective business capital management can be actualised.*

Keywords_*Cash-to-Cash Cycle, economic indicators, Financial Supply Chain Mangement, Retail Industry*

1. INTRODUCTION

Beside physical goods flow also cash flow in supply chain management (SCM) exists. By applying a healthy cash flow, no shortage of cash in company occurs and value of firm increases in an efficiently financial supply chain. To apply a succesful planing in financial supply chain management (FSCM), firms should have a knowledge of which basic economical values are effective and the effectiveness degree on cash flow. The aim of this study is to constitute a succesful cash flow planing by determining the basic economical values (BEV) effecting FSCM. In our analysis, retail industry is selected as target sector because SCM plays an important role in industry.

As research method, linear regression analysis is applied. Dependent variables are Days in inventory, Days sales outstanding, Activity Period and Working Capital turnover. Dependent variables are €/TL Exchange, \$/TL Exchange, £/TL Exchange, CHF/TL Exchange, Cunsomer Prices, Producer Prices, Interest of deposit rate p.a., Unemployment Ratio, GNP Growth Rate, Exort and Import.

2. CASH-TO-CASH CYCLE: DEFINITION AND MEASUREMENT

Cash-to-Cash cycle is the duration between the purchase of a firm's inventory and the collection of accounts receivable for the sale of that inventory. (Duration measured in days). Usually a company acquires inventory on credit, which results in accounts payable. The company will then sell the inventory on credit, which results in accounts receivable. Cash is therefore not involved until the company pays the accounts payable and collects accounts receivable. So the cash conversion cycle measures the time between outlay of cash and the cash recovery (Ref. 6).

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The cycle is composed of three main working capital components: Days Inventory Outstanding (DIO), Days sales outstanding (DSO) and Days Payable Outstanding (DPO). The Cash Conversion Cycle (CCC) is equal to the time is takes to sell inventory and collect receivables less the time it takes to pay the company's payables (Ref. 1):

Cash Conversion Cycle (CCC) = DIO + DSO – DPO

A short cycle allows a business to quickly acquire cash that can be used for additional purchases or debt repayment. The lower the cash conversion cycle, the more healthy a company generally is. Businesses attempt to shorten the cash conversion cycle by speeding up payments from customers and slowing down payments to suppliers. CCC can even be negative; for instance, if the company has a strong market position and can dictate purchasing terms to suppliers (i.e. can postpone its payments).

There are various key performance indicators that are relevant for measurement in financial supply chain management. One key metrics is the cash flow cycle and working capital turnover. Cash flow cycle is show in figure 1. It is the time period required for the company to receive the invested funds back in the form of cash. The longer the cash flow cycle, the greater is the working capital requirement of a company, which means that a reduction of the cash flow cycle will immediately free up liquidity (Ref. 3)

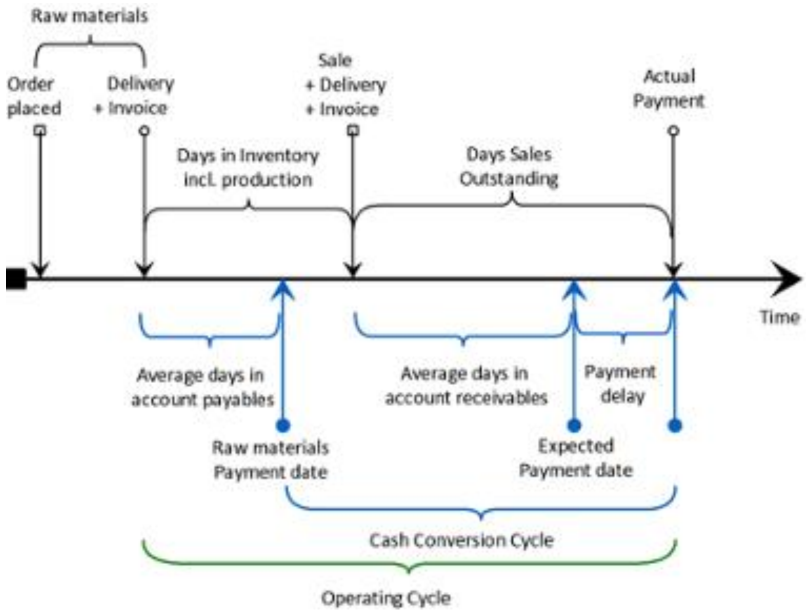

Figure. 1 Cash to cash cycle (Ref 7)

Within the cash flow cycle we can differentiate the following parameters, which are delimited in Figure 1 with curly brackets (Ref. 4):

1)Days in inventory (DIO): This is the length of time between the delivery of the goods and the invoice from the supplier, and the sale of the goods and the invoice to the customer. It describes the average number of days the goods of a company remain in inventory before being sold. This metric is the focus for all activities around classical supply chain management.

2)Days in payables (DIP): This is the length of time between delivery of the goods and the invoice from the supplier, and the actual payment for the inventory. This figure describes the average time it takes to pay a supplier. The parameter considers the outstanding receivables of a company, and is an important metric for debtors concentrating on their efforts to optimize the purchase-to-pay cycle.

3)Days sales outstanding (DSO): This is the length of time between the sale of the goods and the invoice to the customer, and the actual payment date of the customer. This metric measures the average number of days companies need to collect revenue after a sale has been made. A high DSO number means that an enterprise is selling to its customers on credit and taking longer to collect money.

4)Days in receivables (DIR): This is the length of time between the sale of the goods and the invoice to the customer, and the expected payment date. This key performance indicator is similar to DSO, and indicates the average time, in days, that receivables are outstanding. Days in receivables can also be called best possible DSO, since the company would collect all receivables before the due date.

5)Activity Period: DIO+DSO

6)Net Working Capital Turnover

3. RESEARCH DESIGN/METHODOLOGY

3.1. Companies

In this study are used five retail companies, that are listed on Borsa Istanbul: BİM, Migros, CarrefourSa, Kiler and Tesco Kiper.

DIO, DSO, Activity Period and Net working capital turnover are calculated for tis companies. For these calculations the data used from Borsa İstanbul (Ref. 8) and Public Disclosure Platform (KAP) (Ref. 9). The economic indictors for the analysis have been obtained from Turkish Central Bank (Ref. 10) and Turkish Statistical Institute (Ref. 11).

3.2. Variables and Regression Model Equation

Since it is not possible to calculate DIP by using balance sheets in Türkey, in the analysis only DIO, DSO, AP and WCT were used. The dependent and independent variables in the analysis are:

Variables	**Abbreviation**	**Measurements**	
Dependent variable			
Days Inventory Outstanding	DIO	DIO = Average inventory/COGS* per day Average Inventory = (beginning inventory + ending inventory)/2	
Days sales outstanding	DSO	DSO = Average AR / Revenue per day Average AR = (beginning AR + ending AR)/2	
Activity Period	AP	AP=DIO+DSO	
Working Capital Turnover	WCT	WCT= WC/Revenue peer Day	
Independent variables			
€/TL Exchange	EX1	Interest of deposit rate p.a.	IDR
$/TL Exchange	EX2	Unemployment Ratio (%)	UR
£/TL Exchange	EX3	GNP Growth Rate (%)	GGR
CHF/TL Exchange	EX4	Export	EXP
Cunsomer Prices (%)	CP	Import	IMP

Producer Prices (%)	PP

***cost of goods sold**=COGS

The regression equation gives an estimation of the linear relationship between a dependent and one or more independent variables. General syntax for regression equation is (Ref. 5):

$$Y = \beta 0 + \beta 1\ X1 + \beta 2\ X2 + \beta 3\ X3 + \beta 4\ X4 + \ldots\ldots\ldots\ldots + \beta nXn + \epsilon$$

Left side (Y) of the equation contains the outcome variable while right side contains the coefficients of independent variables X1, X2……so on and βn specifies the coefficient of the independent variable (Xn).

4. DATA ANALYSIS AND RESULTS

4.1. Correlation and Regression Results

In the analysis R-squared method (**coefficient of determination**) is applied for statistical analysis Ref. (2)

- The coefficient of determination is the square of the correlation (r) between predicted y scores and actual y scores; thus, it ranges from 0 to 1. With linear regression, the coefficient of determination is also equal to the square of the correlation between x and y scores.

- An R^2 of 0 means that the dependent variable cannot be predicted from the independent variable. An R^2 of 1 means the dependent variable can be predicted without error from the independent variable. An R^2 between 0 and 1 indicates the extent to which the dependent variable is predictable. An R^2 of 0.10 means that 10 percent of the variance in *Y* is predictable from *X*; an R^2 of 0.20 means that 20 percent is predictable; and so on

Regression analysis were performed for quarter periods between 2000 and 2014. In table 1 the results of regression analysis for 1st quarter between 2000 and 2014 is given.

Table 1. Results For The First Quarter

	DIO				DSO		
DIO in day	y = 11,103x - 22148	R^2 = 0,9002	Positive	**DSO in day**	y = 2,0961x + 12,424	R^2 = 0,4468	Positive
€/TL	y = 69,95x + 7,0933	R^2 = 0,6689	Positive	€/TL	y = 12,959x + 5,3695	R^2 = 0,3197	Positive
$/TL	y = 99,61x - 10,272	R^2 = 0,4954	Positive	$/TL	y = 18,694x + 1,801	R^2 = 0,243	Positive
Sterlin/TL	y = 54,287x + 4,9062	R^2 = 0,4073	Positive	Sterlin/TL	y = 9,215x + 6,9934	R^2 = 0,1634	Positive
CHF/TL	y = 85,672x + 23,763	R^2 = 0,8059	Positive	CHF/TL	y = 14,246x + 10,581	R^2 = 0,3103	Positive
Cunsomer Prices (%)	y = -1,4812x + 164,91	R^2 = 0,3527	Negative	Cunsomer Prices (%)	y = -0,2492x + 34,108	R^2 = 0,139	Negative
Producer Prices (%)	y = -1,3311x + 162,17	R^2 = 0,3538	Negative	Producer Prices (%)	y y = -0,2354x + 33,876	R^2 = 0,1541	Negative
Interest of deposit rate p.a. (%)	y = -1,5151x + 175,97	R^2 = 0,4578	Negative	Interest of deposit rate p.a. (%)	y = -0,2279x + 35,252	R^2 = 0,1442	Negative
Unemployment Ratio (%)	y = -1,3999x + 152,53	R^2 = 0,003	Negative	Unemployment Ratio (%)	y = 1,3701x + 12,705	R^2 = 0,0395	Positive
GNP Growth Rate (%)	y = -0,0241x + 135,81	R^2 = 9E-06	Negative	GNP Growth Rate (%)	y = -0,6883x + 32,678	R^2 = 0,1043	Negative
Export ($)	y = 4E-09x + 42,028	R^2 = 0,8658	Positive	Export ($)	y = 8E-10x + 10,767	R^2 = 0,4666	Positive
Import ($)	y = 3E-09x + 45,905	R^2 = 0,8711	Positive	Import ($)	y = 5E-10x + 13,294	R^2 = 0,3804	Positive

	Activity Period				WC Turnover		
Activity Period (Day)	y = 11,413x + 66,594	R^2 = 0,8954	Positive	**WC Turnover**	y = -0,8905x + 11,106	R^2 = 0,4901	Negative
€/TL	y = 71,797x + 25,914	R^2 = 0,6633	Positive	**€/TL**	y = -5,3102x + 13,744	R^2 = 0,3262	Negative
$/TL	y = 99,965x + 11,423	R^2 = 0,4697	Positive	**$/TL**	y = -6,3201x + 13,242	R^2 = 0,1688	Negative
Sterlin/TL	y = 54,513x + 26,577	R^2 = 0,3866	Positive	**Sterlin/TL**	y = -4,1341x + 13,941	R^2 = 0,1999	Negative
CHF/TL	y = 86,1x + 45,417	R^2 = 0,7662	Positive	**CHF/TL**	y = -5,754x + 11,499	R^2 = 0,3077	Negative
Cunsomer Prices (%)	y = -1,5303x + 188,09	R^2 = 0,3544	Negative	**Cunsomer Prices (%)**	y = 0,1374x + 1,2708	R^2 = 0,257	Positive
Producer Prices (%)	y = -1,3639x + 185,03	R^2 = 0,3497	Negative	**Producer Prices (%)**	y = 0,1262x + 1,4699	R^2 = 0,2694	Positive
Interest of deposit rate p.a. (%)	y = -1,5245x + 198,43	R^2 = 0,4363	Negative	**Interest of deposit rate p.a. (%)**	y = 0,1551x - 0,1422	R^2 = 0,406	Positive
Unemployment Ratio (%)	y = 0,3572x + 153,6	R^2 = 0,0002	Positive	**Unemployment Ratio (%)**	y = -0,3561x + 8,2673	R^2 = 0,0162	Negative
GNP Growth Rate (%)	y = -0,3489x + 159,67	R^2 = 0,0018	Negative	**GNP Growth Rate (%)**	y = 0,0165x + 3,8979	R^2 = 0,0004	Positive
Export ($)	y = 4E-09x + 60,711	R^2 = 0,8776	Positive	**Export ($)**	y = -4E-10x + 11,748	R^2 = 0,5039	Negative
Import ($)	y = 3E-09x + 65,624	R^2 = 0,8663	Positive	**Import ($)**	y = -2E-10x + 11,147	R^2 = 0,4696	Negative

As a result of analysis, for the 1st periods of the focused time period, DIO is mostly affected by €/TL, CHF/TL, Export and Import and it is also noted that the effect of these parameters are the same way. On the other hand, there are no macroeconomic indicators that effect DSO strongly. There are strong and positive relation of export and import on Activity periods. Besides it has also moderate-strong relation with CHF/TL and €/TL. However there is no moderate or strong relation of the selected independent parameters on WC turnover. In table 2. the results of regression analysis for second quarter between 2000 and 2014 is given.

Table 2. Results For The Second Period Quarters

	DIO				DSO		
DIO in day	y = 5,344x + 29,225	R^2 = 0,8767	Positive	**DSO in day**	y = 0,766x + 9,3668	R^2 = 0,2853	Positive
€/TL	y = 37,153x + 2,171	R^2 = 0,671	Positive	**€/TL**	y = 5,2883x + 5,5586	R^2 = 0,2153	Positive
$/TL	y = 49,736x - 2,8972	R^2 = 0,4583	Positive	**$/TL**	y = 7,401x + 4,3529	R^2 = 0,1608	Positive
Sterlin/TL	y = 26,578x + 5,1476	R^2 = 0,3725	Positive	**Sterlin/TL**	y = 4,2193x + 4,8854	R^2 = 0,1487	Positive
CHF/TL	y = 42,976x + 14,132	R^2 = 0,8071	Positive	**CHF/TL**	y = 4,7109x + 9,1539	R^2 = 0,1536	Positive
Cunsomer Prices (%)	y = -0,8791x + 88,444	R^2 = 0,4103	Negative	**Cunsomer Prices (%)**	y = -0,1491x + 18,287	R^2 = 0,1869	Negative
Producer Prices (%)	y = -0,774x + 86,206	R^2 = 0,3867	Negative	**Producer Prices (%)**	y = -0,1363x + 18	R^2 = 0,1899	Negative
Interest of deposit rate p.a. (%)	y = -1,2425x + 101,05	R^2 = 0,6495	Negative	**Interest of deposit rate p.a. (%)**	y = -0,1907x + 19,958	R^2 = 0,2424	Negative
Unemployment Ratio (%)	y = 1,697x + 55,366	R^2 = 0,011	Positive	**Unemployment Ratio (%)**	y = 0,9732x + 5,9682	R^2 = 0,0575	Positive
GNP Growth Rate (%)	y = 0,0211x + 71,881	R^2 = 2E-05	Positive	**GNP Growth Rate (%)**	y = -0,2273x + 16,526	R^2 = 0,0394	Negative
Export ($)	y = 2E-09x + 25,831	R^2 = 0,8316	Positive	**Export ($)**	y = 3E-10x + 8,6391	R^2 = 0,2907	Positive
Import ($)	y = 1E-09x + 28,067	R^2 = 0,8359	Positive	**Import ($)**	y = 2E-10x + 9,150	R^2 = 0,2764	Positive

	Activity Period				WC Turnover		
Activity Period (Day)	y = 5,7829x + 38,553	R^2 = 0,8793	Positive	**WC Turnover**	y = -1,0465x + 16,224	R^2 = 0,1719	Negative
€/TL	y = 39,934x + 9,7857	R^2 = 0,6639	Positive	**€/TL**	y = -5,7201x + 18,599	R^2 = 0,0813	Negative
$/TL	y = 53,164x + 4,7807	R^2 = 0,4486	Positive	**$/TL**	y = -2,4159x + 11,489	R^2 = 0,0055	Negative
Sterlin/TL	y = 28,833x + 12,315	R^2 = 0,3755	Positive	**Sterlin/TL**	y = -3,4612x + 16,555	R^2 = 0,0323	Negative
CHF/TL	y = 45,289x + 23,857	R^2 = 0,7677	Positive	**CHF/TL**	y = -5,8804x + 15,767	R^2 = 0,0773	Negative
Cunsomer Prices (%)	y = -0,9436x + 102,49	R^2 = 0,4049	Negative	**Cunsomer Prices (%)**	y = 0,1514x + 5,0164	R^2 = 0,0622	Positive
Producer Prices (%)	y = -0,8261x + 100	R^2 = 0,3774	Negative	**Producer Prices (%)**	y = 0,149x + 5,113	R^2 = 0,0733	Positive
Interest of deposit rate p.a. (%)	y = -1,3214x + 115,73	R^2 = 0,6291	Negative	**Interest of deposit rate p.a. (%)**	y = 0,3325x + 0,0727	R^2 = 0,2378	Positive
Unemployment Ratio (%)	y = 2,3137x + 62,169	R^2 = 0,0176	Positive	**Unemployment Ratio (%)**	y = 0,8437x - 0,4066	R^2 = 0,0139	Positive
GNP Growth Rate (%)	y = -0,2677x + 86,031	R^2 = 0,003	Negative	**GNP Growth Rate (%)**	y = -0,007x + 7,8841	R^2 = 1E-05	Negative
Export ($)	y = 2E-09x + 34,116	R^2 = 0,8598	Positive	**Export ($)**	y = -4E-10x + 17,969	R^2 = 0,2043	Negative
Import ($)	y = 1E-09x + 37,309	R^2 = 0,8381	Positive	**Import ($)**	y = -3E-10x + 18,338	R^2 = 0,2437	Negative

As a result of analysis, for the second periods of the focused time period, DIO is mostly affected by Export and Import and it is also noted that the effect of these parameters are the same way. Besides it has also moderate-strong relation with CHF/TL, €/TL and deposit interest rate. On the other hand, there are no macroeconomic indicators that effect DSO strongly. DIO's relations are valid for the Activity period also applies to. However there is no moderate or strong relation of the selected independent parameters on WC turnover. In table 3. the results of regression analysis for third quarter between 2000 and 2014 is given.

Table 3. The Regression Results For The Thirth Period Quarters

	DIO				DSO		
DIO in day	y = 3,3165x + 22,924	R² = 0,8006	Positive	DSO in day	y = 0,5176x + 7,0321	R² = 0,3455	Positive
€/TL	y = 24,093x + 3,3316	R² = 0,6875	Positive	€/TL	y = 3,8583x + 3,7866	R² = 0,3123	Positive
$/TL	y = 28,408x + 5,794	R² = 0,4175	Positive	$/TL	y = 4,4445x + 4,3421	R² = 0,181	Positive
Sterlin/TL	y = 17,778x + 4,1373	R² = 0,4168	Positive	Sterlin/TL	y = 3,4937x + 2,267	R² = 0,2851	Positive
CHF/TL	y = 26,387x + 13,205	R² = 0,7707	Positive	CHF/TL	y = 3,4411x + 6,4457	R² = 0,2322	Positive
Cunsomer Prices (%)	y = -0,5592x + 59,267	R² = 0,3501	Negative	Cunsomer Prices (%)	y = -0,0933x + 12,81	R² = 0,1728	Negative
Producer Prices (%)	y = -0,431x + 57,072	R² = 0,2755	Negative	Producer Prices (%)	y = -0,0744x + 12,488	R² = 0,1454	Negative
Interest of deposit rate p.a. (%)	y = -0,7921x + 67,702	R² = 0,6178	Negative	Interest of deposit rate p.a. (%)	y = -0,1296x + 14,159	R² = 0,293	Negative
Unemployment Ratio (%)	y = 2,0183x + 29,306	R² = 0,0364	Positive	Unemployment Ratio (%)	y = 0,8554x + 2,6336	R² = 0,1159	Positive
GNP Growth Rate (%)	y = -0,028x + 49,563	R² = 5E-05	Negative	GNP Growth Rate (%)	y = -0,27x + 12,21	R² = 0,0879	Negative
Export ($)	y = 1E-09x + 20,383	R² = 0,7405	Positive	Export ($)	y = 2E-10x + 6,3908	R² = 0,3549	Positive
Import ($)	y = 8E-10x + 20,378	R² = 0,7589	Positive	Import ($)	y = 1E-10x + 6,7703	R² = 0,3082	Positive

	Activity Period				WC Turnover		
Activity Period (Day)	y = 3,3676x + 31,043	R² = 0,7853	Positive	WC Turnover	y = -1,921x + 29,004	R² = 0,1963	Negative
€/TL	y = 24,446x + 11,183	R² = 0,6734	Positive	€/TL	y = -9,3226x + 31,79	R² = 0,0716	Negative
$/TL	y = 28x + 14,95	R² = 0,3859	Positive	$/TL	y = 2,5258x + 10,849	R² = 0,0021	Positive
Sterlin/TL	y = 18,045x + 11,984	R² = 0,4085	Positive	Sterlin/TL	y = -4,8569x + 26,574	R² = 0,02	Negative
CHF/TL	y = 26,057x + 22,188	R² = 0,715	Positive	CHF/TL	y = -7,6404x + 24,53	R² = 0,0426	Negative
Cunsomer Prices (%)	y = -0,569x + 67,967	R² = 0,3449	Negative	Cunsomer Prices (%)	y = 0,6148x + 3,4278	R² = 0,3736	Positive
Producer Prices (%)	y = -0,4292x + 65,568	R² = 0,2599	Negative	Producer Prices (%)	y = 0,5616x + 4,3458	R² = 0,4156	Positive
Interest of deposit rate p.a. (%)	y = -0,802x + 76,459	R² = 0,6025	Negative	Interest of deposit rate p.a. (%)	y = 0,6816x - 1,7487	R² = 0,391	Positive
Unemployment Ratio (%)	y = 2,9758x + 28,276	R² = 0,0753	Positive	Unemployment Ratio (%)	y = -3,4318x + 48,682	R² = 0,0932	Negative
GNP Growth Rate (%)	y = -0,3762x + 59,428	R² = 0,0092	Negative	GNP Growth Rate (%)	y = -1,8811x + 22,074	R² = 0,2135	Negative
Export ($)	y = 1E-09x + 28,12	R² = 0,7433	Positive	Export ($)	y = -7E-10x + 31,334	R² = 0,2122	Negative
Import ($)	y = 8E-10x + 28,468	R² = 0,7439	Positive	Import ($)	y = -5E-10x + 32,449	R² = 0,2522	Negative

As a result of analysis, for the third periods of the focused time period, DIO has also moderate-strong relation with CHF/TL, €/TL, export, import and deposit interest rate. On the other hand, there are no macroeconomic indicators that effect DSO strongly. DIO's relations are valid for the Activity period also applies to. However there is no moderate or strong relation of the selected independent parameters on WC turnover. In table 4. the results of regression analysis for fourth quarter between 2000 and 2014 is given.

Table 4. The Regression Results For The Fourth Period Quarters

	DIO				DSO		
DIO in day	y = 2,5894x + 16,031	R² = 0,9451	Positive	**DSO in day**	y = 0,1099x + 5,9581	R² = 0,0242	Positive
€/TL	y = 17,416x + 2,7272	R² = 0,7173	Positive	**€/TL**	y = 0,2701x + 6,3098	R² = 0,0024	Positive
$/TL	y = 22,68x + 1,6553	R² = 0,5652	Positive	**$/TL**	y = -1,2548x + 8,779	R² = 0,0245	Negative
Sterlin/TL	y = 12,901x + 3,8607	R² = 0,445	Positive	**Sterlin/TL**	y = -0,6541x + 8,504	R² = 0,0162	Negative
CHF/TL	y = 19,148x + 9,5985	R² = 0,8287	Positive	**CHF/TL**	y = -0,3455x + 7,3272	R² = 0,0038	Negative
Cunsomer Prices (%)	y = -0,4029x + 43,349	R² = 0,3405	Negative	**Cunsomer Prices (%)**	y = -0,0286x + 7,3058	R² = 0,0243	Negative
Producer Prices (%)	y = -0,2692x + 41,35	R² = 0,2396	Negative	**Producer Prices (%)**	y = -0,0226x + 7,2243	R² = 0,024	Negative
Interest of deposit rate p.a. (%)	y = -0,1575x + 41,631	R² = 0,3143	Negative	**Interest of deposit rate p.a. (%)**	y = -0,0118x + 7,2041	R² = 0,0251	Negative
Unemployment Ratio (%)	y = -0,0938x + 37,774	R² = 0,0001	Negative	**Unemployment Ratio (%)**	y = 0,6363x - 0,1348	R² = 0,0903	Positive
GNP Growth Rate (%)	y = -0,0332x + 36,884	R² = 0,0003	Negative	**GNP Growth Rate (%)**	y = -0,2069x + 7,6974	R² = 0,1417	Negative
Export ($)	y = 1E-09x + 12,266	R² = 0,8995	Positive	**Export ($)**	y = 7E-11x + 5,1167	R² = 0,063	Positive
Import ($)	y = 6E-10x + 12,826	R² = 0,9292	Positive	**Import ($)**	y = 3E-11x + 5,7098	R² = 0,0293	Positive

	Activity Period				WC Turnover		
Activity Period (Day)	y = 2,66x + 21,163	R² = 0,9265	Positive	**WC Turnover**	y = -1,839x + 27,289	R² = 0,2324	Negative
€/TL	y = 17,573x + 8,117	R² = 0,6784	Positive	**€/TL**	y = -11,86x + 35,743	R² = 0,1622	Negative
$/TL	y = 21,882x + 8,5867	R² = 0,4887	Positive	**$/TL**	y = -9,5976x + 27,426	R² = 0,0494	Negative
Sterlin/TL	y = 12,21x + 11,319	R² = 0,3702	Positive	**Sterlin/TL**	y = -9,4031x + 36,54	R² = 0,1153	Negative
CHF/TL	y = 18,992x + 15,517	R² = 0,7573	Positive	**CHF/TL**	y = -9,3933x + 25,894	R² = 0,0972	Negative
Cunsomer Prices (%)	y = -0,3981x + 48,967	R² = 0,3088	Negative	**Cunsomer Prices (%)**	y = 0,5894x + 2,9167	R² = 0,3554	Positive
Producer Prices (%)	y = -0,2665x + 47,002	R² = 0,2183	Negative	**Producer Prices (%)**	y = 0,4399x + 5,0522	R² = 0,3121	Positive
Interest of deposit rate p.a. (%)	y = -0,1584x + 47,353	R² = 0,295	Negative	**Interest of deposit rate p.a. (%)**	y = 0,168x + 7,367	R² = 0,1743	Positive
Unemployment Ratio (%)	y = 0,269x + 39,495	R² = 0,0011	Positive	**Unemployment Ratio (%)**	y = -3,4286x + 50,146	R² = 0,0902	Negative
GNP Growth Rate (%)	y = -0,2746x + 43,585	R² = 0,0164	Negative	**GNP Growth Rate (%)**	y = -0,7753x + 15,8	R² = 0,0684	Negative
Export ($)	y = 1E-09x + 16,806	R² = 0,9164	Positive	**Export ($)**	y = -8E-10x + 31,574	R² = 0,2641	Negative
Import ($)	y = 6E-10x + 17,911	R² = 0,9079	Positive	**Import ($)**	y = -4E-10x + 29,766	R² = 0,234	Negative

As a result of analysis, for the fourth periods of the focused time period, DIO is mostly affected by Export and Import and it is also noted that the effect of these parameters are the same way. Besides it has also moderate-strong relation with CHF/TL and €/TL. There are no macroeconomic indicators that effect DSO strongly. DIO's relations are valid for the Activity period also applies to. However there is no moderate or strong relation of the selected independent parameters on WC turnover.

4.2. Conclusion

DIO has every quarter strong relation between €/TL, CHF/TL, Export and import. When these variables are increasing, DIO is increasing too. There are no macroeconomic indicators that effect DSO strongly. DIO's relations are valid for the Activity period also applies to. However there is no moderate or strong relation of the selected independent parameters on WC turnover.

In the planning periods for DIO, companies should be consider €/TL, CHF/TL, Export and Import. However, DSO and WC except for specified in the planning of economic indicator should be taken into consideration.

When the companies consider the economic indicators, there won't be any problem in the cash flow processes. If companies are constituting their FSCM planing considering economical values affected by cash flow, an effective business capital management can be actualised. This will conclude not only in an increase of trade value of the firm but also will increase the added value to the economy.

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SUPPLY CHAIN PRACTICES OF WAL-MART AND MIGROS: BENCHMARKING WAL-MART FOR IMPROVING EFFICIENCY

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Abstract_-Broadly, objective of this paper is to conduct a research about supply chain management initiatives of Wal-Mart and Turkish retailer Migros in general and to specifically focus on what strategies can be transferred to Migros for efficiency improvement. For Migros, it is aimed to identify potential change for the better. Data about existing supply chain management practices of Wal-Mart and Migros were obtained through academic sources, online industry sources, covering consultancy web sites, press releases and whitepapers. Detailed and supportive information about Migros supply chain initiatives and limitations of some practices were discovered through interviews with industry experts. Gathering the information and analyzing contributed to form a proposal for benchmarking.

Keywords - Supply Chain Management, Wal-Mart, Migros, Benchmarking, Information Technology.

INTRODUCTION

This paper's goal in searching the academic literature for Wal-Mart was to identify its best supply chain practices and analyze its background for the reasons of success. The aim in conducting Migros interviews was exploring company's logistics and supply chain management practices. As business strategies are critical and closely linked to company's supply chain strategies, it was tried to find out what is important for firm in conducting its business and what their current policies are for supporting supply chain management. Together with assessing industry expert's views and current state of Migros from literature potential areas for improvement were discovered. Comparing with Wal-Mart and analyzing important strategic success factors of Wal-Mart it was proposed that Migros can add value to its supply chain by benchmarking and adopting some best practices of Wal-Mart.

LITERATURE REVIEW

Wal-Mart's Background

Since the first Wal-Mart Store opened in 1962 in Rogers, Arkansas with the strategy of "lowest prices anytime, anywhere", company's success has grown significantly. In 90s, Wal-Mart became America's top retailer and opened its one-stop shopping and everyday low price strategies to the world. After hitting a sales number of $1 billion per week in 1993, in the new millennium company offered online shopping to its customers through walmart.com. In 2014, Wal-Mart sales scaled up to $473,076 million, and currently company serves more than 200M customers every week with its 2.2M associates and 11,000 sales units [21]. Based on the data provided from Wal-Mart Annual Report of 2014, Wal-Mart U.S., Sam's Club and Wal-Mart International are three segments of the company [13]. Wal-Mart U.S. segment includes supercenters, discount stores and neighbourhood markets. Sam's Club operates warehouse membership clubs which generally sell wholesale merchandise. Wal-Mart International segment has around 6,100 stores operating at 26 countries [13].

As seen in the table below Wal-Mart enhanced its revenue by 1.6% and 5.0% in 2014 and 2013, respectively. During fiscal 2014, company's primary focus was e-commerce activities and information systems' investments. Wal-Mart has a high gain in market share. According to Deloitte's Top 10 Global Retailers List, Wal-Mart having revenue of 4.5 times greater than its closest competitor Costco remained the world's largest retailer in 2013 [20].

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Table 1. Wal-Mart’s 3 Year Net Sales Growth

2014	2014	2013	2013	2012
Net Sales (Amounts in millions)	Percent Change	Net Sales (Amounts in millions)	Percent Change	Net sales (Amounts in millions)
$473,076	1.6%	$465,604	5.0%	$443,416

Source: Wal-Mart Annual Report 2014 [13]

Wal-Mart’s strategy is based on its EDLC-EDLP business model (Everyday Low Costs- Everyday Low Prices). Conducting EDLC by boosting productivity so that to transfer the savings to customers, facilitates the EDLP strategy. Wal-Mart provides significant discounts on prices and enhances the overall revenue.

Chandran (2003) reports that strategies in center of attention were always eliminating costs, raising sales, implementing efficient distribution and logistics management systems and utilization of innovative information technology (IT) mechanisms [3]. Chandran (2003) also supports the views of analysts on underlying efficient supply chain management practices led Wal-Mart to become an industry leader [3]. Another Wal-Mart policy is the use of its bargaining power and negotiating on prices for passing the price to customers. Moreover, Wal-Mart products cannot be defined as high-end, luxury or fashionable which drives EDLP strategy. Goal is offering a wide range of products with lowest prices under one-stop shopping experience [4].

Migros’ Background

Migros, considered the pioneer of retailing in Turkey offers customers a very wide range of merchandise in various store formats. In order to give customers benefits of technological developments, company is densely focusing on information technology and giving special effort in its R&D center. Among retailers in Turkey, Migros is the only one having a R&D center. According to world’s retailing league table Migros was the top retailer of Turkey and ranked 199th in the world by 2011.

Migros has 1,264 stores in total offering different store formats such as supermarket, hypermarket, online and wholesale. These stores having totally a sales area of 1,617,144 square meter locate in 70 provinces in Turkey and some countries abroad. “Sanal Market” channel offers one stop shopping experience in 21 provinces. Altogether with Migros supermarkets, Migros Jet discount stores, international Ramstore shopping centers, online shopping, wholesale stores, and mobile sales units, Migros Ticaret A.Ş. serves an estimated 1.75 million customers every day [10].

Table 2. Migros’ 3 Year Net Sales Growth

2014	2014	2013	2013	2012
Net Sales (Amounts in millions)	Percent Change	Net Sales (Amounts in millions)	Percent Change	Net sales (Amounts in millions)
$3,457	14%	$3,032	10%	$2,758

Source: Migros Annual Reports of 2014 and 2013 [10]

In 2014, Migros grew by around %14 with consolidated sales of $3,457 million and market share improved reaching %14.7 of FMCG sales in the organized sector in Turkey. In terms of stock turnover, company improvement on inventory days (2 days) was recorded as a result of company’s efficiency enhancement strategies.

Unlike Wal-Mart Migros is not an EDLP strategy implementer. However, in private label product lines regular Every Day Low Pricing is implemented mostly under Migros Jet format. Customer relationships management (CRM) application for various customer segments is important for company. By offering holistic marketing campaigns and by clever promotions for Money Club Card owners competitive pricing is aimed, and Club Card Loyalty Program is maintained. Migros is offering a wide range of branded FMCG and fresh food. Macrocenter supermarkets' goal is providing exclusive shopping with luxurious store design and premium quality in products such as diverse gourmet products. In addition to these, Migros wholesale & food service channel concentrate on "Horeca" penetration with sales team and warehouses.

As a business strategy Migros' priority is not the lowest price in the market. Quality is the must-have of the company and according to experts' views even this should be reflected to price, they try to lower the prices as much as possible through special promotions.

Wal-Mart and Migros Overview

Wal-Mart is the world's largest retailer and one of the world's biggest companies. Besides, Wal-Mart is known as the best-in-class company for its supply chain management which provided efficiency improvement in logistics, distribution, customer services and many other operations. The main emphasis in Wal-Mart is the information technology which drives all other best practices.

Certainly, characteristics of Wal-Mart and Migros differ in many aspects and they are two different companies with different strategies. Some comparative statistics of Wal-Mart and Migros demonstrated in Table 3 represents Wal-Mart's significant hugeness. Wal-Mart and Migros are operating in different environments. Regulations, distributions systems, economic and cultural structures are completely different. Moreover, they have different supply chain processes linked to their business strategy. Price is much more important for Wal-Mart and Migros' focus is on quality for customers. Nevertheless Migros tries to provide competitive prices by promotions and discount stores. However, Migros is not an EDLP implementer. In order to lower prices and maintain EDLP strategy Wal-Mart always concentrates on minimizing costs through inventory management and information technology initiatives. However, by taking these differences into account and analyzing them Migros can add value to its supply chain by transferring Wal-Mart's best practices.

Table 3. Wal-Mart and Migros Comparison

	Wal-Mart	Migros
Total Revenue	$473 (Amounts in billions)	$3,457 (Amounts in millions)
Number of Stores	11,000	1,264
Revenue(per store)	$43 (Amounts in millions)	$3,032 (Amounts in million)
Number of Customers (per day)	36 (Amounts in millions)	1.75 (Amounts in millions)
Consolidated Net Income	$16,695 (Amounts in millions)	$42 (Amounts in millions)
Net Income (per customer)	$1.28	$0.06

Improving supply chain performance is a challenging issue. Turkish retailer Migros is eager to search and implement strategic concepts for its supply chain in order to enhance the efficiency of its supply chain practices. Over the past decade Migros has focused on inventory management, information technology, in store applications and supplier collaboration that are further discussed in this paper. In the case of information technology Migros pioneered many applications in Turkey, and this is the reason for focusing on comparison with Wal-Mart and technology transferability from Wal-Mart to Migros. However, compared to world's largest retailer, it is apparently clear that Migros still has a long way to go.

WAL-MART'S SUPPLY CHAIN PRACTICES

Wal-Mart has 158 distribution centers which serve as hubs for their supply chain operations. Each distribution center is more than 1 million square feet and capable of supporting 90-100 stores in a 200 mile-radius [13]. DCs and stores operations are based on hub and spoke system. Logistics and distribution can be considered Wal-Mart's heart of supply chain competence. Growth strategy is closely associated with the system of distribution centers. New decision is done based on the ability of the area in locating stores so as to support a DC. After building a DC, stores are opened around it for providing supply of the area. Each time when a center is added to network re-optimization is performed to redesign the distribution network [2]. In addition to DC area analysis, outbound transportation costs to stores are taken into account. DC can both serve as a warehouse for storage and a cross-docking facility for providing consolidation of products for direct shipment to the store without being stored. Center Point Distribution Center (CP) is another facility of Wal-Mart that provides low inbound freight costs. Suppliers send less than truckload (LTL) loads directly to the closest CP, and consolidation is conducted for providing a full truckload for a particular store.

The Wall Street Journal reports that Wal-Mart aims building four more distribution centers designed with the purpose of supplying e-commerce demand. Brian Kilcourse, managing partner at RSR Research LLC, a retail consulting firm said "Building fulfilment centers designed to cater e-commerce, which demands the ability to handle a large number of small orders, can help retailers conduct more profitable sales." In contrast to traditional warehouses enabling pallet storage, an e-commerce center is fine-tuned for item-level storage [18].

Warehouse, assembly and direct-to-store are three processes of Wal-Mart that enable product flow. If products are stored at first so as to distribute to stores later, they go through the warehouse replenishment process. These are generally highly demanded products with high profit margin. Assembly replenishment means consolidation of products from different vendors based on a particular store demand, and for this process warehouse serves as a cross-docking center. In the other case, products are directly delivered to stores from vendors [4].

Wal-Mart stores' design is based on low complexity with same type of simple shelves and layout. Hand-held mobile devices such as 'Magic Wand' and 'Texlons' are used for tracking inventory levels in store and distribution centers. Asda Direct Kiosk provides customers in store ordering from online catalogues.

Technology and Information Systems

Wal-Mart's heavy information technology investments and expertise in information systems lead to revolutionary supply chain performance. Wal-Mart has world's largest private satellite communication system that provides tracking, replenishing inventory, processing transactions and controlling the store temperature as well.

Another tool, Retail Link considered the backbone of the inventory management is the biggest civilian database in the world [6]. This is known as supply chain visibility tool and supports share of information such as POS, price, level of inventory and order quantity between partners. Vendor finding the opportunity of analyzing this data improves efficiency of supply chain activities and this platform supports vendor-managed inventory and co-managed inventory approaches [4].

In the case of inventory replenishment, system called Inforem is used. Taking POS data and inventory in hand into account together with trends, demand variety, shelf space and pack size program generates order time and quantity automatically. As stated by The City Wire, Wal-Mart is testing a new global replenishment system that provides just-in-time inventory concept and generates more accurate and stable order quantities. In contrast to Inforem, GRS is capable of eliminating irregular seasonal and promotional data resulting in lower inventory levels [19].

Wal-Mart uses barcode and RFID technology for data capturing and anticipating. Early implementations of barcode provided visibility through the supply chain processes and RFID adoption started by 2003 boosted Wal-Mart's supply chain management. Following pallet level tracking, case level implementations were introduced and currently item level applications can be observed for some items. RFID applications decreased out-of-stock cases, provided high degree of visibility, lowered costs and bullwhip effect. In addition to these benefits, RFID improves performance of vendor-managed inventory and affects other collaborative initiatives positively such as collaborative planning forecasting and replenishment (CPFR) [7].

A further initiative electronic data interchange (EDI) facilitates real-time information sharing for accurate orders, transparency and visibility. Business documents are exchanged electronically provides online communication, less paperwork and cost.

In addition to these, Wal-Mart uses data mining and market-basket analysis involving identification of common mix of items that a specific customer averagely buy in a shopping trip. Dependent on sales patterns optimization is performed for product mix on shelves by advanced inventory analysis and this contributes to minimize transportation, carrying and any other relevant costs [2].

Wal-Mart and Supplier Collaboration

One collaborative approach of Wal-Mart is vendor-managed inventory with continuous replenishment. Wal-Mart establishes relationship with vendors and gives them responsibility of replenishing and managing the inventory. Vendor tracks levels of inventory of Wal-Mart continuously, and replenishes inventory automatically when re-order point is reached [7]. Co-managed inventory (CMI) approach differs from VMI in the way of giving Wal-Mart more responsibility in DC level. Responsibility is shared between partners so that to prevent some order scenarios of vendors.

Collaborative planning, forecasting and replenishment (CPFR) is a more advanced and recent strategy for collaboration. Contrary to VMI, CPFR takes demand forecasting and production planning activities into consideration by involving both vendor and retailer in demand forecasting and inventory replenishment planning activities. This approach originated from Wal-Mart's initiatives of developing demand forecast and comparing them with vendor's each week. Distinguishing inaccuracies and irregular data provides a single precise forecast and contributes to decrease cost of inventory management [5].

Wal-Mart Transportation

Wal-Mart private trucking fleet is the largest one in United States which provides company savings in terms of transportation. Outbound transportation to stores from DCs is conducted by this fleet, and route optimization techniques contribute fuel savings and less carbon emissions. Goal is the minimization of empty miles of delivery and recently company's focus is on backhauls. Wal-Mart drivers picking the merchandise from vendors and bringing to DC after delivery to store provided efficiency by eliminating number of trips [13].

MIGROS' SUPPLY CHAIN PRACTICES

Migros states that improvements due to the business processes in logistics and supply chain management supported gross profit margin growth during the last four years. Gross profit margin for 2014 is %26.7 which is mostly associated with these developments. Projects such as distribution center automation, sales area optimization, and space and assortment alterations in hypermarkets that include redesign of layout according to strategic importance of categories were implemented. Product variety and categories generating high sales volume were identified.

In terms of distribution, Migros added seven electric vehicles to its fleet for energy efficiency. Migros has 21 distribution centers. At locations where fresh food and meat distribution is dense, delivery of this two different type of products were consolidated for productivity. In 2010, Migros initiated the distribution of fresh food products over the distribution centers (cross-docking) and maintains this in all regions. So as to keep stock minimum at store level, item level delivery enabling item level ordering for certain product categories started. Store associates are able to track transportation from tablet PCs and by this way, they can do workforce and stock planning immediately. As a first step of technological improvements at Gebze Distribution Center, approximately 565 meter long conveyor belt was put into use.

In the case of finding location for new stores, Migros started to use a decision support system as a management tool that identifies potential locations for new stores with smart algorithms in smart phone and tablet PC applications.

Migros initiated many in-store projects. 'Benim Ofisim' project provides store level management and gives store managers the opportunity of obtaining necessary management information related with product flow in warehouses, customer data, stock level and products with high sales volume via reports from their tablet PCs. By this way, managers by monitoring the product promotions and immediate sales data are able to behave proactively. Besides, store managers can communicate customers and associates by working in sales area rather than an office. Migros's number of printed reports decreased by %40 and shelf availability increased by %3. Another in-store project 'Beacon' is a device which is currently in the test phase. Is is fixed to shelves and software is embedded in commonly used mobile applications. If the appropriate application is installed and Bluetooth is open, customer passing in front of that shelf is catched.

'Smart Badge' is a wireless electronic employee identity that reads barcode, and this is instrumental in getting product information rapidly, managing in-store operations and obtaining training documents about processes via corporate portal. 'Mio' is a management tool for operational, reporting, control, analysis and other communication purposes of managers, and has a multi-dimensional analysis application for forecasts.

Migros also have a 'Mobile Product Picking' implementation which is specifically designed for virtual market operations' automation. Content of the project is reengineering the processes of picking, handling, packaging, delivery and payment to minimize loss and mistakes by providing transparency and efficiency. This is an innovative and creative Migros project with the goal of decreasing operational lead times and improving customer satisfaction. Similar to Wal-Mart's 'Asda Kiosk' application, Migros offers 'Sınırsız Alışveriş Kioskları' for providing customers ordering from Kiosks in stores to offer and sell the products that are not in store.

Related to inventory, Migros has a project about inventory infrastructure transformation. In this project's framework periodic inventory processes in stores were supported with a new system [10].

Supplier collaboration is an issue that Migros focuses on seriously as well. Migros B2B system is an electronic business platform that enables information flow about operations and their management. Now, Migros's %90 of total purchasing with 1300 suppliers is done via this platform. B2B is also believed to be a trigger for future prospects such as Vendor Managed Inventory (VMI), Collaborative Forecasting, Planning and Replenishment (CPFR) and Customer Relationship Management over B2B (CRM on B2B) by establishing the proper infrastructure. Suppliers through B2B platform can track operations flow in stores and update their business strategies accordingly. B2B application and some other technological developments in Migros will be further discussed in the next section.

DISCUSSIONS

Wal-Mart and Migros cases reveal that Wal-Mart gives significant amount of attention to information technology and pioneered many applications in retail industry. Migros implemented various forms IT including EDI, point-of-sales systems, B2B systems and data mining (DM) for enhancement of collaboration, information sharing inventory management and customer relationships management (CRM). Both of two get benefit from EDI systems in increasing efficiency of transactions, order, planning and control processes.

In the case of RFID adoption, although Migros pioneered the application in Turkey it is at the very beginning of the application. There is a test center for suppliers at Gebze DC for this purpose and because of the high costs of tags, case based implementations are performed [17]. Mostly Migros still uses barcode technology and by the widespread applications company can get the advantage of RFID that offers real time data capturing, automation, efficiency in visibility and tracking. Migros is a customer-focused company, and RFID is believed to have the biggest impact for improving efficiency in SCM practices. Customers' satisfaction can be enhanced by having deep insight about their shopping habits, promoting efficiency and preciseness. RFID has the capability of giving much more information than bar coding which supports inventory management at retails [1]. In Turkey, retailers are confronting many difficulties related with shrinkages associated with supply chain problems. Migros, by implementing RFID at first can eliminate costs related with loss and inventory control. RFID readers with no need for human intervention can read many tags at the same time.

Since collaboration with suppliers is important for retailers and Migros has an attempt such as B2B to support this. RFID can contribute for improving their collaboration. Based on the fact that, Migros reported CPFR intentions after B2B platform, RFID has significant potential to support this system. Moreover, Attaran (2012) suggests that despite CPFR does not have to be based on technology it suggests utilization of common tools and processes for accuracy in supply chain planning [1]. According to Attaran (2012) RFID integration with CPRF process improves visibility by supporting share of past data and forecasts [1]. Kosasi et al. (2014) also suggests that RFID and CPRF are closely related [7].

Leung, Cheung and Chu (2014) argue that various organizations were influenced by Wal-Mart's pioneering RFID implementation and they examined whether retailers should follow RFID pioneers [9]. Their findings reveal that organizations at first should analyze their supply chain strategies and needs, evaluate market usage of RFID deeply and give importance to automation for supporting operational change. Migros seems to have a good understanding of technology and capable of handling technological changes. Thus, with considering the factors above and accelerating RFID applications, company can get many benefits.

Wal-Mart has far more collaboration efforts with suppliers such as assisting suppliers in research &development and quality efforts, providing resident institutions at Wal-Mart headquarters, and involving in their production plan [15].

As it is stated in Migros Annual Report (2014), Migros's loyalty card named Money Club with its 8.7 million members by 2014, provides company extensive amount of information [10]. Migros gathers all details about customers and their transactions, and analyzes so as to react accordingly. For instance, Migros forms a list for every member of Money Club reflecting their shopping habits and favourite products. Data mining is important for Migros and deploying CRM, and industry experts point out that this is what Migros is very successful at. Customer Relationship of Migros provides distinction and a competitive advantage that cannot be easily copied by competitors. Combining technologies like Beacon and Money Club data gives Migros opportunity for providing the right data for the right person. However, presently Beacon is an expensive technology and cannot be applicable extensively because of the cost.

In the case of Wal-Mart, Xie and Allen (2013) reports that Wal-Mart prefers decreasing prices so that to maintain EDLP, and invest more in technologies for store information as opposed to customer information[14]. Wal-Mart's interest is more on analyzing the Retail Link data for effective inventory management and replenishment.

'Migros Sanal Market' is an online supermarket offering service via internet, phone, smart phone and tablet PC. Totally there are 98 sales points supported by Migros Sanal Market service, and 'Mobile Market' application had a great impact on sales by 2014, constituting 30% of orders. 'Mobile Market' gives customers opportunity of ordering by scanning the barcode over the package with the help of phone cameras. In 2014, around 1 million digital catalogues 'Migroskod' were distributed, and this supported 'Migros Sanal Market' sales by barcode scanning with one touch. Migros has the foresight that 'Migros Sanal Market' is a channel promising substantial growth potential [10].

For an online supermarket model, Migros has a last-mile supply chain strategy of using existing supermarket infrastructure. Orders are packed at the closest supermarket and distributed by its own transportation in return for a fee [16]. Because of the fact that online supermarket is a growing channel of Migros, there is no doubt that it will require transformation as a result of changing conditions. In the case of Wal-Mart it is discussed above that company builds fine-tuned distribution centers for supplying e-commerce demand. Due to prospects for future growth, Migros can adapt new strategies to its last-mile supply chain to provide efficiency. Yoruk (2007) suggests that distribution decision between the two models is based on sales volume, and when huge amount of e-commerce sales achieved it is more convenient to use customized distribution centers for this purpose for productivity [16].

Another initiative of Migros is the e-procurement system "e-tedarik" that has e-catalogue, e-purchasing and e-auctions modules. Migros initiated its e-procurement system in 2009 and annually almost $100 million purchase was recorded. Approximately %25 savings achieved only through e-auction module and around 400 e-auctions were conducted by means of e-tedarik system. Although Migros can achieve easier and faster transactions than before, in Turkey this is a new business model and in terms of integration currently it is not capable of supporting accounting and inventory link for the payment module [8].

TRANSFER OF RETAIL TECHNOLOGY

Retail technology is not only about software and equipment. It requires organizational change. POS and EDI technologies are widely used by retailers. Other IT tools such as internet shopping, advanced inventory management techniques, automated replenishment systems, wireless scanning and hand-held computers are employed by global leaders. These technologies mostly have roots in United States [11]. As discussed in this paper, Wal-Mart pioneered most of these technologies.

Due to Migros's new vision at the beginning of 1990s, company started amending its retail technology. Company hired American consultants and allocated significant amount of resources for this purpose. Qualified graduates from top universities were recruited, new ideas and management techniques were examined so that to deploy new retail technology [11]. Migros is still investing in technology heavily and is forerunner in Turkey despite of global retailers. Migros adapted B2B, barcode, virtual marketing and many in-store applications. Improvement of organisational capabilities contributed to the success of technology use, which is considered the major success factor of Migros in technology transfer [11].

Some of the Migros' technological achievements are still in the test phase and due to high costs full benefit cannot be obtained. The level of supplier collaboration is still an era that needs improvement. For instance, B2B system of Migros is not capable of fully supporting initiatives like VMI and CPFR currently.

However, Migros has accomplished many technology transfers so far as analyzed above and has proved the capability of handling technology adaptation well. Hence, Wal-Mart technologies offer Migros great opportunity for efficiency improvement in supply chain practices. However, compatibility of these practices should be evaluated seriously. High level of communication, employee involvement, interaction, more resource allocation for information systems, providing training and more personnel with well-education support these changes [12].

CONCLUSIONS

The purpose of this paper was to conduct a research about supply chain management practices of the world giant Wal-Mart and Turkish retailer Migros Turk, and to concentrate on some potential improvement areas for Migros. Based on the discussions above, Migros Turk can be considered a successful retailer with high globally growth potential.

Although many supply chain initiatives have been implemented by Migros so far, and compared to Wal-Mart, Migros needs improvements especially in terms of information technology. Wal-Mart's robust and sophisticated information technology and investments are major contributors of superiority. Wal-Mart is the world's top retailer with thousands of stores and with $476 billion revenue. Migros followed many retailer technologies such as EDI, barcode, RFID, mobile devices, B2B, data mining. Even 'Endless Shopping Kiosks' of Migros were very similar to Wal-Mart's 'ASDA Kiosks' representing Migros' close tracking.

As discussed in both cases, Wal-Mart's and Migros' business strategies are different. Information technology advancements and inventory management facilitate cost reduction and EDLP strategy is maintained by this way in Wal-Mart. As a result, distribution network is very sophisticated with high level of automation and information systems. Optimization tools regarding DC locations are widely used. Wal-Mart builds fine-tuned distribution centers for only e-commerce demand and design of these centers are totally different for making these processes more efficient. Migros expects high growth in e-commerce sales and in the long term this kind of facilities or specialized management tools for this purpose can be helpful.

Cross-docking provides substantial efficiency. Migros uses cross-docking as well, but in a limited manner. More efforts can be spent on getting more benefit from cross-docking by carefully analyzing types of products and their flow through supply chain.

As examined in Wal-Mart example, Information technology is a competitive advantage. Migros having a private R&D center values in-house developments as much as solely transferring. Although many in-store applications such as Beacon have been developed by Migros, because of costs they are not currently applicable widely.

Wal-Mart's interaction with suppliers is very close and is implementing CPFR which can be very advantageous for Migros as well. B2B system has contributed efficiency improvement in Migros and has potential to support CPFR. RFID pioneering of Wal-Mart and its success triggers many retailers for implementation. Migros started applications in a small scale as well. Extending the scope of application by considering the factors discussed above, Migros can get significant benefits of RFID.

In the past, Migros proved its success of transferring and implementing some retail technologies. It is believed that if Migros is able to manage these processes with dedicated workforce and information technology attention, it can get benefit from adapting Wal-Mart's superior supply chain initiatives.

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FUZZY TOPSIS METHOD IN SELECTION SUPPLIERS FOR FOOD AND BEVERAGE COMPANIES

Mehmet SARIOĞLAN[128], Gülhan CEVİZKAYA[129]

Abstract-Food *and beverage companies strengthen their position day by day among the indispensable institutions of daily life. Hence, these companies not only meet the physical requirements of individuals but also contribute to their socializing. However, it is assumed that applying new methods in selection suppliers is crucial for enabling these functions of food and beverage companies. The partial case method, which is one of the qualitative research methods regarding the applicability of fuzzy TOPSIS method in selection suppliers for food and beverage companies, is used in this study. As a result of this implementation, the applicability of fuzzy TOPSIS method in food and beverage companies is confirmed. However, a model proposal that is necessary for the food and beverage companies to implement the fuzzy TOPSIS method effectively is made. Consequently, food and beverage companies proposed the fuzzy TOPSIS method as a new alternative method in selection suppliers.*
Keywords: *Food and Beverage Companies, Fuzzy TOPSIS, Selection Suppliers.*

INTRODUCTION

The most important way of eliminating raw material shortage that is possible to occur in the production line is working with multiple suppliers that can provide the necessary raw material (Lima Junior et al, 2014). The suppliers should be periodically evaluated and sorted in order to provide conformity of the incoming raw material to quality standards (Ding, 2011). Suppliers should be selected not only on the basis of price but also in terms of the ability to meet various requirements regarding overall costs and they should be evaluated according to other prioritized criteria. Supplier selection is one of the most fundamental and strategic decisions made by purchasers. The root cause of this arises from the high level of complexity in the thoughts on supplier performance and associated factors (Ashrafzadeh et al., 2012; Wang and Chang, 2007).
The correct techniques in selection suppliers include AHP (Analytical Hierarchy Process), BAHP (Fuzzy Analytical Hierarchy Process) and VIKOR. Another supplier selection technique in addition to these is the TOPSIS method. TOPSIS is a widely-known multi-criteria decision-making method which is used for multi-criteria decision-making problems and developed by Hwang and Yoon for the first time. TOPSIS is commonly used in various fields in multi-criteria group decision-making problems (Liao and Kao, 2011; Madi and Tap, 2011).
TOPSIS method focuses on the idea of the shortest distance from the chosen alternative to the positive ideal solution and the furthest distance to the negative ideal solution. TOPSIS method not only reveals the distance between the chosen alternative and the positive and negative ideal solutions but also determines the ideal and non-ideal solutions. Unlike the basic weighted sum method, TOPSIS method is particularly preferred for being an intuitive method that is easy to understand and implement and for being based on logical thinking by revealing the closeness to the positive ideal solution and distance to the negative ideal solution as most appropriate results (Krohling and Campanharo, 2011; Torfi et al. 2010; Bottani and Rizzi, 2006). Compared to other multi-criteria decision-making methods, the performance of the TOPSIS method is partially affected by the number of alternatives and provides an advantage for being reinforced against the increase in the number of alternatives and criteria within sorting discrepancies. Considering the fact that the order of alternatives are changed when a non-optimal alternative is offered, TOPSIS is one of the best methods in changing the order (Sun, 2010; Mahdavi et. al, 2008).

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The fuzzy TOPSIS method is used in preventing the negative situations caused by changes in decision criteria when facing uncertainty and changing conditions. Using fuzzy TOPSIS method instead of TOPSIS, eliminates the need for assigning an initial weight for every criteria and the direct assumption of positive ideal solution and negative ideal solution when the numbers are 1 and 0 (Saghafian and Hejazi, 2005; Chu and Lin, 2003).

MATERIAL AND METHOD

This study researches the applicability of Fuzzy TOPSIS method in three different large-scale companies in Istanbul, Ankara and İzmir as a new technique in selection suppliers for food and beverage companies. In the study, all implementations required by the TOPSIS method are performed in selection suppliers for food and beverage companies. The study attempted to test the applicability of this technique with partial case study method. Case studies from automotive, textile and healthcare industries where fuzzy TOPSIS method is effectively implemented in selection suppliers are collected and adapted to food and beverage companies.

A Model Proposal For the Applicability of Fuzzy TOPSIS Method in Food and Beverage Companies

This section of the study provides a six-phased model proposal for the applicability of fuzzy TOPSIS method regarding the supplier selection in food and beverage companies. The most important feature of this proposal is that it is and can be applied in food and beverage companies if desired after this study (Prascevic and Prascevic, 2013; Emami et al., 2012; Sun, 2010; Benitez et al., 2007; Chen et al., 2006; Jahanshahloo et al, 2006; Opricovic and Tzeng, 2004).

Phase I; Initially, the definitions of fuzzy TOPSIS method in food and beverage companies are made. In this framework, m (number) alternative companies (suppliers) Ai=(1,2,3,4,5…..,m) are evaluated against n (number) selection criteria Cj=(1,2,3,4,5……). Subjective assesments are identified by the decision-makers using linguistic terms, while weight vector W=(w1,w2,…..) and decision matrix X={xij , i=1,2,…,m; j=1,2,….,n} are determined. Weight vector (W) indicates the relative importance of n (number) selection criteria Cj=(1,2,3,……) for the problem. Decision matrix X={xij, i=1,2,…,m; j=1,2,….,n} shows the benefit ratios of alternative Ai in terms of selection criteria Cj. Sequencing is achieved in terms of all alternatives and in line with the purpose of the problem by using a given weight vector and decision matrix.

	C_1	C_2	….	C_n
A_1	x_{11}	x_{12}	….	
A_2	x_{21}	x_{22}	….	
….	….	….	….	
A_m	x_{m1}	x_{m2}	….	

Phase II; Total weight is obtained as a result of alternative assessments performed in terms of fuzzy performance evaluation in food and beverage companies. These values are put through normalization. Normalization is a mathematical ess that is performed to reduce every criteria range of [0,1] and that enables to compare t lts. The mathematical notation of a fuz nalized decision matrix is as follows:

$$
R=\begin{array}{c|ccc}
 & C_1 & C_j & C_n \\
\hline
A_1 & r_{1,1} & r_{1,j} & r_{1,n} \\
A_i & r_{i,j} & r_{i,j} & r_{i,n}
\end{array}
$$

$$
R=\begin{array}{c|ccc}
 & C_1 & C_j & C_n \\
\hline
A_1 & r_{1,1} & r_{1,j} & r_{1,n} \\
A_i & r_{i,j} & r_{i,j} & r_{i,n}
\end{array}
$$

Phase III; In the supplier selection process of food and beverage companies with fuzzy TOPSIS method, the weight of every criteria after normalization is multiplied by the values after normalization and the weighted normalization values are obtained at this phase. Thus, the weighted normalized matrix (R matrix) is formed. The mathematical expression of this matrix is as follows:

$$
V=\begin{array}{c|ccc}
 & C_1 & C_J & C_n \\
\hline
A_1 & v_{1,1} & v_{1,j} & v_{1,n} \\
A_i & v_{i,1} & v_{i,j} & v_{i,n} \\
A_m & V_{m,1} & v_{m,j} & v_{m,n}
\end{array}
$$

Phase IV; The positive ideal solution A (4) and the fuzzy negative ideal solution A(-) is determined at this phase. The purpose of this procedure is to reveal that fuzzy expressions of the structures determined for positive ideal solution and negative ideal solution in terms of benefit and cost criteria are different from each other.

Phase V; Separation distances with n dimensions are obtained after the positive and negative ideal solutions are identified. The distances are applied to the fuzzy positive ideal solution (A+) and fuzzy negative ideal solution A (-) of every criteria (i=1,2,….,m) and the separation is made with mathematical calculations. Values received as a result of separation distances in food and beverage companies are not fuzzy but real numbers.

Phase VI; The proximity index (Ci) is calculated for every criteria at the last phase. Thus, the best alternative (Aopt.) is determined. By determining this alternative, the positive ideal solution and negative ideal solution are identified while considering the external environmental conditions.

CONCLUSION AND RECOMMENDATIONS

This study analyzes the applicability of fuzzy TOPSIS method which is one of the supplier selection techniques in food and beverage companies. In this context, the first section of the study focuses on the importance of supplier selection in food and beverage companies and the importance of fuzzy TOPSIS method. The second section of the study offers a six-phase model proposal that is applied in food and beverage companies.

The most important feature of the model proposal in this study is its applicability. This study concludes that the fuzzy TOPSIS method can be applied effectively in the supplier selection process of food and beverage companies. While this study reveals the applicability of fuzzy TOPSIS method in food and beverage companies, future studies can research the applicability of different supplier selection techniques that can be applied in food and beverage companies.

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FROZEN FOODS LOGISTICS AT TOURISM DESTINATIONS

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Abstract − In this paper we present a multiple case study on the distribution models used for cold chain logistics of frozen foods producers serving to hotels and other food providers at touristic destinations, and we report on the comparisons and the advantages and disadvantages of the models. Our comparison is based on criteria listed in the literature and on our interviews conducted with frozen foods producers and a third party logistics provider in Antalya, Turkey (which is among the most visited cities in the world). We also discuss problems and main issues in implementation of the distribution models. Among our findings, we state that the level of the demanding nature of their customer base during the peak season and temperature requirements has substantial impact on the outsourcing decisions of the producers for logistics. We also discuss the potential effects of the delays due to simultaneous arrivals of multiple deliveries to the hotel and temperature conditions at the hotel delivery ramp on the performance of the distribution channel.

Keywords *−frozen foods, logistics management, tourism destinations*

INTRODUCTION

One of the major criteria in tourist satisfaction is the quality of the food; hence the freshness, cleanliness, and tastiness of the food served to tourists. Due to the natural seasonality in tourism sector and all-inclusive serving policy, the demand for various international cuisine and other foods peaks at certain times of the year, and the seasonality factor makes having full-time employees all year very costly. All these effects result in a high demand for frozen foods at tourism destinations with lots of hotels and resorts working only in the summer season. Therefore, frozen foods producers serving to a touristic destination should have capable distribution systems that would enable frequent, timely and efficient distribution of frozen foods to hotels and other food providers during the peak season while satisfying the food safety requirements.

Determining successful strategies on how to design a distribution model for frozen foods at a touristic destination requires concerning many intricate factors. One of the factors in managing a frozen food logistics system is satisfying the food safety requirements. The importance of food safety in food logistics is also globally appreciated at the countries that signed the ATP (Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage) agreement [10]. This agreement mainly aims to: prevent any damages made to the perishable food product due to not being able to preserve it at the required temperature during logistic activities occurring between production completion and delivery to the customer; and setting standards for improvements in such logistics activities.

The quality standards concerning the food safety for a distribution model of frozen foods logistics are very demanding, since a single fluctuation at the food temperature at any phase of the logistics activities can ruin the whole process’ performance. Chaowarut et al. (2009) found that food safety and responsiveness to customer requests are key performance indicators for frozen foods supply chain [2]; however, these standards may not be appreciated enough in practice. For instance, Wang (2010) found that according to expert opinion obtained via Analytic Hierarchy Process, transportation and preservation of food safety is found to be one of the most neglected criteria by producers in assessing the potential success of a frozen dumpling supply chain [11]. Even if the quality of the frozen food at the completion of the production could be very high, not

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conforming to the food safety standards during transportation would ruin the quality perception of the customers as well as create potential hazards to their health.

From the customer's perspective, besides preservation of food safety and quality, timeliness and speed of delivery are also important criteria to determine the performance of frozen foods distribution. The studies on the effect of these criteria on policy decisions are generally focused on grocery chains. The emphasis of these criteria for grocery chains is expressed by McKinnon and Campbell (1998) to depend on two factors: grocery stores' policy of working with as low amount of inventory as possible and hence requesting frequent deliveries in small amounts; and the availability of temperature controlled local warehouses that make this policy feasible [8]. While there could be a certain level of seasonality in grocery business (e. g. during holiday season), the seasonality effect on the demand at a touristic destination would put much more pressure on the producer since the consumption at many hotels located near each other with all-inclusive policy and open-buffet services simultaneously peaks in the summer season. This suggests a distribution system similar to one used for a grocery chain may not be suitable to satisfy the needs of a frozen foods producer serving a tourist resort. However, to our knowledge there are not any studies that provide clear guidelines on constructing distribution systems for frozen foods logistics at touristic destinations.

In addition to the factors listed above that emphasize the need for planning and strategies; there are more complexities specific to the chains serving to touristic resorts. In such destinations, extremely hot and sometimes humid weather, and the frequent stops on the route to distribute the frozen foods to the hotels which are located very close to each other, further complicates the cold chain logistics problems faced by frozen foods producers. Thus, it is very important for producers, logistics providers, and customer organizations to understand the logistics management issues specific to frozen food supply chains at touristic destinations where final consumer satisfaction is top priority.

Another effect of the extremely high temperature and route structure (hotels located next to each other cause frequent stops on the route and hence cause exposure of the frozen food to the high temperature so frequently) is the increase on investment and management costs of the logistics chain. Until this point we focused on the characteristics desired in a frozen food logistics chain that ensure final customer satisfaction. However, it is also extremely important that customer satisfaction is obtained in an efficient way; otherwise sustainability of the logistics chain would be jeopardized. Due to the required temperature being under the freezing point, energy and investment costs for the necessary equipment are very high, and this would result in setting long-term agreements at the beginning of the distribution channel design. Hence, any errors made on the planning stage of a frozen foods logistics chain would be very costly. This also suggests that any improvements made on the existing systems could provide considerable savings.

Moreover, policy makers at the macro level can also be involved in enhancing the capabilities of the frozen food cold chains in their regions. On the studies for macro policies to adopt to improve logistics activities in general, İris and Tanyaş (2011) recommend using the "logistic villages" and various combinations of different modes of transportation together [6]. Similar recommendations were also made during our interview with a third party logistics provider where a macro level warehouse located at a central location with easier access to all hotels in a particular region and arranging all logistics activities mainly to and from this macro warehouse was proposed as a potential idea for policy makers [7]. As another example of macro level recommendations, Fernie and McKinnon (2003) emphasize potential consequences of infrastructure design and indicate that traffic congestion would be the most critical factor affecting the costs of retail-oriented frozen food supply chains in United Kingdom [4].

All these factors discussed reveal that frozen foods logistics at tourism destinations is a topic that requires careful planning and policy making, and to our knowledge there are not any studies on frozen food logistics specifically focusing on a customer base of hotels and other food providers at a touristic destination. With this motivation our main purposes in this study can be described as below:

- Description of the current policies and practice implemented in designing and managing distribution channel of a frozen food producer serving to a customer base located at a touristic destination, mainly the roles and financial responsibilities of the firms (e.g. third party logistic providers) involved in different steps of the logistics chain
- Comparison of potential models from practitioner perspective in designing a frozen food logistics chain at a touristic destination with respect to the criteria of: efficiency, flexibility, responsiveness, and process quality (Aramyan et al., 2007) [1], and main guidelines and managerial insights on the choice of a distribution model for such a logistic chain
- Definition of problems and main issues in implementation of distribution models used in practice for a frozen food logistics chain

METHODOLOGY

Our main purpose in this study is to establish a theoretical foundation that would help to analyze frozen food logistics at tourism destinations via describing and comparing different distribution channel alternatives and discussing the most important issues in designing and managing them. To do this we selected to conduct a multiple case study in order to gather as much detailed information as possible. This would also allow us to observe similarities and differences between perspectives of different firms [5]. We have chosen semi-structured interviews as the data collection method to avoid any ambiguities in communication of terms and definitions while allowing an enriched information sharing experience.

To conduct the interviews we selected to contact the firms located in the city of Antalya, one of the most visited cities in the world with lots of hotels and touristic facilities located very close to each other at the beach side as well as in downtown. Although the research questions focus on producers from a decision making perspective, we believe a thorough analysis of our topic requires the inclusion of third party logistics providers to be contacted for interviews. For interview questions we have prepared two different sets; one for frozen food producers and another for third party logistics providers. For producers, the content of the interview questions can be summarized as below:

- Demographic information request
- Brief description of logistics activities in their distribution channel along with information on which (if any) logistic chain partner is executing each process
- Whether the producer works with a third party logistics (3PL) provider and if this is the case what type of services they request from the 3PL provider (e.g. transportation, packaging, inventory, inspection, etc.)
- Whether they work with a distributor or any other partners
- Comparison of different distribution channel alternatives from their perspective with respect to the criteria of efficiency, flexibility, responsiveness, and process quality (Aramyan et al., 2007) [1] (the question includes the definitions of these criteria as given below)
- Description of the problems occurring in their distribution channel

Comparison criteria used: For the purpose of comparison between different distribution channels we have used criteria from Aramyan et al. (2007) [1] with necessary modifications at the definitions, since originally these criteria was developed to assess performance of agri-food supply chains, and production processes were also included in the scope of their study. In our study, *efficiency criterion* refers to the capability of successful utilization of resources and measured through the level of investment and variable costs. *Flexibility criterion* refers to the capability of satisfying a broader range of customer demands and readiness to positively react to alteration requests on planned deliveries. *Responsiveness* refers to the capability of conforming to the quality standards to satisfy the customer; a channel with better preservation of food quality and speedy deliveries with fewer errors is more preferable in terms of this criterion. Finally, *process quality* refers to factors such as traceability of orders until delivery and conditions of the vehicles and warehouses.

For 3PL providers, our questions consist of demographic information on the company, the type of services they offer to frozen food producers, and conclude with questions on the factors that positively affect the producers on outsourcing logistics activities to them as well as factors that has exactly the opposite effect.

Totally three interviews were conducted in August, 2015 with all the firms located in Antalya Organized Industrial Region. The data was recorded via taking notes, and an interview was also taped. One of the interviews was made with a chief executive officer of a frozen white meat producer (Company A), another one was made with a regional manager of a nationwide producer of frozen white meat, vegetables (including potatoes), and fruits (Company B). Company B also works as a wholesaler by buying the same type of frozen foods from small-scale local producers and reselling them. Our last interview was done with a regional manager of a 3PL provider firm (Company C).

ANALYSIS

In this section we present the information we gathered from our interviews and discuss the answers to our research questions.

Company A: produces frozen white meat for hotels and other touristic facilities. It has a history of 20 years; more than 250 employees; and a warehouse in İstanbul, Turkey and 40 distributors in Turkey working as independent partners rather than branches. During the peak season for tourism (roughly for six months) the company has 65-70% of its total sales to hotels and other touristic facilities.

They describe the logistics activities at their distribution channel and its structure as follows. After the frozen food is produced, it is stored at the warehouse next to the production facility. Then, it is transported to the distributor who buys the product. When the final customer (touristic facility) gives an order to the distributor, Company A arranges transportation of the product from the distributor's place to the final customer. If requested, Company A and distributor's employees place the product at the storeroom of the hotel after emptying the truck. In this system, distributors could be thought as small-scale warehouses with the financial responsibility of the product and regional contacts at touristic facilities. The only logistic service Company A outsources to 3PL providers is transportation, and they only request this service when their own trucks are all occupied and there are still deliveries to be made during the peak season. Hence, their distribution channel is composed of themselves and their distributors with transportation activity executed by the firm itself and sometimes outsourced to 3PL.

For comparison of different distribution channel alternatives, they expressed that they are satisfied with the system of working with distributors; however, they believe the services offered by 3PL firms to them are not preferable and has disadvantages compared to executing the activity themselves.

For the efficiency criterion, they find working with a 3PL more costly for two reasons: for the deliveries to hotels that are located next to each other in central areas at downtown or nearby districts, big trucks used by 3PLs are not necessary and increase the cost without any benefit; also because of the sensitivity of the product to temperature changes they do not want to take any risks during emptying and other handling of the product so they prefer to use their own or their distributor's employees.

For the responsiveness criterion, they also believe that 3PL services are not fast enough to adjust to the very hectic pace during the peak tourism season. The hotels usually request for deliveries with short lead times and

3PL firms need to do consolidation of many deliveries since their trucks are much bigger. This causes delays and loss of satisfaction at the customer. They believe the same reason also applies for lack of flexibility of 3PLs in answering any requests of changes at planned deliveries.

Process quality criterion was the only criterion they find working with a 3PL firm can be advantageous for, in case of large deliveries with a single stop to another town 3PLs have more storage space in their vehicles and their trucks are more suitable for highway conditions.

As the main issues and needs for improvement, they commented on lack of sensitivity on the customer's part for preservation of temperature and condition of the product during delivery. Their products are to be stored and delivered at -14 degrees Celsius; however the ramp or platform they have to empty the truck at the hotel is usually under sunlight and there are no equipment used to help preserve the temperature such as an air curtain. Moreover, due to the quality requirements, a food engineer has to be present during deliveries to control whether the product has been preserved until arrival under the necessary conditions and has the required quality, and this causes deliveries to be made only at certain times of the day. This further causes congestion at the hotel delivery area if more than one producer has to deliver products to the hotel and unaccounted waiting at the hotel to empty the truck makes the delivery process harder to manage. In case of damage to the product, hotels usually demand that the producer and the distributor bear the responsibility and request a new order to be sent without any additional payment, even though the damage could more likely be caused by the improper conditions at the hotel during delivery.

For potential improvement opportunities, they recommend that if government gives incentives to the firms to renew their trucks and work with more suitable vehicles that can get closer to the hotel ramp and connect with it more easily, the deliveries can be made faster and the congestion problem could be alleviated. Another recommendation they made in regards to macro level policies is for the government to give incentives to producers to obtain automated shelving systems. At the current practice, stock keeping is generally done manually with blue collar employees and it poses a potential risk for errors, also with the current layout, space has to be spared for aisles. With automated shelving systems, more space could be used since no manual work or walking will be required at the shelf area. This would also eliminate most potential risks due to human error.

Company B: This firm works as a regional office of a nationwide producer selling frozen white meat and vegetables (including potatoes) and fruits. They do not produce frozen foods at the regional office and the products come from the central production facility located at another city. They store the products and make deliveries. This regional office also works as a wholesaler by buying the same type of frozen foods from small-scale local producers and reselling. The producer has a history of 20 years; more than 250 employees; a total of seven branches all but one located in Turkey. The average total sales of the producer to the tourism sector amounts up to 25 million Turkish liras. This company serves to restaurants and fast food sector as the main customer base, and sales to tourism facilities constitute roughly 3% of their total sales.

The logistics activities the regional office performs for the main producer are the rest of the distribution channel process after the goods are delivered to them from the central production facilities. They do not use any further partners or agents through the rest of the distribution channel, and similar to Company A the only logistic activities this company outsources to 3PL providers is transportation, and they also only request this service when their own trucks are occupied.

For the efficiency criterion, they commented outsourcing to 3PL depends on the type of the frozen food transported, the volume of the delivery, and the location of the customer. They generally experience deliveries to hotels located at central areas are less costly if done by their own smaller vehicles, and deliveries to other cities are better to be outsourced.

For responsiveness criterion, they commented on the effect of traffic regulations preventing large trucks of 3PL firms from entering city traffic at business hours and hence the deliveries by 3PLs have to wait until nighttime to be made. This causes delays and at the same time poses more risk to the product.

As the main issues and needs for improvement they also discussed lack of sensitivity on the customer's part for preservation of temperature and condition of the product during delivery. Similar to Company A, they find it very hard to preserve the temperature of the product at the hotel delivery area, and in case of damage the hotel holds them responsible and demands a repeat delivery with no extra payment. Additionally, they stated that hotels pressure them to work with very short lead times since the competition at tourism industry during the peak season is fierce. The pressure on lead times usually causes them to start transportation without a full truck load, and this leads to a big increase in their variable transportation costs. Another comment they made was about the risk for unintentional errors by 3PL providers in preserving the temperature at the required level, since 3PL firms transport many different types of goods. This was also one of the reasons they prefer transporting their goods via their own trucks and employees. They finally discussed that they usually have to carry goods with different temperature requirements together at the same truck; for ex, frozen foods and vegetables at four degrees Celsius may have to be carried in the same truck, and using equipment such as an air curtain may not be completely successful in preserving the ideal temperature of frozen products.

Company C: is the regional warehouse of a global-scale 3PL provider, has a history of nine years, has more than 7000 employees, has 75 warehouses in the world with 50 of them located in Turkey. They own vehicles with separators that allow them to transport products at different temperatures in the same vehicle; they have a total of 3029 vehicles with many different volume capacities. In Antalya, they have 11.000 m^2 storage area and their global annual sales are 1.345 billion Turkish liras. At the Antalya warehouse customers from the tourism sector make up a very high proportion of the total sales. They process all sorts of frozen products, mostly being ice-cream, red and white meat, fish, and sandwiches.

The logistics services they offer are: transportation, storage, packaging and value-added activities for delivery preparation, inventory management, inspection, insurance, and even customer relations data (historical records of deliveries on behalf of the producer are kept up to three years). Their database can help the producer to determine the customer base to which they sell the highest volume.

They discuss that the main reasons for producers to outsource logistic activities to them are cost savings and successful preservation of food quality. They comment that the biggest cost savings they offer to producers are in terms of initial investment needed for space and equipment. They provided a brief list of investment items would the producer pay with its own resources if they do not use the services Company C offers. The initial necessary investments are: warehouse construction, handling equipment such as a forklift, reach truck, transpalet, etc., shelving system, and IT structure; while they also have to pay for variable costs as personnel, electricity, insurance, etc. They claimed that with their pricing scheme, the fee they charge for a complete set of logistics services per palette would not be more than what the producer would pay for one blue collar warehouse personnel in keeping the same palette in store for the same amount of time. However, without 3PL they claim the producer has to pay for all the other fixed and variable costs and the total cost of storage would be much higher. In terms of service quality, they also comment that with their qualified personnel and technical equipment including generators, preservation of required temperature is well accomplished in their facility.

For reasons to explain why the producers may not choose to work with them (or stop working with them) they listed several potential causes as below:

- Local producers not being completely aware of the extent and quality of their services
- Producers' insistence to have their products stored at a place near their production facility so that they can personally observe the condition of their inventory whenever they wish
- Unsatisfied alteration requests by the producer from planned delivery schedules that happened in the past; however, they claimed that these customers restarted to work with them after working with other 3PL firms or executing logistics activities themselves
- Producers' being unable to discontinue previously made agreements with other 3PL firms due to social connections or emotions of guilt for the high investment amounts the other 3PL incurred at the time of the agreements
- Lack of accurate cost calculations of logistics and hence not being able to appreciate the correct amount of potential savings

CONCLUSIONS

In this section, we further comment on the data analyzed and present managerial insights obtained from our multiple case study. At the end we summarize our findings and suggest related future research.

Designing the distribution channel: Company A works with distributors whereas Company B has its own warehouse, which it also uses as a wholesaler to have a bigger return on investment. We see that while Company B does centralized stock-keeping with a high level of initial investment, Company A prefers to allocate its goods to many small-scale distributors by selling the products to them. This also causes Company A to share a considerable amount of its profit margin with its distributors.

From these observations, we can conclude that if the firm decides to invest in their own warehouse, they can also use the extra space for wholesale purposes and they will have the whole profit margin to themselves. Otherwise, the firm will need to choose logistics partners to allocate the distribution channel activities. For the choice of logistics partners, Company A emphasized to us that they select to work with the distributors who are familiar with the demanding nature of the hotels and touristic facilities as customers.

The similarities we have observed at Company A and B were the sheer pressure from hotels to deliver fast and generally at inappropriate delivery ramp area conditions. Another similarity was the tendency of the customer to hold them responsible for any damage and request a second delivery with no charge. Hence, the pressure for service quality and frequency felt by these companies were so high that they were reluctant to take any additional risk by involving a 3PL logistics partner. Since the 3PL partner does not buy the product and the financial responsibility is still on the producer during 3PL's activities, the pressure and financial risk may make the producer not confident enough to use a 3PL. The only cases they outsourced a logistic activity to a 3PL was for less risky large volume deliveries made to a single distant location.

When a similar pressure from the customer side exists, there are studies reporting on the same decision of not working with a 3PL. Yıldız et al. (2013) study a steel pipe producer which did not choose to work with a 3PL firm, and they list the increase in the frequency of logistics activities and aiming for high service quality among the reasons for this decision [12]. On the other hand, when the pressure on the producer is not as high, the choice on outsourcing to a 3PL could be different. For a grocery oriented frozen food chain, Durak and Ünverdi (2014) find that it is more advantageous to work with a 3PL firm in terms of costs [3]. At other cases, the capacity required for transportation can be an important factor based on the product type and the industry. For instance, Özyörük (2008) found that the reason behind the decrease in the sales of a cement producer was the distributors' insufficient number of trucks in their fleet and the producer choose to outsource transportation to a 3PL provider [9].

Main issues and improvement opportunities: We essentially recommend redesigning the storage rooms and delivery ramp areas in hotels and other touristic facilities so that the temperature of the frozen product would be well preserved during emptying the truck and restocking to the storage room. The temperature regime of the frozen product should be preserved even at the last stage, and doing this would cause large savings for the distribution channel.

Moreover, 3PL firms should assure the producers of their care on avoiding unintentional errors in preserving the temperature. They may also invest in smaller vehicles that can be driven in narrow roads at central areas and during business hours. The government or other capable entities may also give incentives to producers to upgrade their technology to automated shelving systems, vehicles with separators, and similar state of the art equipment.

To summarize, in this paper we provide a first step in systematically analyzing frozen food logistics management at tourism destinations. We have observed that designing a distribution channel for such a business could be governed by different principles compared to other logistics systems due to intricate factors specific to touristic destinations. For future research we believe more comprehensive data collection with more firms from the same region and also from other touristic destinations would be helpful to verify our conclusions, and studies aimed at model construction for this problem can also be helpful to improve theoretical foundation on the subject.

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STOCK MANAGEMENT AND AN APPLICATION IN THE MILK PRODUCTION FACILITY

Melih Altınbaş[133]

Abstract – *Stocks can be optimized variety of technics. It's so important that control the stocks and take actions with firms own sources as soon as possible time. At this study, four illustrations are determined with ABC analysis method from four types of stock using the simulation technic at a milk production facility. Samples are examined with statistic methods their last year demand distributes and lead time changes. After the distribute types are defined, data sets are existed with Minitab. An electronic excel table helped to exist simulation model with the Microsoft Excel and using the model is tried to forecast next year stock quantity. Forecasts are always wrong, though they are necessary to predict future occurrence for an event so as to make adequate and optimal decisions [1]. Prepared model is supported with macro and detected reorder and quantity points simulated to reach the minimum costs. Last part of study, simulation values are compared with economic order quantity model formula results and they are evaluated.*

Keywords *ABC Analysis, Minimum Cost, Simulation, Stock*

INTRODUCTION

Competition is getting develop every day at business world, especially as the economic value of inventories kept, has become extremely important. Improved operation of supply chains for manufactured goods is worth billions of dollars to the national economy effective inventory management plays an important role in this regard [2]. Not only stocks are economic value but also they are accepted a precaution against the unexpected situation, seasonal changes, achieving the scarce resources.

Firms keep the stocks depend on their size of structure and as raw materials, semi-finished products, technic and final products stocks must be managed by a strong system namely the firms need efficient stock policies. Especially food, chemical sector firms must keep their inventories so attentive cause consumption too quick and keeping condition and time important. As a result, these examples show us how inventory management is important.

DEFINITION OF PROBLEM

Application firm has huge capacity about milk production and variety of stock types so that at this study some raw materials and technic stocks are constrained and determined. Milk is main material at facility but it's difficult to follow it and quantity is so much therefore this study doesn't include it. Additive stuffs (domestic and imported), cans, technic stocks are examined deeply.

The firm decides production quantities with marketing firm and production planning department common decisions. Due to the fact that firm need a support which satisfy orders, keep the stocks on minimum level, control the planning and cost constraints. This study's aim is using the last year data; controlling the stock levels and determining economic reorder point and quantity.

ABC ANALYSIS

The ABC analysis provides a mechanism for identifying items that will have a significant impact on overall inventory cost, while also providing a mechanism for identifying different categories of stock that will require different management and controls [3].

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The ABC analysis suggests that inventories of an organization are not of equal value. Thus, the inventory is grouped into three categories (A, B, and C) in order of their estimated importance[4]. Determined four stock type's unit prices and annual consumes are achieved from SAP in order to focus on the valuable stock items and not dealing with less valuable items. Domestic additive stuff (K.M.Y.İ) unit price and annual consumption quantity are multiplied and achieved total figure as follows;

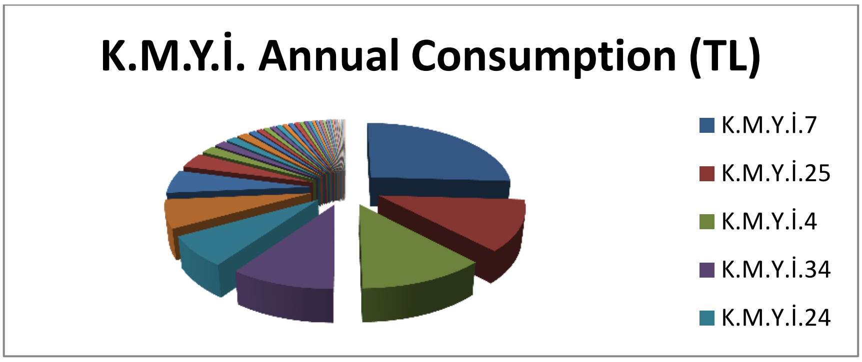


Figure 17. Additive Stuff Annual Consumption

Cumulative Consumption and Cumulative Sum % columns are added table for determined unit price and annual utility quantity stocks. And then ABC Analysis technic is applied to stock and appeared important stock items. Table 1 shows that K.M.Y.İ.7 is first one and hold %26 in all domestic additive stuff.

Table 18. Domestic Additive Stuff ABC Analysis Table

Stock Code	Annual Cons. Quant.	Unit Price	Annual Cons. (TL)	Cum. Cons.	Cum. Sum %	Rank.	Stock Code	Annual Cons. Quant.	Unit Price	Annual Cons. (TL)	Cumulative Cons.	Cum. % Sum	Rank.
K.M.Y.İ.7	7,789	14,85	115.666,65	115.666,65	26%	A	K.M.Y.İ.2	718	3,8	2.728,40	423.526,97	95%	C
K.M.Y.İ.25	8,967	5,98	53.622,66	169.289,31	38%	A	K.M.Y.İ.31	249	9,02	2.245,98	425.772,95	95%	C
K.M.Y.İ.4	5,924	9,01	53.375,00	222.664,31	50%	A	K.M.Y.İ.8	209	9,5	1.985,59	427.758,54	96%	C
K.M.Y.İ.34	4,879	8,95	43.661,59	266.325,90	60%	A	K.M.Y.İ.32	1	1,87	1.870,00	429.628,54	96%	C
K.M.Y.İ.24	649	49	31.801,00	298.126,90	67%	A	K.M.Y.İ.16	329	5,35	1.760,15	431.388,69	97%	C
K.M.Y.İ.22	8,795	3,4	29.903,00	328.029,90	74%	A	K.M.Y.İ.23	529	3,18	1.682,22	433.070,91	97%	C
K.M.Y.İ.18	4,879	5,07	24.736,53	352.766,43	79%	A	K.M.Y.İ.21	658	2,53	1.664,74	434.735,65	97%	C
K.M.Y.İ.12	431	38	16.378,00	369.144,43	83%	B	K.M.Y.İ.29	389	4	1.556,00	436.291,65	98%	C
K.M.Y.İ.27	778	10,8	8.402,40	377.546,83	85%	B	K.M.Y.İ.19	154	10	1.540,00	437.831,65	98%	C
K.M.Y.İ.5	711	9,96	7.081,48	384.628,31	86%	B	K.M.Y.İ.30	323	4,65	1.501,95	439.333,60	99%	C
K.M.Y.İ.10	1,258	5,07	6.378,06	391.006,37	88%	B	K.M.Y.İ.6	465	2,78	1.292,70	440.626,30	99%	C
K.M.Y.İ.11	773	8,25	6.377,25	397.383,62	89%	B	K.M.Y.İ.14	305	3,44	1.049,20	441.675,50	99%	C
K.M.Y.İ.37	635	6,96	4.419,60	401.803,22	90%	B	K.M.Y.İ.13	918	1,1	1.009,80	442.685,30	99%	C
K.M.Y.İ.26	675	5,1	3.442,50	405.245,72	91%	C	K.M.Y.İ.17	172	5,34	918,48	443.603,78	99%	C
K.M.Y.İ.35	961	3,55	3.411,55	408.657,27	92%	C	K.M.Y.İ.28	214	4	856	444.459,78	100%	C
K.M.Y.İ.3	387	8,2	3.173,40	411.830,67	92%	C	K.M.Y.İ.38	62	10,95	678,84	445.138,62	100%	C
K.M.Y.İ.9	660	4,79	3.161,40	414.992,07	93%	C	K.M.Y.İ.36	67	6,75	452,25	445.590,87	100%	C
K.M.Y.İ.1	847	3,5	2.964,50	417.956,57	94%	C	K.M.Y.İ.20	118	1,66	195,88	445.786,75	100%	C
K.M.Y.İ.15	580	4,9	2.842,00	420.798,57	94%	C	K.M.Y.İ.33	524	0,23	120,52	445.907,27	100%	C

DETERMINED STOCK ITEMS

Last year determined stock item's supply values and order numbers are shown following table;

Table 2.Stock Type Details

Items	Annual Total Order	Annual Order Num.
K.M.Y.İ.7	7.789	24
K.M.Y.D.19	3.567	11
Amb.36	8.972	29
Teknk. Malz.24	7.045	25

Determined domestic stock item orders are more frequent than import additive items. When the can orders are investigated, can be seen that they are used many and giving order numbers are too frequent in a year.

Order quantity, order date, warehouse entry date details are given for K.M.Y.İ.7. At this part difference between order time – warehouse entry date shows lead time and order releasing distribution.

Table 3.K.M.Y.İ.7 Order Quantity and Lead Time

Order No	Items	Piece	Order Date	Warehouse Entry Date	Lead Time	Order No	Items	Piece	Order Date	Warehouse Entry Date	Lead Time
1	K.M.Y.İ.7	100	03.01.2014	07.01.2014	4	13	K.M.Y.İ.7	200	18.06.2014	26.06.2014	8
2	K.M.Y.İ.7	100	12.01.2014	20.01.2014	8	14	K.M.Y.İ.7	500	28.06.2014	03.07.2014	5
3	K.M.Y.İ.7	128	22.02.2014	03.03.2014	9	15	K.M.Y.İ.7	300	14.07.2014	18.07.2014	4
4	K.M.Y.İ.7	170	03.03.2014	10.03.2014	7	16	K.M.Y.İ.7	400	25.07.2014	06.08.2014	12
5	K.M.Y.İ.7	130	15.03.2014	21.03.2014	6	17	K.M.Y.İ.7	565	04.08.2014	11.08.2014	7
6	K.M.Y.İ.7	210	26.03.2014	03.04.2014	8	18	K.M.Y.İ.7	620	12.08.2014	20.08.2014	8
7	K.M.Y.İ.7	230	08.04.2014	17.04.2014	9	19	K.M.Y.İ.7	358	16.08.2014	19.08.2014	3
8	K.M.Y.İ.7	300	15.04.2014	20.04.2014	5	20	K.M.Y.İ.7	560	20.08.2014	25.08.2014	5
9	K.M.Y.İ.7	150	01.05.2014	14.05.2014	13	21	K.M.Y.İ.7	535	09.09.2014	20.09.2014	11
10	K.M.Y.İ.7	400	09.05.2014	21.05.2014	12	22	K.M.Y.İ.7	390	11.10.2014	21.10.2014	10
11	K.M.Y.İ.7	278	21.05.2014	02.06.2014	12	23	K.M.Y.İ.7	285	14.11.2014	19.11.2014	5
12	K.M.Y.İ.7	390	10.06.2014	15.06.2014	5	24	K.M.Y.İ.7	490	19.11.2014	29.11.2014	10

Generally normality test is used stock applications. At this study, normality test is examined with Minitab 17 for order data. Hypotheses are existed for normality test.

Ho: The demand for order is normally distributed

Hı: The demand for order is not normally distributed

Alpha equals 0.05 ($\alpha = 0.05$)

According to the results that when viewed in the figures;

p − value $\geq \alpha$ equals 0.05, namely Ho hypothesis is accepted and it appropriates for normal distribution.

Results; meaning equals 324.5, standard deviation equals 161.3, p – value is bigger than 0.15. Figure 2 shows Minitab screenshot.

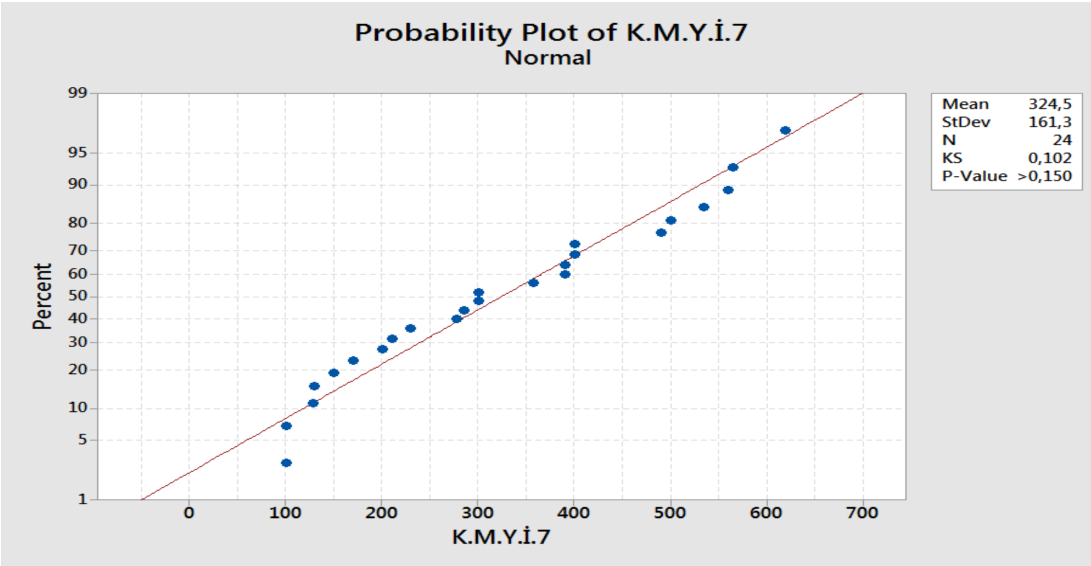


Figure 2. K.M.Y.İ.7 Lead Time Distribution Screenshot

K.M.Y.İ.7's lead time data are examined with Promodel. Are they appropriate for uniform distribution or not? Data set which is appropriated, minimum value equals 3, maximum value equals 13. Uniform distribution graph is shown Figure 3 for K.M.Y.İ.7. Determined distribution data and meaning will be infrastructure for preparing simulation model.

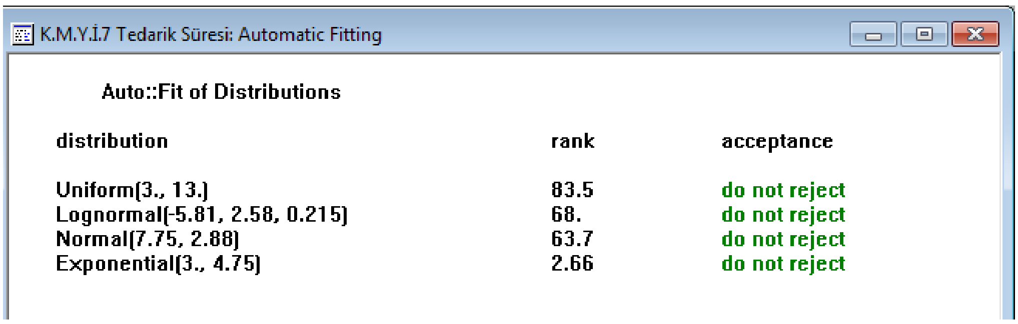


Figure 3. K.M.Y.İ.7 Lead Time

SIMULATION APPLICATION

Determined stock item's order and lead time are variable. Simulation model table investigates deeply at Table 5 for K.M.Y.İ.7. Table 4 includes beginning quantity, order cost, inventory holding cost data. Holding cost is accepted 1 because additive stuff and other stock items uses different productions so that holding cost couldn't be calculated truly.

Table 4. Item Details

Items	Beginning Stock (Piece)	Order Cost (TL/Week)	Holding Cost (TL/ Week)	Stock-Out Cost (TL/ Week)
K.M.Y.İ.7	550	250	0,5	1
K.M.Y.D.19	260	1600	1,4	1
Amb.36	1700	160	0,3	1
Teknk. Malz.24	260	300	2,1	1

Before the simulation table some details as follows;

Simulation model is determined 52 weeks. Last year order distribution is shown 24/52 weeks namely order accepting ratio is %46. Simulation table has an order situation column. It means that system exist a number 1 to 100, if the number is bigger than 54 orders will be existed.

Forecast order quantity data is existed with Minitab using last year data and statistic distribution as follows Fig. 4:

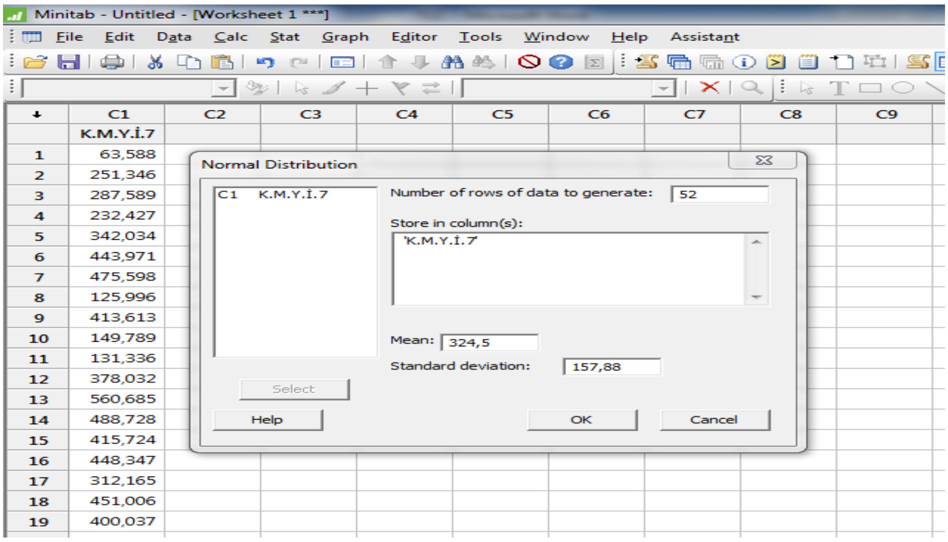


Figure 4. K.M.Y.İ.7 Order Quantity Random Value Existing Minitab Screenshot

In the remaining inventory quantity column is obtained as a result of subtracting the amount of data being written demand from existing stocks remaining value. Order release decision is depend on determined reorder point and quantity. Reorder point is determined as 100 pieces at Fig. 5 and if the quantity declines from the 100 pieces, new order will release by purchasing department. Also, lead time random data is produced using Minitab appropriate last year statistic distribution

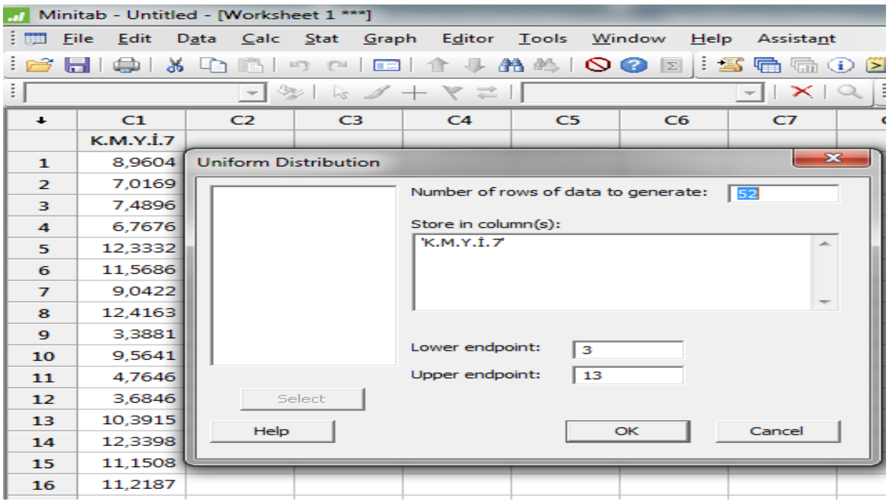


Figure 5. Table K.M.Y.İ.7 Lead Time Random Value Existing Minitab Screenshot

Inventory holding cost is calculated; unit inventory holding cost multiply by remaining stock quantity. Stock-out cost: As mentioned before unit stock-out costs is accepted 1 and multiply by remaining stock quantity. Order cost includes; logistic, custom and other expense items. Order cost is defined 250 TL for K.M.Y.İ.7. total cost is included order cost, inventory holding cost and stock-out cost.

Table 5. K.M.Y.İ.7 Simulation Table

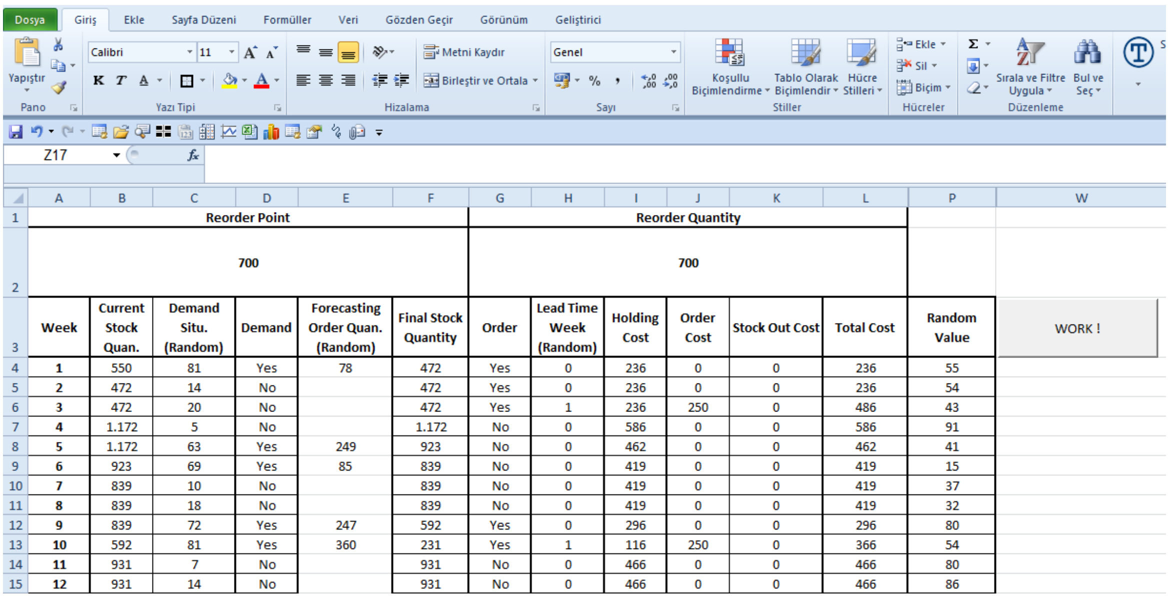
K.M.Y.İ.7											
Week	Current Stock Quan.	Demand	Forecasting Order Quan. (Random)	Forecasting Order Quan. (Random)	Final Stock Quantity	Order	Lead Time Week (Random)	Holding Cost	Order Cost	Stock-Out Cost	Total Cost
1	550	12	No		550	No	0	275	0	0	275
2	550	90	Yes	147	403	No	0	202	0	0	202
3	403	75	Yes	274	129	No	0	65	0	0	65
4	129	28	No		129	No	0	65	0	0	65
5	129	19	No		129	No	0	65	0	0	65
:	:	:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:	:	:	:
48	-113	58	Yes	371	-484	Yes	1	0	250	484	734
49	-384	30	No		-384	Yes	2	0	250	384	634
50	-384	79	Yes	10	-394	Yes	1	0	250	394	644
51	-194	63	Yes	277	-471	Yes	2	0	250	471	721
52	-471	25	No		-471	Yes	1	0	250	471	721

Simulation model has worked one time with Table 5 data and results are shown Table 6. When the result is evaluated, reorder point value 100 pieces, reorder quantity value 400 pieces provide minimum cost. But one time working doesn’t enough for reaching the goal. Because simulation system is worked random values and every working exists new results.

Table 6. Simulation Result

		Reorder Quantity (K.M.Y.İ.7)						
		100	200	300	400	500	600	700
Reorder Point	100	47.550,52	35.262,38	16.229,33	14.021,40	14.359,53	14.171,67	17.976,25
	200	168.927,02	54.227,02	20.150,36	17.311,47	15.953,25	16.138,99	17.316,49
	300	57.668,67	20.776,73	16.369,43	17.226,63	16.608,48	19.370,54	19.258,06
	400	57.188,80	26.304,57	18.320,86	16.751,04	19.528,23	20.513,96	22.494,03
	500	105.015,91	21.528,30	19.631,71	20.279,91	19.862,54	22.277,68	21.568,62
	600	97.175,53	20.991,36	23.527,69	21.800,67	22.789,79	26.048,72	27.057,87
	700	125.930,98	25.332,23	23.897,02	23.987,02	23.982,67	26.544,19	31.333,00

An excel macro is existed for working simulation, produce random values and use these values. Macro's aim understands every value's effects the costs and achieves to results faster than manual using and provides a dynamic structure. Macro is fed with data sets which were existed with Minitab. Finally macro is achieved the final average values with using every reorder point and reorder quantity data.



Reorder Point						Reorder Quantity						
700						700						
Week	Current Stock Quan.	Demand Situ. (Random)	Demand	Forecasting Order Quan. (Random)	Final Stock Quantity	Order	Lead Time Week (Random)	Holding Cost	Order Cost	Stock Out Cost	Total Cost	Random Value
1	550	81	Yes	78	472	Yes	0	236	0	0	236	55
2	472	14	No		472	Yes	0	236	0	0	236	54
3	472	20	No		472	Yes	1	236	250	0	486	43
4	1.172	5	No		1.172	No	0	586	0	0	586	91
5	1.172	63	Yes	249	923	No	0	462	0	0	462	41
6	923	69	Yes	85	839	No	0	419	0	0	419	15
7	839	10	No		839	No	0	419	0	0	419	37
8	839	18	No		839	No	0	419	0	0	419	32
9	839	72	Yes	247	592	Yes	0	296	0	0	296	80
10	592	81	Yes	360	231	Yes	1	116	250	0	366	54
11	931	7	No		931	No	0	466	0	0	466	80
12	931	14	No		931	No	0	466	0	0	466	86

Figure 6. Simulation Model Excel Table

Simulation model is worked 1000 time for K.M.Y.İ.7 and results shown Table 7. Prepared simulation model can be worked how many times user wants. As a result minimum costs seen for reorder point 100-200 pieces, order quantity 300-400 pieces. As a point; reorder point equals 100, reorder quantity equals 400 pieces.

Table 7. Simulation Result

		Reorder Quantity (K.M.Y.İ.7)						
		100	200	300	400	500	600	700
Reorder Point	100	88.714,83	25.190,20	15.862,64	14.266,94	14.728,26	14.614,70	13.317,14
	200	79.129,00	24.937,18	16.400,06	15.123,27	15.885,82	16.966,72	17.992,18
	300	78.583,12	24.080,60	16.440,04	16.424,91	17.243,23	18.661,69	20.512,69
	400	83.505,08	22.772,02	17.766,96	18.168,65	19.298,70	20.610,67	22.034,31

	500	75.217,00	22.899,65	19.611,64	20.121,07	21.512,79	22.850,56	24.273,09
	600	73.878,85	23.619,40	21.769,29	22.702,10	24.177,47	25.702,81	27.195,46
	700	74.021,13	24.310,62	24.019,41	24.958,48	26.383,87	27.574,62	29.226,00

Application economic order point and quantity formulas for K.M.Y.I.7;

Reorder quantity formula;

α= 150 pieces

Cs= 250 TL

Ch=0.5 TL

$$Q^{*}=\sqrt{\frac{2\alpha C_S}{C_H}} \tag{1}$$

$$Q^{*}=\sqrt{2.150.250/0,5} = 387 \tag{2}$$

Reorder point formula;

D=7789 Pieces

T= 52 Weeks

L=1.1 Weeks

=(Demand Quantity)/(Total Week).Average Lead Time (3)

=7789/52.1.1

=136

RESULTS

Reorder point and quantity are calculated with mathematical formulas which tell at stochastic stock models for K.M.Y.İ.7. Finally reorder point is found 164 pieces, reorder quantity 570 pieces.

When the EOQ model result values are put the simulation model and it is worked 1000 times. Therefore total cost is found 16.498,03 TL. This result shows that simulation conclusion cost value lower than EOQ formulas. Generally, other determined stock items calculated low cost than formulas.

Finally results show; reorder quantities are calculated with simulation model bigger than EOQ but reorder points are calculated with EOQ bigger than simulation model. At this study keeping the reorder point low and high ordering quantities are reduced the costs.

Table 8. Simulation Result

Items	Simulation Reorder Quantity	Q*	Simulation Reorder Point	R*
K.M.Y.İ.7	400	387	100	164
K.M.Y.D.19	200	151	100	154
Amb.36	500	423	300	321
Teknk. Malz.24	200	194	200	289

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THE ROLE OF MANAGEMENT LEADERSHIP ON SUPPLY CHAIN QUALITY PERFORMANCE: AN EMPIRICAL ANALYSIS THROUGH TURKISH ENTERPRISES

Seyhan Teoman[134]

Abstract – Today, quality has become the essence of competitive advantage for all enterprises. As competition moves beyond a single firm into the supply chain, focus on quality is shifted from management of firms' internal quality practices alone to integrating them with those of external supply chain partners (i.e. Supply Chain Quality Management - SCQM). On the other hand, the literature suggests that quality executives' leadership capability in the form of transformational style is the key determinant to success in all quality management practices and excellence models. Through the private and public enterprises operating in Turkey, this empirical study investigates the transformational leadership capability of quality related managers, and its impact on the corporate quality performance from both internal and external supply chain perspective. A proposed research model and hypothesis are tested by using a Structural Equation Model. The results show that transformational leadership has significantly positive affect on SCQM performance.

Keywords - Leadership, Structural Equation Modeling (SEM), Supply Chain Quality Management (SCQM), Total Quality Management (TQM), Transformational Leadership (LD)

I. INTRODUCTION

The basic definition of quality is "fitness for use" [35]. According to Juran, this basic definition branches into: (a) Quality consists of those product features that meet customer needs (b) Quality consists of freedom from deficiencies [35]. In general, the literature considers four stages as the most important in the development of quality concept. In late 1980s, Garvin identifies these four stages of quality movement over the last five decades, namely as follows; (a) inspection, (b) statistical quality control, (c) quality assurance, (d) strategic quality management [28]. These stages of quality movement describe the major paradigm shifts in quality management evaluation. Quality assurance procedures for goods and services have evolved continuously in line with the socio-cultural and technological changes that have marked the rapid evolution of society. Quality gurus W.M. Deming, J.V. Juran, and A.V. Feigenbaum have developed new concepts in the field of quality assurance, which have found application in the first place in Japan [18]-[21]-[35]. The most important features of the new philosophy regarding quality assurance were specified by Feigenbaum in 1961 [21]. He called the philosophy; Total Quality Control (TQC), which means a global approach to safeguarding activities of the quality control at the plant. The first steps used by Deming in statistical methods have been supplemented by Juran which stressed the necessity and importance of customer orientation of management in quality assurance. Total quality concept definitions are relatively recent; some authors consider overall quality as the product quality, while others consider this as customer satisfaction. Total quality is a philosophy, an approach, a set of processes, a strategy or a policy of the enterprise. It can be seen that the term "total quality" has a much wider meaning than the quality of a product or service. Total quality relates to the organization in a cost-effective manner, by means of a cross-sectional approach, processes holistically. The theories of Deming, Juran and Feigenbaum, the spiritual masters of quality, were accepted in Japan since the early 1960s developed subsequently by Ishikawa, Taguchi and some others. Since the 1970's in Japan and in the 1980s in the Western European, are designed and developed a range of new methods and techniques. It outlines a new concept called "Total Quality Management (TQM)".

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Wilkinson and Witcher defined TQM with three simple equations where each equation represents the three letters that make up TQM [83]. Their definition is as follows; Total = participation of everyone, Quality = meeting customer requirements exactly, and Management = enabling conditions for total quality. Based on this definition we can say that total quality is the goal, and TQM, is the means to achieve this aim. Corning defines the relationship between quality, total quality and TQM: quality means fulfilling customer requirements continued; total quality means fulfilling customer requirements in the conditions of minimal cost; TQM, satisfy these requirements in terms of cost, with the involvement of all personnel of the organization.

As competition intensified and markets became global in the 1990s, supply chain management (SCM) began to take center stage as a means to respond rapidly, correctly, and profitably to market demands. There is a growing attention on global supply chain management. SCM is a holistic and a strategic approach to demand, operations, procurement, and logistics process management [41]. In an effective supply chain network, members maintain and sustain a customer-driven culture, offering the right product in the right place, at the right time and at the right price [43]. Traditionally, the focus of supply chains was on specific functionalities such as purchasing, manufacturing, and shipping to support logistics operations. The competitive environment of the 21th century requires the delivery of cost, efficiency, high service levels, rapid response, and high quality of products and services. The effective management of technology and quality is the key to increased quality and enhanced competitive position in today's global environment. Supply chain quality is a key component in achieving competitive advantage [48].

As competition moves beyond a single firm into the supply chain, focus on quality is shifted from management of firms' internal quality practices alone to integrating them with those of customers and external supply chain partners, e.g. [22]-[37]-[59]-[71]-[40]. Integrating quality management (QM) and SCM will be important for future competitiveness [22]-[50]-[59]. Quality practices must advance even further "from traditional firm centric and product based mindsets to an inter-organizational supply chain orientation" [59]. A merging of SCM and QM approaches can be seen within research as "Supply Chain Quality Management (SCQM)". The focus of quality-based paradigm has shifted from the traditional company-centered setting to complete supply chain systems [43]-[48]-[71]-[40]-[85]-[42]. Levy refer to "total quality supply chain management" as a paradigm shift in which supplier-customer relationships and co-making quality products would emerge as the major concern instead of the traditionally firm-centered concern such as price, quality and delivery time [46]. In fact, competitive priorities in many firms have shifted from simply product quality to overall supply chain quality. Kuei and Madu use three equations to define SCQM, where each equation represents the three letters that make up SCQM: SC = a production-distribution network, Q = meeting market demands correctly, and achieving customer satisfaction rapidly and profitably, and M = enabling conditions and enhancing trust for supply chain quality [42].

The growing literature on TQM stresses the importance of TQM to organizational performance and has repeatedly stresses the lack of leadership support for the failure of many TQM initiatives [44]. Many researchers in the total quality and management literatures have pointed to the importance of the role of leadership in managing quality, e.g. [3]-[17]-[58]. There seems to be a strong consensus among the founders of the quality movement as far as the importance of leadership to managing quality is concerned, as evidenced by their writings, with all of these founders viewing quality as a leadership responsibility and viewing TQM principles as being principles of leadership [16]-[18]-[21]-[35]. Deming's argument that his views are in fact statements of good principles of leadership suggests that the behaviors associated with total quality management are themselves appropriate leadership behaviors [18]. Experience shows that successful firms in terms of the good functioning of the quality system was largely due to a strong leadership. Leaders with a strong vision constitutes the most important element in quality management approach. An important aspect of leadership in a vision of the "total quality" is to extend the power of decision at the lower levels of the managerial hierarchy, by involving employees in the process of quality improvement. Many quality experts believe that the key to successful management of quality begins at the top of the organization. The TQM literature argues that because senior managers create the organizational systems that determine how products and services are designed and produced, the quality improvement process must begin with management's own commitment to total quality. Thus, creating and designing systems that have an impact on how products and services are produced, and fostering organizational culture is the responsibility of leadership at the top of the organization [80]. Although some of the principles and practices of TQM differ in different firms and industries, there is a unanimous appreciation of the importance of leadership in top management of the company, linked to the implementation of this concept. The leader's role in the implementation of QM programs has been stressed also by many empirical studies, e.g. [2]-[67]-[72]-[39].

The basic rationale for the importance of leadership to QM is that leaders influence the motivation of a system's members and motivated members help to improve quality performance [81]. Modern theories have proposed two types of leadership: transactional and transformational [14]-[13]. Transactional leadership attempts to preserve the status quo, whereas transformational leadership seeks to inspire and engage the emotions of individuals in organisations. Transactional leadership concentrates on exchanges between leaders and staff, offering rewards for meeting particular standards in performance. Transformational leadership highlights the importance of leaders demonstrating inspirational motivation and concentrates on relationships. A number of commonalities between transformational leadership and the leadership views of the total quality management philosophy have been discussed from the point of view of (a) communication and reinforcement of values and (b) articulation and implementation of vision, and (c) visionary leadership in the form of defining, communicating, and motivating continuous improvement [3]. This study focuses on transformational leadership, because many researchers argue that transformational leadership is the visionary leadership espoused by Deming [18] as being the most appropriate type of leadership for QM [3]-[81]-[17].

Through enterprises located in Turkey, this empirical study investigates the relationship between the level of transformational leadership behaviors and the level of compliance with the critical success criteria of SCQM. This study contributes to the literature by focusing on transformational leadership in the context of SCQM. The specificity of this study is that examining directly the specific transformational leader behavior dimensions associated with SCQM principles, as opposed to the generic leader behavior dimensions and generic TQM principles traditionally examined. Besides, to date, this is the most comprehensive empirical study performed in Turkish business environment to evaluate the importance of leadership to quality management.

The remainder of this paper is organized as follows. In the next section, a review of relevant literature on SCQM, leadership concept and the role of leadership styles in SCQM is presented. Based on the review of the literature, a conceptual research model and related hypotheses are proposed, and also the methodology of this research is presented in section three. Section four presents the data analysis and results of hypotheses testing carried out by Structural Equation Modeling. The conclusions are summarized in the last section.

II. LITERATIVE REVIEW

Quality Management within Supply Chain Context

SCM is a holistic approach advocating the "philosophy by which firms can operate inter-organizationally and merge both strategic initiatives and upstream and downstream processes in order to achieve business excellence" [59]. The concept of SCM has evolved from two separate paths: "purchasing and supply management", and "transportation and logistics management" [47]. SCM consists of internal practices, which are contained within a firm, and external practices, which cross organizational boundaries to integrate a firm with its customers and suppliers [47]. From the operations management perspective, flow management and quality management are the two dimensions of the supply chain [25]. As one significant dimension of supply chain, SCQM not only requires QM to be implemented internally within each supply chain member's organization, but also requires communication, collaboration, and integration with both upstream and downstream supply chain members with respect to quality [40].

QM is more and more recognized as a significant dimension of the supply chain. With a comprehensive literature review, Robinson and Malhotra point out that SCQM has received scant research attention [59]. The authors define SCQM as follows: "SCQM is the formal coordination and integration of business processes involving all partner organizations in the supply channel to measure, analyze and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers in the market place". According to Ross SCQM can be seen as "the latest stage in the total quality movement" [62].

SCQM requires simultaneous integration of internal practices, upstream supplier quality performance and downstream customer requirements. Forker et al. demonstrate that the proper implementation and coordination of quality management activities in the upstream side of the supply chain improve supplier quality performance [24]. Ross points out the three general trends leading to an increased emphasis on supply chain quality: expansion of quality initiatives, deregulation in the transportation sector, and expansion of logistics activities [62]. Tracey and Tan state that customer satisfaction can be improved through supplier involvement and selecting suppliers based on product quality, delivery reliability, and product performance [77]. Salvador et al. demonstrate that by interacting with suppliers and with customers regarding materials flow and quality, a firm can obtain better time-related operational performance in terms of speed and delivery punctuality [65]. Romano and Vinelli, in their case study, examine the two different supply chains operated by a textile and apparel manufacturer – one is traditionally managed without formal integration, whereas the other is more coordinated with suppliers and customers [61]. Their findings indicate that the integrated supply network is able to better meet the quality expectations of the final customers through the joint definition and co-management of quality practices. Kuei et al. extend the QM instrument proposed by Saraph et al. by including four quality factors (supplier selection, supplier participation, customer relations and benchmarking) to study the association between SCQM and organizational performance [43]-[67]. Fynes et al. found a positive impact of supply chain relationship quality on quality performance [27]. Kaynak and Hartley which uses supplier quality management and customer focus to extend the causal framework for QM practices and performance in Kaynak into the supply chain [39]-[40]. This study examines how these two upstream and downstream practices lead to improved performance and how other practices mediate those relationships. The findings reveal that supply chain members need each develop inter-clocking practices based on communication, collaboration and integration to improve quality performance at the end of the supply chain.

Over the last 30 years many empirical studies have investigated and measured QM practices, and various aspects of a firms performance, e.g. [1]-[2]-[19]-[23]-[39]-[52]-[67]-[66]-[73]-[85], while some others particularly linked QM and SCM thus more concentrated on SCQM constructs, e.g. [6]-[22]-[26]-[36]-[37]-[42]-[43]-[48]-[59]-[76]-[78]-[84]-[85]. Through an intensive review on this literature as well as on leading business excellence models, e.g. EFQM, MBNQA, this study determines eight critical success factors for measuring a firm's SCQM performance. These factors and associated quality practices are listed as follows;

- **Top Management Commitment to Quality:** Acceptance of quality responsibility by top management; support, involvement in and constant commitment of the company top management in all its functions to quality improvement; specificity of quality goals; designing internal functions to reflect the organization's mission; comprehensive quality planning; importance attached to quality in relation to cost and schedule.

- **Focus on Human Resources:** Provision of trade-related and task-related training for all employees; employee suggestion regarding improvements; open communications; employee empowerment; open employee participation in quality decisions; responsibility of employees for quality; employee recognition for superior quality performance; effectiveness of supervision in handling quality issues.
- **Overall Participation and Teamwork:** Implementation of all employee involvement in quality improvement activities; involvement and cooperation of all affected departments and the entire staff in design reviews; top management support on group works and group goals rather than individual.
- **Customer Focus:** Frequent meetings with customers; customer visits to the plant; encouragement of customer feedback on quality; customers involvement in product design; use of customer needs survey; global customer satisfaction as regards products and services received.
- **Commitment to Continuous Improvement:** Availability of information on quality performance and productivity; less reliance on inspection; statistical process control; preventive maintenance; conformity to product specifications which the product reaches at the end of the production process; employee self-inspection; automated testing; provision of statistical training; clarity of process ownership, boundaries, and steps.
- **Cooperative Relations with Supply Chain Partners:** Long-term relationships with suppliers; supplier involvement in product development; open communication and timely information sharing; availibility of quality data; feedback of quality data; fewer dependable suppliers.
- **Suppliers and Logistics Partners Quality Management:** Quality rather than price focus in selecting suppliers and logistics partners; supplier and logistics partner involvement in quality improvement; reliance on supplier process control; strong interdependence of supplier and customer; supplier quality control; supplier certification.
- **Focus on Sustainability and Environment:** Giving consideration to, and actively promoting social responsibility and ecological sustainability both now and for the future; meeting and exceeding the expectations and regulations of the local and where appropriate, the global community; seeking out and promoting opportunities to work on mutually beneficial projects with society inspiring and maintaining high levels of confidence with stakeholders; being aware of the organization's impact on both the current and future community and take care to minimize any adverse impact (EFQM, 2013)

Leadership's Role on Quality Management

The role of leadership at the top management levels in successfully managing quality has been addressed by many case studies, examining issues such as; the attitudes of top managers that are necessary for effectively managing quality [15]; the struggles faced by organizations in implementing total quality management [57]; leadership styles that are used in implementing TQM in organizations [68]; the impact of leadership roles on quality initiatives and the interrelationship between organizational culture and leadership [82]. The general consensus of the authors of these case studies is that organizations that successfully manage quality tend to have leaders that can effectively involve people at multiple levels in the organization and motivate them to participate in, and as, teams in the management of quality. An important aspect of leadership in a vision of the "total quality" is to extend the power of decision at the lower levels of the managerial hierarchy, by involving employees in the process of quality improvement.

The Deming model proposed a QM theory that is initiated by visionary management, which leads to improved customer satisfaction [3]-[4]-[64]. Multiple researchers have argued that transformational leadership is the visionary leadership espoused by Deming [18]-[17]-[81]-[70]. If visionary leadership and transformational leadership are equivalent, then the Deming model suggests that increased transformational leadership directly increases supplier and customer cooperation, which are infrastructure practices, and through these practices transformational leadership affects process management, which is a core QM practice. So, based on investigation of the Deming model, it is expected that an increased level of transformational leadership would increase the level of both infrastructure and core QM practices in a firm. For example, transformational leadership should help establish a vision of an organized, clean, and efficient plant with a low defect rate. These high expectations should then help create an infrastructure of cooperation both internally and externally, which should enhance the establishment of core process management practices such as design quality management.

Leadership's role in QM has primarily been investigated using the constructs of top management support or commitment [74]-[72]. Roethlein et al. found that quality performance increased when top management was supportive [60]. Howard and Foster, and Routhieaux and Gutek found that leader commitment and attitude were important for good QM [32]-[63]. Also, Kathuria and Davis found that in plants with a high-quality emphasis, those leaders who emphasized relationship-oriented leadership practices (for example, consulting and inspiring) and communication leadership practices (for example, informing and clarifying) were viewed as more effective leaders [38]. Both approaches to modeling leadership, however, suggest that companies that have a higher level of quality performance will have higher levels of transformational leadership than companies that are unsuccessful quality performers [3]-[81]. Another related study by Laohavichien et al. tested the influence of both transactional and transformational leadership on a firm's quality improvement [45]. Through a study of quality managers in the United States, the study found that although transformational leadership affects infrastructure and core quality management, transactional leadership does not affect either. Waldman even argues that transactional leadership may negatively affect quality performance by encouraging individuals to pursue their own goals instead of the company's goals [81].

Transformational leadership is viewed as the type of leadership needed to create radical change while transactional leadership as the type of leadership used to produce incremental change [11]. Transactional leadership is an exchange process [10]. The leader rewards or punishes based on the degree to which the followers comply with their requests and/or achieve organizational goals. Transactional and transformational leadership are different behaviors, but they are complementary and not oppositional, and leaders exhibit varying degrees of transformational and transactional behaviors as needed [7]-[49]-[31]. There is evidence that more effective leaders exhibit higher levels of transformational leadership than transactional leadership [49]-[31]. Since scholars describe charismatic leadership, supportive leadership, visionary leadership and inspirational leadership as forms of transformational leadership, this study interchangeably uses such leadership to represent transformational leadership.

In line with Burns [14], Bass [13] identified four components of transformational leadership: They are: (a) Idealized Influence, (b) Inspirational Motivation, (c) Intellectual Stimulation, (d) Individualized Consideration. Bass [13] also identifies two behavioral dimensions of transactional leadership as follows: (a) Management-by-Exception, (b) Contingent Reward. In contrast to the previous two styles, "laissez-faire (i.e. non-leadership)" leaders prefer to avoid making decisions and delay taking necessary actions, and importantly, they completely ignore authorities and responsibilities. In order to measure these transformational, transactional and non-leadership factors scales, Bass and Avolio developed the Multifactor Leadership Questionnaire (MLQ) [9].

According to Podsakoff et al. transformational leadership is composed of six dimensions [55]. They are: (a) Articulating a Vision, (b) Providing an Appropriate Model, (c) Fostering the Acceptance of Group Goals, (d) High Performance Expectation, (e) Providing Individualized Support, (f) Intellectual Stimulation. Podsakoff et.al's (1990) "leadership behavior inventory" is another measure of transformational leadership behaviors. Podsakoff et.al.'s scale is designed to measure six key dimensions of transformational leadership and two dimensions of transactional leadership. Podsakoff et al. confirmed psychometric of the transformational leadership scales and demonstrated that the six dimension model significantly fits the data [55]. There is a strong evidence to support the reliability and validity of the Podsakoff et al.'s [54]-[55] scales as they have been used and supported by many other researchers, e.g. [79]-[49]-[53]-[45].

As found more associated with SCQM constructs, this study uses Podsakoff et al.'s leadership behavior inventory to assess transformational leader behaviors [55]. These scales were designed to measure the six dimensions of transformational leadership and are identified as follows:

- **Articulating a Vision:** Multiple researchers and practitioners have stressed the need for the leader to articulate a vision and have suggested that vision leads to successful quality performance.
- **Providing an Appropriate Model:** Measures whether top management exhibits behaviors in agreement with the vision. It is expected that employees will recognize these behaviors as a path to success if top management uses them. Once the employees recognize the importance of these behaviors, it is expected that they will demonstrate these behaviors, which will result in continuous improvement.
- **Fostering the Acceptance of Group Goals:** It is likely that employees of companies with leaders who foster the acceptance of group goals will support the group goals. Employees who accept their firm's goals are more likely to become involved in quality improvement efforts themselves and to support efforts by others to improve quality performance. Consequently, it is expected that the leader's fostering of group goals will improve quality performance.
- **Setting High-Performance Expectations:** Since successful implementation of QM requires high performance from employees, it is expected that when leaders set high-performance expectations that employees will be encouraged to make an extra effort to improve quality performance.
- **Providing Individualized Support:** It is expected that leaders who provide higher levels of individualized support will have more motivated employees than the employees of leaders who provide lower levels of individualized support. Further, this motivation will lead to greater effort and improved quality performance.
- **Intellectual Stimulation:** Leaders who provide intellectual stimulation for their employees should have higher levels of quality performance, since intellectual stimulation inspires employees to find ways to improve their performance.

III. RESEARCH MODEL AND METHODOLOGY

Figure 1 presents the proposed conceptual framework in a structural equation model. In this model, Transformational Leadership (LD) and Supply Chain Quality Management (SCQM) are presented as the latent constructs which are linked to each of their measurement scales. Transformational Leadership (LD) measurement scales represent six behavioral dimensions of Podsakoff et al. [55]: (1) Articulating a Vision (LD1), (2) Providing an Appropriate Model (LD2), (3) Fostering Acceptance of Group Goals (LD3), (4) High Performance Expectations (LD4), (5) Intellectual Stimulation (LD5), (6) Providing Individualized Support (LD6). Supply Chain Quality (SCQM) measurement scales represent eight performance dimensions: (1) Top Management Commitment to Quality (SCQM1), (2) Focus on Human Resources (SCQM2), (3) Overall Participation and Teamwork (SCQM3), (4) Customer Focus (SCQM4), (5) Commitment to Continuous Improvement (SCQM5), (6) Cooperative Relations with Supply Chain Partners (SCQM6), (7) Suppliers and Logistics Partners Quality Management (SCQM7), (8) Focus on Sustainability and Environment (SCQM8).

In addition, the structural relationship between these two latent variables depicted by arrow H correspond to research hypotheses.

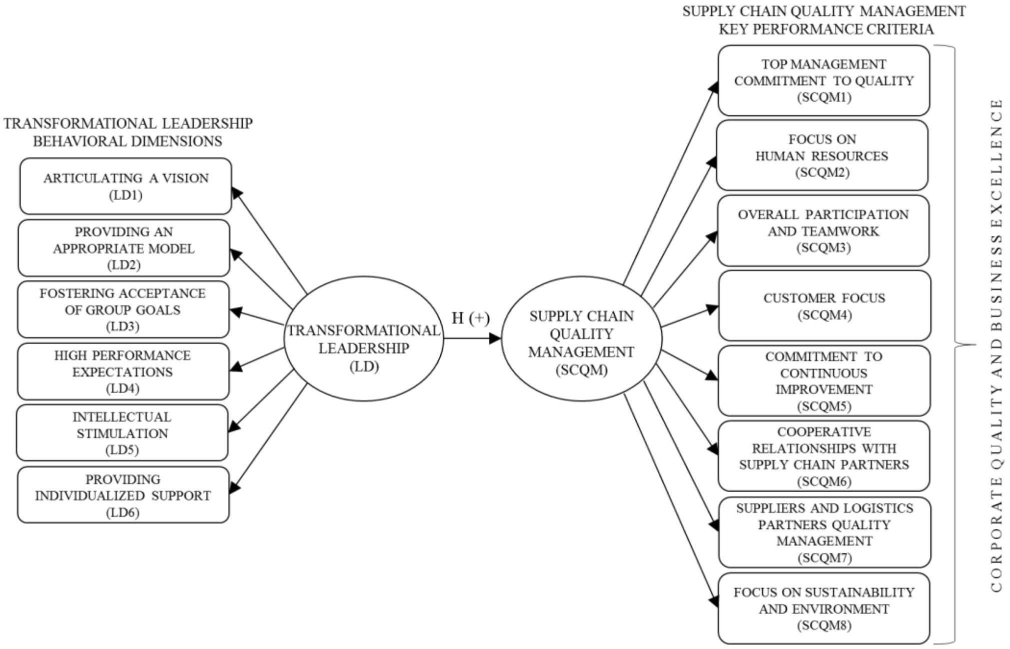

Figure 1. Conceptual Research Model

H: Companies accommodating higher levels of transformational leadership show significantly better performance on SCQM than companies having lower levels of transformational leadership.

Research Methodology

This study implements a questionnaire to measure the six dimensions of LD and eight dimensions of SCQM using two items for each from the prior literature. There is strong evidence to support the reliability and validity of these scales and items from prior studies, e.g. [9]-[55]-[54]-[49]-[67]-[2]-[56]-[26]-[40]-[48]-[37]-[42]-[45]-[59]-[78]-[85]-[20]-[51]. All items were measured on a seven-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Totally ten questions were asked in order to learn demographic information. These questions include; Private or Public Company, Sector of the Company, Number of Employees, Share of Foreign Capital, Regional Location, Existence of any Official Quality Certificate, Existence of any Official Quality Program, Manufacturing or Service or Trading Company, Department of the Respondent, the Position or Title of the Respondent in the Company, the title of the Respondent's First Manager.

The sample frame for the survey was randomly selected from the database in the Turkish Society for Quality (KalDer). The questionnaire was administered through a website. An announcement letter together with a web-link of questionnaire was sent to 550 contact names and e-mail addresses registered in the KalDer database. It was required mainly the executives which are most related to quality (e.g. quality, production, logistics, supply chain, and purchasing managers) to answer the questionnaire.

Totally 259 person answered the survey at the Web site, resulting in a response rate of 47 percent. After examination 101 questionnaire were found incomplete and/or unreliable. Some of them were eliminated because of unsuitable demographic profile. Thus total number of valid questionnaire are 158, resulting in a response rate of 28.7 percent.

As mentioned earlier, reliability and validity of the scales and items used in this survey were supported by many prior studies. However, as the questionnaire items were translated from their original language into

Turkish, and as we combined some items in relevant scales, we needed to conduct a validity test to find out the internal coherence of each scale. This test was done through a Cronbach Alpha analysis. As a result of this analysis, we concluded that all scales are valid as the Cronbach Alpha values were found over 0.70 for each scale (LD1=0.94, LD2=0,84, LD3=0.95, LD4=0.80, LD5=0.91, LD6=0.91, SCQM1=0.95, SCQM2=0.86, SCQM3=0.81, SCQM4=0.89, SCQM5=0.87, SCQM6=0.85 ,SCQM7=0.84 , SCQM8=0.81)

IV. DATA ANALYSIS AND HYPOTHESIS TESTING

Before analyzing our structural model and hypothesis testing, we present the main findings of our survey, by geometric mean and standard deviation of respondents' rates for each scale, in Table 1.

Table 1. Main Findings of the Survey

LD Behavioral Dimensions		μ	s
LD1	Articulating a Vision	4,56	1,652
LD2	Providing an Appropriate Model	4,68	1,450
LD3	Fostering Acceptance of Group Goals	4,60	1,610
LD4	High Performance Expectations	**4,96**	1,496
LD5	Intellectual Stimulation	4,65	1,588
LD6	Individualized Support	4,61	1,595

SCQM Performance Dimensions		μ	s
SCQM1	Top Management Commitment to Quality	4,88	1,628
SCQM2	Focus on Human Resources	4,67	1,524
SCQM3	All Employee Involvement and Teamworks	4,38	1,551
SCQM4	Customer Focus	**5,12**	1,556
SCQM5	Commitment to Continuous Improvement	4,81	1,591
SCQM6	Cooperative Relationships with SC Partners	4,76	1,418
SCQM7	Suppliers and Logistics Partners Quality Management	4,50	1,542
SCQM8	Focus on Sustainability and Environment	4,91	1,620

It can be seen in Table 1 that the rate given to "High Performance Expectations" dimension of Transformational Leadership is significantly higher than the others. Besides, the answer of respondents to this dimension is rather homogenous. The lowest rate is given for the LD dimension of "Articulating a Vision". The rates for "Fostering Acceptance of Group Goals" and "Individualized Support" dimensions are also poor. According to this result it can be said that the focus of managers is on individual performance rather than teamwork and group performance. Besides, the managers don't articulate a strong vision to stimulate the employees for a better performance. This may result and most probably perceived by employees as "pressure" on work.

As far as SCQM dimensions are concerned, it can be seen on Table 1 that the respondents give the highest rate to the "Customer Focus" dimension of SCQM. Also the rates for "Focus on Sustainability and Environment" and "Top Management Commitment to Quality" dimensions are relatively high. Which is a good sign for firms' success on SCQM. However, the relatively lower rates for "All Employee Involvement and Teamwork", "Focus on Human Resources" and "Supplier and Logistics Partners Quality Management" dimensions denote a lack of participative and supportive relations with and between internal and external partners of supply chain.

In this study, Anderson and Gerbing's [5] two-step approach is used, i.e. the measurement model is estimated prior to the structural model. As we have one endogenous (SCQM) and one exogenous (LD) latent variable, for each we measure the fitness of measurement model separately. The LISREL 9.1 Student version software is used to test the measurement and structural models based on the maximum likelihood estimation method.

Analysis on Measurement Model

We test the measurement models using the confirmatory factor analysis (CFA) method as described in Hair et al. [30]. Figure 2 shows the factor loading estimates of the measurement models. Here, we present the results for the final measurement models. Measurement models for LD and SCQM yield χ^2/df = 1.93 and 1.69 respectively which are below the threshold of 3.00. Additionally, we calculate other goodness-of-fit measures. Based on the recommendations of Hu and Bentler [33] and Jöreskog and Sörbom [34], we choose standardized root mean square (SRMR), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), normed fit index (NFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA). The recommended values for these fit indices and the results for the measurement models are given in Table 2 and Table 3 which show that all values are within the recommended ranges indicating that both measurement models have a good fit.

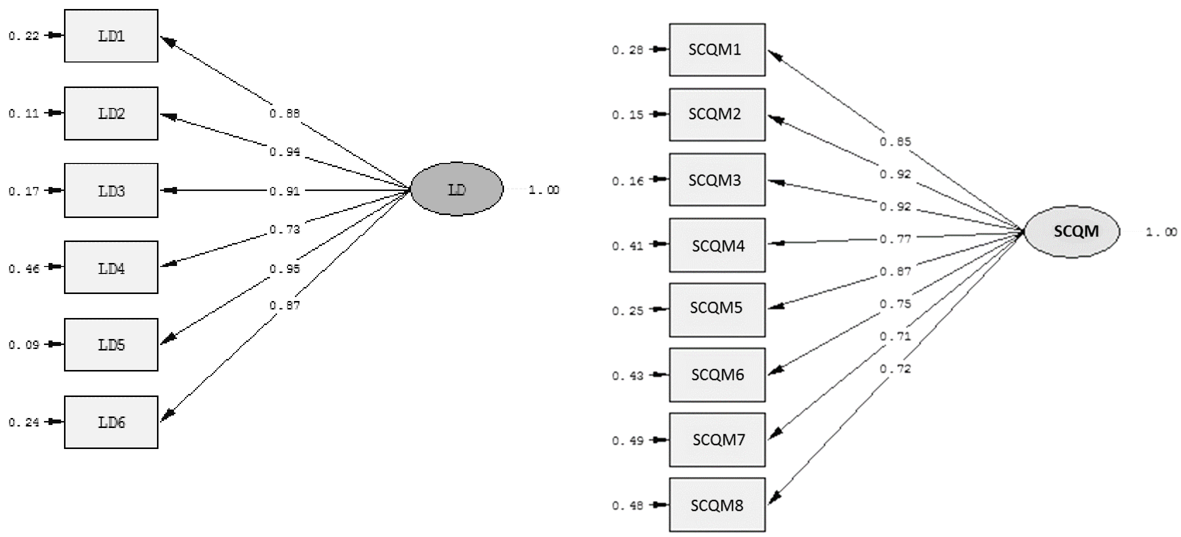

Figure 2. Factor Loadings of the Measurement Models

After evaluating the fit of the measurement models, we assess the construct validity by testing the convergent validity. We test the convergent validity by examining the factors loadings first. The factor loadings of LD and SCQM are significant at the 0.05 and 0.01, respectively, and all are above or equal to 0.70. All are acceptable as the factor loadings are above 0.50. Second, the average variance extracted (AVE) is calculated for each latent construct. AVE values are calculated 0.780 and 0.668 for LD and SCQM, respectively. Since an AVE of 0.50 or higher suggests adequate convergent validity, both are acceptable. Finally, we calculate the construct reliability (CR) which is another indicator of convergent validity. CR values are calculated as 0.960 and 0.941 for LD and SCQM, respectively. Since they both exceed the threshold of 0.70, this also validates convergent validity.

Table 2. Goodness-of-Fit Measures for the Measurement Model for Exogenous Variable LD

Goodness-of-fit measure	Recommended value (Schermelleh-Engel et al., 2003)	Result
χ^2/df	≤ 3.00	1.933
SRMR (Standardized Root Mean Square Residual)	≤ 0.10	0.015
GFI (Goodness-of-Fit Index)	≥ 0.90	0.972
AGFI (Adjusted Goodness-of-Fit Index)	≥ 0.85	0.915
NFI (Normed Fit Index)	≥ 0.90	0.991
CFI (Comparative Fit Index)	≥ 0.95	0.995
RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.077
	(Hair et al., 2010)	
CR (Construct Reliability)	≥ 0.70	0.960
AVE (Average Variance Extracted)	≥ 0.50	0.780

Table 3. Goodness-of-Fit Measures for the Measurement Model for Endogenous Variable SCQM

Goodness-of-fit measure	Recommended value (Schermelleh-Engel et al., 2003)	Result
χ^2/df	≤ 3.00	1.694
SRMR (Standardized Root Mean Square Residual)	≤ 0.10	0.028
GFI (Goodness-of-Fit Index)	≥ 0.90	0.958
AGFI (Adjusted Goodness-of-Fit Index)	≥ 0.85	0.906
NFI (Normed Fit Index)	≥ 0.90	0.987
CFI (Comparative Fit Index)	≥ 0.95	0.995
RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.066
	(Hair et al., 2010)	
CR (Construct Reliability)	≥ 0.70	0.941
AVE (Average Variance Extracted)	≥ 0.50	0.668

Analysis on Structural Model and Hypothesis Testing

After testing the measurement model, we test our structural model and our main focus is to test the hypothesized relationship. Our structural model consists of one exogenous variable (LD) and one endogenous variable (SCQM). Recall that the exogenous variable LD has six and endogenous variable SCQM has eight indicators.

The goodness-of-fit of the structural model is evaluated with the same measures used to test the measurement models. The goodness-of-fit measures for the structural model are given in Table 4. The results denote that all the measures are within desirable ranges and the structural model fits the data well.

After evaluating the goodness-of-fit measures for the structural model, we turn our attention to the path coefficients and loading estimates, which are given in Figure 3. When we compare the loading estimates of the measurement and structural models, we can see that they are nearly the same and the maximum difference is 0.01. This is an evidence of stability among the measured indicator variables and supports the validity of the measurement model [30].

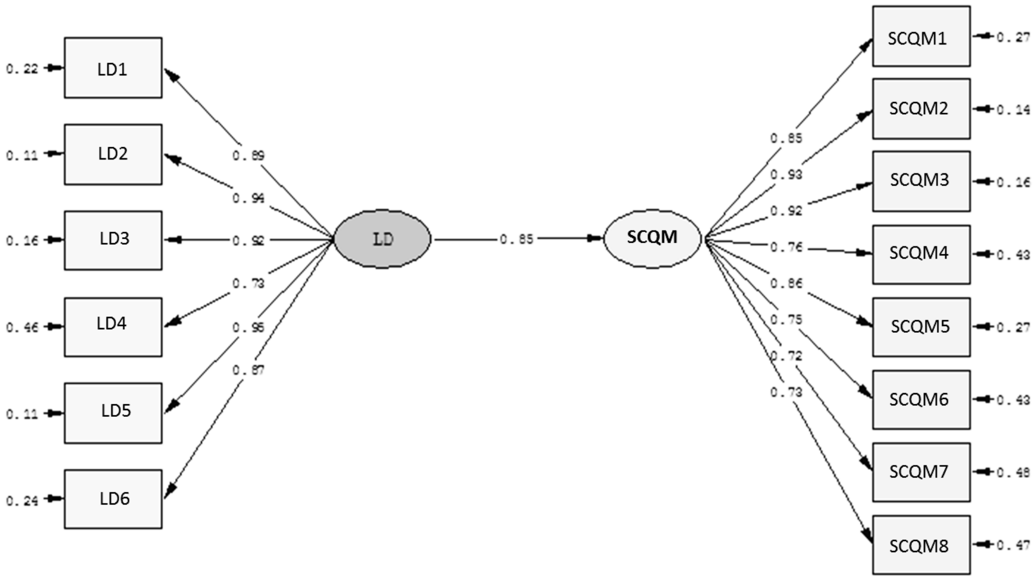

Figure 3. Results of the Path Analysis for the Structural Model

It can be seen that the path coefficient estimate between two latent constructs is 0.85 and it is significant at the 0.001 level. Thus our hypothesis is strongly supported, i.e., one degree increase on transformational leadership level may lead a 0.85 degree increase on firm's supply chain quality management performance.

Table 4. Goodness-of-Fit Measures for the Structural Model

Goodness-of-fit measure	Recommended value (Schermelleh-Engel et al., 2003)	Result
χ^2/df	≤ 3.00	1.716
SRMR (Standardized Root Mean Square Residual)	≤ 0.10	0.030
GFI (Goodness-of-Fit Index)	≥ 0.90	0.905
AGFI (Adjusted Goodness-of-Fit Index)	≥ 0.85	0.858
NFI (Normed Fit Index)	≥ 0.90	0.981
CFI (Comparative Fit Index)	≥ 0.95	0.992
RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.067

V. CONCLUSION

The aim of this empirical study is to investigate the effect of transformational leadership level of managers on the corporate SCQM performance. The results denote that the research hypotheses is supported, i.e., there is a significantly positive relation with transformational leadership style of managers and SCQM performance. On the other hand, research findings show that managers in Turkish organizations need to improve their behavioral leadership skills particularly on "Fostering Acceptance of Group Goals" and "Individualized Support" dimensions of transformational leadership. A further conclusion of the study is that in order to success in SCQM, the organizations must turn their focus much more on human resources and co-operative relations with internal and external supply chain partners.

The results of the study provides important insights to quality-related managers in enterprises about how to manage their quality programs, and which leadership skills need to be improved for successful implementation of SCQM practices. The results of this study provides a general view as it combines samples from various sectors. It is noteworthy that the results of this study might differ on sector base. As a further study, this analysis can be done by focusing more on a specific sector. We also propose a comprehensive study of a leadership model to guide quality managers.

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SUPPLIER PERFORMANCE MEASUREMENT WITH GREY REATIONAL ANALYSIS IN A FOOD COMPANY

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Abstract _ It has become more complicated to select the best suppliers in today's competitive market. The monthly or yearly performance measurement of these selected suppliers has become a complex process. Supplier evaluation process is based on multi criteria and performance measurements of the selected suppliers need detailed analysis of these criteria. The selection criteria depend on the sector of the purchaser and the supplier. After measurement of supplier's performance, the suppliers may cooperate with purchaser company for improving the areas that need improvement, and they may reach sustainable high performance. In this study, suppliers' performance measurement is performed by using grey relational analysis for fifteen suppliers of a main producer that works in food sector.

Key Words _ Grey Relational Analysis, Multi-criteria Decision Making, Supplier Measurement, Supply Chain Management,

1. INTRODUCTION

Suppliers play a key role in supply chain, since they supply direct or indirect input materials to manufacturing process. The performance of suppliers, affects the whole supply chain from the main manufacturer to the last consumer. Performance evaluation activities have key factor for the firms, since it helps firms to realize their position in the market. It also helps them to discover the areas that need improvement [2].

Supplier evaluation and selection process is considered as a multi criteria decision making problem. In literature, there are many different performance evaluation methods such as; discriminant analysis, factor analysis, principle component analysis, cluster analysis etc. More recently, new models like fuzzy theory, data envelopment analysis etc. are developed for performance evaluation. Nevertheless, such statistical methods need detailed data with normal distribution[3].

In this study, fifteen certificated suppliers of a food company are evaluated by grey relation analysis method. The scores of suppliers are determined by an expert team of the company. The scores used in evaluation process are the average of all scores from the experts.

2. LITERATURE SEARCH

Grey theory was first developed by Julong Deng in 1982 [4]. It has been used many different areas. Grey theory was used by Hsu and Wen [5], in order to design the traffic and flight frequency in airways. Feng and Wang [6] used grey theory for measuring the financial performance of airway companies, and Yuan [7] used it for defining the ratios which affect the performance of company.

Chang [8]has measured performance of the banks by grey relation analysis. Wang [9] used grey relation analysis for measuring the performance of logistic companies. One of the methods used for optimization of wire erosion system is grey relation analysis method in the study of Lin and Lin [10]. Karunamoorty and Karthikeyan [11] used grey relation analysis method to optimize the results of polymer material process. Uçkun and Girginer [12] used this method for measuring the performance of the banks based on profitability

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and quality. Peker and Baki [13] evaluated the performance of Turkish Insurance Companies via grey relation analysis method. Şişman and Eleren [14] compared grey relation analysis method with ELECTRE method for selecting the most suitable automobile.

3. GREY RELATIONAL ANALYSIS METHOD

The grey theory was first developed by Julong Deng in 1982. The information that is either incomplete or undetermined is called grey information up to this theory. The model includes three types of information points; black, white or grey. The main goal is to transfer black points in the system to the grey points [15].

The grey system provides solutions to problems where the information is limited, incomplete and characterized by random uncertainty. In recent twenty years, the grey theory has become a popular technique providing multidisciplinary approaches.

Grey relation analysis is a multi-criteria decision making method that helps managers to take the right decision under circumstances with limited and uncertain data [16].

Grey relation analysis includes six steps. These steps are explained below [17]:

1. Step: Construction of Norm Matrix
An "m x n" norm matrix made up of "m" alternatives and "n" criteria is constructed as follows:

$$\begin{matrix} X_1(1) & X_1(2) & \dots & X_1(n) \\ X_2(1) & X_2(2) & \dots & X_2(n) \\ .. & .. & & .. \\ X_m(1) & X_m(2) & \dots & X_m(n) \end{matrix} \quad (1)$$

In the norm matrix (1), $X_i(k)$ value shows the "k"th criterion of supplier"i".
2. Step: Construction of Reference Sequence
The reference sequence can be changed up to the application area. The reference sequence of this study is defined as $X_0 = (1, 1, \dots, 1)$. The aim is to find the closest sequence to the reference among the alternatives [18].

3. Step: Normalization
Since MCDM problems may contain a variation of different criteria, the solution needs normalization. Normalization process has following three equations [14]:

$$X_i(k) = (x_i(k) - \min x_i(k)) / (\max x_i(k) - \min x_i(k)) \quad (2)$$

$$X_i(k) = (\max x_i(k) - x_i(k)) / (\max x_i(k) - \min x_i(k)) \quad (3)$$

$$X_i(k) = 1 - \left| x_i(k) - u_i \right| / \max \left| x_i(k) - u_i \right| \quad (4)$$

Here, normalization based on the characteristics of three types of criteria, namely maximum the better (equation 2), minimum the better (equation 3) and nominal the best (equation 3)

4. Step: Calculation of Absolute Value Table
The difference between a normalized entity and its reference value is calculated. The difference is shown as ΔX_i.

$$\Delta X_i(k) = \left| Y_0(1) - X_1(1) \right|, \left| Y_0(2) - X_1(2) \right| \dots \left| Y_0(n) - X_1(n) \right| \quad (5)$$

5. Step: Construction of Grey Relational Coefficient Matrix
In the difference matrix, Δ_{max} and Δ_{min} values are calculated, where,

Δ_{max} : maximum difference value in the matrix
Δ_{min} : minimum difference value in the matrix

$$K_{(j)} = (\Delta_{min} + \delta\Delta_{max}) / (\Delta_i(j) + \delta\Delta_{max}) \qquad (6)$$

In equation 6, $\Delta_i(j)$; shows the "j"th value in Δ_i difference data sequence. δ is known as distinguishing coefficient for the index for distinguishability and in most situations it takes the value 0,5 for good stability.
6. Step: Calculation of Grey Relational Degree
The grey relation degree of "i"th alternative is expressed as following eq.:

$$\acute{\tau}_i = 1/n \sum_{m=1}^{n} K(m) \qquad (7)$$

If the criteria have different weights, the grey relation degree is formulated as:

$$\acute{\tau}_i = 1/n \sum_{m=1}^{n} K(m) w(m) \qquad (8)$$

Where, w(m) refers to weight of "n"th. criterion. The sum of the weights of all criteria must equal to 1.

4. THE MAIN CRITERIA FOR SUPPLIER PERFORMANCE EVALUATION

The indicators that are used to determine the effectiveness and efficiency of an activity are called performance criteria and the set of these criteria is performance measuring system [19]. The main performance measuring criteria which are used in this study are explained in the following sections.

4.1.Delivery

On time delivery is an important criterion for evaluation and selection of suppliers. It is also important for strong, long term supplier-buyer relationship [24]. A delivery criterion includes delivery of products on time and in a reliable way. The way of delivery [plane - ship] also affects the performance of delivery. Suppliers should have flexibility for the changes in production and order, and have adequate capacity to match the buyer's needs. The shipping cost is also effective in on time delivery of products.

4.2.Quality

Along the way from the supplier to the customer, a small defect in quality may cause serious problems in the whole supply chain cycle. Because of that, the quality problems causing from suppliers are great concern to the manufacturing firms. The rejected product ratio is an important factor, since it may cause insufficient amount of manufacturing. It may cause also defects or cuts in production. Suppliers should be in continuous enhancement, in order to supply the best product to manufacturer.

The quality criterion includes the quality control methods and quality certificates of the supplier. It also includes defective product ratio. The certificates which are taken in to consideration in assessment process are the documentations like migration tests, TSE, ISO, analysis certificates etc.

4.3.Service

The service criterion is one of the most difficult criteria for transferring quantitative values and it can be separated to many sub-criteria according to customer needs [28]. A supplier needs modern communication channels and tools to cooperate with buyer. Recovery of defective products, technical support, warranty conditions and customer service productivity will increase the efficiency of cooperation. After sales support and accessory security should also be taken in to consideration.

4.4.Price

Price criterion includes the real price and quantity discounts of the product that is purchased from the supplier [24]. Purchaser companies usually prefer lower price products in order to minimize their purchasing costs and hence maximize their profits. The price criterion is very critical for manufacturing companies in order to get competitive advantage in the sector. Therefore, the total cost of a product or service is one of the most important factors in supplier evaluation and selection process for a purchasing company.

5. SUPPLIER PERFORMANCE EVALUATION BY USING GREY RELATION ANALYSIS METHOD

In application part of this study, grey relation analysis method is used in order to evaluate the suppliers in a food manufacturing company. It is aimed to measure the performance of fifteen suppliers and then to select the best performing supplier.

In this study, the performance evaluation and selection is based on four main criteria and fifteen sub criteria. These criteria can be seen in figure 1. The criteria and their weights are determined by an expert team of the company.

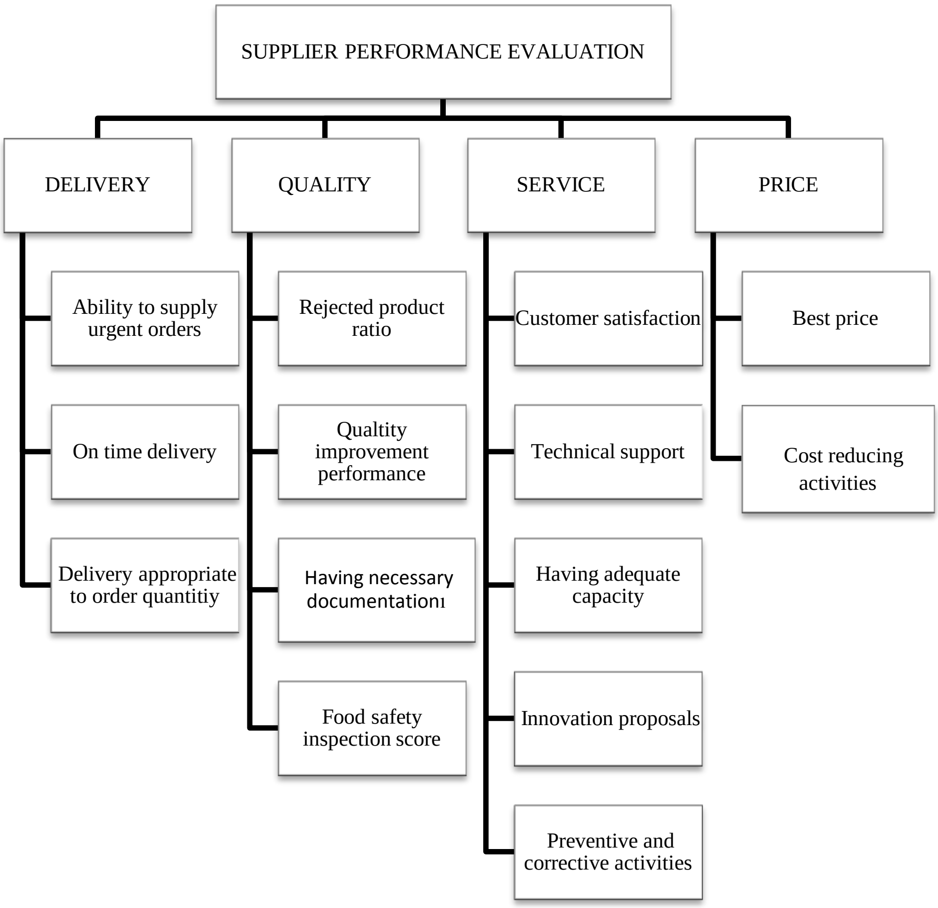

Figure 1. Supplier Performance Criteria

All the criteria in this study are expressed in quantitative values. Criteria are named as K1, K2,.....,K14, and suppliers are named as T1, T2,......,T15. The evaluations of criteria K4 and K5 are based on the minimum is better principle, while the other criteria are evaluated by maximum is better principle. Table 1 shows the performance criteria with their explanations.

Table 1. Performance Criteria with Explanations

Criteria	Name of Criteria	Explanation	Evaluation Principle
K1	On time delivery	If a supplier delivers on time, he gets the score 2, otherwise he gets 1	Max. is better
K2	Delivery appropriate to order quantity	If a supplier delivers exact amount, he gets score 2, otherwise he gets 1	Max. is better
K3	Ability to supply urgent orders	Amount of urgent supply / Amount of urgent order [in a year]	Max. is better
K4	Ratio of rejected products	Rejected product amount / Order amount [in a year]	Min. is better
K5	Quality improvement performance	Complaintment number / Order amount [in a year]	Min. is better
K6	Having necessary documentation	Existing Documents / Requested Documents	Max. is better
K7	Food safety inspection score	Maximum score is 1000. The score is divided by 1000.	Max. is better
K8	Customer satisfaction	The % score in the customer satisfaction survey.	Max. is better
K9	Technical support	Technical support / Demanding support	Max. is better
K10	Having adequate capacity	Monthly order / Monthly capacity of supplier	Max. is better
K11	Innovation proposals	Innovation proposals by supplier in a year	Max. is better
K12	Preventive and corrective activities	Preventive and corrective activities / Supplier based problem	Max. is better
K13	Best price	Number of auction winning in a year	Max. is better
K14	Cost reducing activities	Number of cost reducing activities in a year	Max. is better

The six step of grey relational analysis is performed in the following order:

1. **Step:** For the solution of supplier evaluation problem the first step is construction of the norm matrix. The norm matrix formation with (m x n) elements are given below in the table 2.

Table 2. The Norm Matrix

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
T1	1	2	0,4	0,10	0,30	0,40	0,97	0,7	1	1	2	1	6	1
T2	2	1	1	0,02	0,53	0,40	0,40	0,75	0,8	1	1	1	4	2
T3	1	2	0,6	0,08	0,41	0,95	0,89	0,55	0,66	1	3	0,8	8	1
T4	1	2	0,8	0,05	0,30	0,25	0,89	0,6	1	1	2	1	23	6
T5	2	2	1	0,00	0,03	1,00	1,00	0,9	1	1	4	1	20	5
T6	2	2	0,8	0,02	0,05	0,95	0,95	0,95	0,24	1	4	1	1	2
T7	1	2	0	0,10	0,08	0,85	0,74	0,75	0,74	0,8	1	0,6	2	1
T8	2	1	0,2	0,01	0,09	0,90	0,56	0,85	1,00	0,65	1	0,5	1	1
T9	1	1	0	0,10	0,02	0,15	0,30	0,55	0,13	0,55	0	0,55	1	0
T10	1	2	1	0,05	0,07	0,55	0,50	0,8	0,75	1	3	1	4	1

T11	2	1	0,4	0,05	0,15	0,80	0,69	0,7	0,92	0,8	2	1	2	2
T12	2	2	0,6	0,00	0,02	0,90	0,70	0,95	1,00	0,9	3	0,9	21	2
T13	1	2	0,8	0,01	0,11	0,75	0,88	0,65	0,00	1	1	0,8	3	3
T14	2	1	0,4	0,25	0,33	0,80	0,71	0,55	0,50	1	1	0,65	2	2
T15	1	2	0,6	0,17	0,40	1,00	0,40	0,65	0,13	1	1	0,55	2	1

2. **Step:** After formation of the norm matrix, the reference sequence is constructed in order to find comparable sequence of alternatives which gives the closest result to reference sequence. (Table 3)

Table 3. Reference Sequence

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
RS	2	2	1	0,95	0	1	0,95	0,95	1	0,85	4	1	100	12
T1	1	2	0,4	0,10	0,30	0,40	0,97	0,7	1	1	2	1	6	1
T2	2	1	1	0,02	0,53	0,40	0,40	0,75	0,8	1	1	1	4	2
T3	1	2	0,6	0,08	0,41	0,95	0,89	0,55	0,66	1	3	0,8	8	1
T4	1	2	0,8	0,05	0,30	0,25	0,89	0,6	1	1	2	1	23	6
T5	2	2	1	0,00	0,03	1,00	1,00	0,9	1	1	4	1	20	5
T6	2	2	0,8	0,02	0,05	0,95	0,95	0,95	0,24	1	4	1	1	2
T7	1	2	0	0,10	0,08	0,85	0,74	0,75	0,74	0,8	1	0,6	2	1
T8	2	1	0,2	0,01	0,09	0,90	0,56	0,85	1,00	0,65	1	0,5	1	1
T9	1	1	0	0,10	0,02	0,15	0,30	0,55	0,13	0,55	0	0,55	1	0
T10	1	2	1	0,05	0,07	0,55	0,50	0,8	0,75	1	3	1	4	1
T11	2	1	0,4	0,05	0,15	0,80	0,69	0,7	0,92	0,8	2	1	2	2
T12	2	2	0,6	0,00	0,02	0,90	0,70	0,95	1,00	0,9	3	0,9	21	2
T13	1	2	0,8	0,01	0,11	0,75	0,88	0,65	0,00	1	1	0,8	3	3
T14	2	1	0,4	0,25	0,33	0,80	0,71	0,55	0,50	1	1	0,65	2	2
T15	1	2	0,6	0,17	0,40	1,00	0,40	0,65	0,13	1	1	0,55	2	1

3. **Step:** In this step, the data are normalized. For the criteria K4 and K5, minimum is better normalization is used, while the other twelve criteria are normalized with maximum is better principle. In the table 4, the normalized data is given.

Table 4. Normalization of the Data

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
RS	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
T1	0,00	1,00	0,40	0,60	0,45	0,29	0,95	0,38	1,00	1,00	0,50	1,00	0,23	0,17
T2	1,00	0,00	1,00	0,93	0,0	0,29	0,14	0,50	0,80	1,00	0,25	1,00	0,14	0,33
T3	0,00	1,00	0,60	0,67	0,23	0,94	0,84	0,00	0,66	1,00	0,75	0,60	0,32	0,17
T4	0,00	1,00	0,80	0,80	0,45	0,12	0,84	0,13	1,00	1,00	0,50	1,00	1,00	1,00
T5	1,00	1,00	1,00	1,00	0,97	1,00	0,99	0,88	1,00	1,00	1,00	1,00	0,86	0,83
T6	1,00	1,00	0,80	0,94	0,94	0,94	0,93	1,00	0,24	1,00	1,00	1,00	0,00	0,33
T7	0,00	1,00	0,00	0,60	0,88	0,82	0,62	0,50	0,74	0,56	0,25	0,20	0,05	0,17
T8	1,00	0,00	0,20	0,95	0,86	0,88	0,36	0,75	1,00	0,22	0,25	0,00	0,00	0,17
T9	0,00	0,00	0,00	0,60	1,00	0,00	0,00	0,00	0,13	0,00	0,00	0,10	0,00	0,00
T10	0,00	1,00	1,00	0,80	0,90	0,47	0,29	0,63	0,75	1,00	0,75	1,00	0,14	0,17
T11	1,00	0,00	0,40	0,78	0,74	0,76	0,56	0,38	0,92	0,56	0,50	1,00	0,05	0,33

T12	1,00	1,00	0,60	1,00	0,99	0,88	0,57	1,00	1,00	0,78	0,75	0,80	0,91	0,33
T13	0,00	1,00	0,80	0,96	0,82	0,71	0,83	0,25	0,00	1,00	0,25	0,60	0,09	0,50
T14	1,00	0,00	0,40	0,00	0,38	0,76	0,59	0,00	0,50	1,00	0,25	0,30	0,05	0,33
T15	0,00	1,00	0,60	0,33	0,25	1,00	0,14	0,25	0,13	1,00	0,25	0,10	0,05	0,17

4. **Step:** Measuring differences and constructing the absolute value table.

Table 5. Table of Absolute Values

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
RS	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
T1	1,00	0,00	0,60	0,40	0,55	0,71	0,05	0,63	0,00	0,00	0,50	0,00	0,77	0,83
T2	0,00	1,00	0,00	0,07	1,00	0,71	0,86	0,50	0,20	0,00	0,75	0,00	0,86	0,67
T3	1,00	0,00	0,40	0,33	0,77	0,06	0,16	1,00	0,34	0,00	0,25	0,40	0,68	0,83
T4	1,00	0,00	0,20	0,20	0,55	0,88	0,16	0,88	0,00	0,00	0,50	0,00	0,00	0,00
T5	0,00	0,00	0,00	0,00	0,03	0,00	0,01	0,13	0,00	0,00	0,00	0,00	0,14	0,17
T6	0,00	0,00	0,20	0,06	0,06	0,06	0,07	0,00	0,76	0,00	0,00	0,00	1,00	0,67
T7	1,00	0,00	1,00	0,40	0,12	0,18	0,38	0,50	0,26	0,44	0,75	0,80	0,95	0,83
T8	0,00	1,00	0,80	0,05	0,14	0,12	0,64	0,25	0,00	0,78	0,75	1,00	1,00	0,83
T9	1,00	1,00	1,00	0,40	0,00	1,00	1,00	1,00	0,87	1,00	1,00	0,90	1,00	1,00
T10	1,00	0,00	0,00	0,20	0,10	0,53	0,71	0,38	0,25	0,00	0,25	0,00	0,86	0,83
T11	0,00	1,00	0,60	0,22	0,26	0,24	0,44	0,63	0,08	0,44	0,50	0,00	0,95	0,67
T12	0,00	0,00	0,40	0,00	0,01	0,12	0,43	0,00	0,00	0,22	0,25	0,20	0,09	0,67
T13	1,00	0,00	0,20	0,04	0,18	0,29	0,17	0,75	1,00	0,00	0,75	0,40	0,91	0,50
T14	0,00	1,00	0,60	1,00	0,62	0,24	0,41	1,00	0,50	0,00	0,75	0,70	0,95	0,67
T15	1,00	0,00	0,40	0,67	0,75	0,00	0,86	0,75	0,88	0,00	0,75	0,90	0,95	0,83

5. **Step:** In this step, the differences between reference sequence and measured values are calculated. The coefficient differences are found a grey relational coefficient matrix is formulated.

Table 6. Calculation of Δ_{min} and Δ_{max}

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
RS	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
T1	0,00	1,00	0,40	0,60	0,45	0,29	0,95	0,38	1,00	1,00	0,50	1,00	0,23	0,17
T2	1,00	0,00	1,00	0,93	0,00	0,29	0,14	0,50	0,80	1,00	0,25	1,00	0,14	0,33
T3	0,00	1,00	0,60	0,67	0,23	0,94	0,84	0,00	0,66	1,00	0,75	0,60	0,32	0,17
T4	0,00	1,00	0,80	0,80	0,45	0,12	0,84	0,13	1,00	1,00	0,50	1,00	1,00	1,00
T5	1,00	1,00	1,00	1,00	0,97	1,00	0,99	0,88	1,00	1,00	1,00	1,00	0,86	0,83
T6	1,00	1,00	0,80	0,94	0,94	0,94	0,93	1,00	0,24	1,00	1,00	1,00	0,00	0,33
T7	0,00	1,00	0,00	0,60	0,88	0,82	0,62	0,50	0,74	0,56	0,25	0,20	0,05	0,17
T8	1,00	0,00	0,20	0,95	0,86	0,88	0,36	0,75	1,00	0,22	0,25	0,00	0,00	0,17
T9	0,00	0,00	0,00	0,60	1,00	0,00	0,00	0,00	0,13	0,00	0,00	0,10	0,00	0,00
T10	0,00	1,00	1,00	0,80	0,90	0,47	0,29	0,63	0,75	1,00	0,75	1,00	0,14	0,17
T11	1,00	0,00	0,40	0,78	0,74	0,76	0,56	0,38	0,92	0,56	0,50	1,00	0,05	0,33
T12	1,00	1,00	0,60	1,00	0,99	0,88	0,57	1,00	1,00	0,78	0,75	0,80	0,91	0,33
T13	0,00	1,00	0,80	0,96	0,82	0,71	0,83	0,25	0,00	1,00	0,25	0,60	0,09	0,50
T14	1,00	0,00	0,40	0,00	0,38	0,76	0,59	0,00	0,50	1,00	0,25	0,30	0,05	0,33

T15	0,00	1,00	0,60	0,33	0,25	1,00	0,14	0,25	0,13	1,00	0,25	0,10	0,05	0,17
Δ_{min}	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Δ_{max}	1,00	1,00	1,00	1,00	1,00	1,00	0,99	1,00	1,00	1,00	1,00	1,00	1,00	1,00

All the elements in the table7, are subtracted from reference values and, Δ_{min} and Δ_{max} values are obtained. After that, these values are analyzed assuming x = 0,5.

Table 7. Grey Relation Coefficient Matrix

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
W	0,025	0,006	0,007	0,267	0,305	0,002	0,037	0,001	0,000	0,001	0,013	0,047	0,273	0,017
T1	1,000	0,333	0,556	0,455	0,527	0,630	0,343	0,571	0,333	0,333	0,500	0,333	0,688	0,750
T2	0,333	1,000	0,333	0,350	1,000	0,630	0,776	0,500	0,385	0,333	0,667	0,333	0,786	0,600
T3	1,000	0,333	0,455	0,429	0,688	0,347	0,371	1,000	0,431	0,333	0,400	0,455	0,611	0,750
T4	1,000	0,333	0,385	0,385	0,524	0,810	0,370	0,800	0,333	0,333	0,500	0,333	0,333	0,333
T5	0,333	0,333	0,333	0,333	0,339	0,333	0,333	0,364	0,333	0,333	0,333	0,333	0,367	0,375
T6	0,333	0,333	0,385	0,348	0,348	0,347	0,348	0,333	0,679	0,333	0,333	0,333	1,000	0,600
T7	1,000	0,333	1,000	0,455	0,362	0,378	0,443	0,500	0,404	0,474	0,667	0,714	0,917	0,750
T8	0,333	1,000	0,714	0,344	0,369	0,362	0,576	0,400	0,333	0,692	0,667	1,000	1,000	0,750
T9	1,000	1,000	1,000	0,455	0,334	1,000	1,000	1,000	0,790	1,000	1,000	0,833	1,000	1,000
T10	1,000	0,333	0,333	0,385	0,356	0,515	0,634	0,444	0,400	0,333	0,400	0,333	0,786	0,750
T11	0,333	1,000	0,556	0,390	0,403	0,395	0,471	0,571	0,353	0,474	0,500	0,333	0,917	0,600
T12	0,333	0,333	0,455	0,333	0,335	0,362	0,464	0,333	0,333	0,391	0,400	0,385	0,355	0,600
T13	1,000	0,333	0,385	0,343	0,378	0,415	0,374	0,667	1,000	0,333	0,667	0,455	0,846	0,500
T14	0,333	1,000	0,556	1,000	0,566	0,395	0,458	1,000	0,500	0,333	0,667	0,625	0,917	0,600
T15	1,000	0,333	0,455	0,600	0,664	0,333	0,776	0,667	0,800	0,333	0,667	0,833	0,917	0,750

6. Step: Determination of grey relation degrees

In this study, since each criterion has different importance degree, grey relation degree is obtained by multiplying the grey relation coefficient of the criterion with the importance degree of the same criterion.

If the reference sequence includes, max is better, min is better and nominal is best evaluations according to the types of the criteria, the calculated grey relation degree shows that the criteria match the needs. In other words, the factor sequence (alternative) which has maximum grey relation degree will be the best alternative in the decision problem[15].

Table 8. Grey Relation Degrees

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	GRD
W	0,025	0,006	0,007	0,267	0,305	0,002	0,037	0,001	0,000	0,001	0,013	0,047	0,273	0,017	
T1	1,000	0,333	0,556	0,455	0,527	0,630	0,343	0,571	0,333	0,333	0,500	0,333	0,688	0,750	0,525
T2	0,333	1,000	0,333	0,350	1,000	0,630	0,776	0,500	0,385	0,333	0,667	0,333	0,786	0,600	0,573
T3	1,000	0,333	0,455	0,429	0,688	0,347	0,371	1,000	0,431	0,333	0,400	0,455	0,611	0,750	0,543
T4	1,000	0,333	0,385	0,385	0,524	0,810	0,370	0,800	0,333	0,333	0,500	0,333	0,333	0,333	0,484
T5	0,333	0,333	0,333	0,333	0,339	0,333	0,333	0,364	0,333	0,333	0,333	0,333	0,367	0,375	0,341
T6	0,333	0,333	0,385	0,348	0,348	0,347	0,348	0,333	0,679	0,333	0,333	0,333	1,000	0,600	0,433
T7	1,000	0,333	1,000	0,455	0,362	0,378	0,443	0,500	0,404	0,474	0,667	0,714	0,917	0,750	0,600

T8	0,333	1,000	0,714	0,344	0,369	0,362	0,576	0,400	0,333	0,692	0,667	1,000	1,000	0,750	0,610
T9	1,000	1,000	1,000	0,455	0,334	1,000	1,000	1,000	0,789	1,000	1,000	0,833	1,000	1,000	0,887
T10	1,000	0,333	0,333	0,385	0,356	0,515	0,634	0,444	0,400	0,333	0,400	0,333	0,786	0,750	0,500
T11	0,333	1,000	0,556	0,390	0,403	0,395	0,470	0,571	0,353	0,474	0,500	0,333	0,917	0,600	0,521
T12	0,333	0,333	0,455	0,333	0,335	0,362	0,464	0,333	0,333	0,391	0,400	0,385	0,355	0,600	0,387
T13	1,000	0,333	0,385	0,343	0,378	0,415	0,374	0,667	1,000	0,333	0,667	0,455	0,846	0,500	0,550
T14	0,333	1,000	0,556	1,000	0,566	0,395	0,458	1,000	0,500	0,333	0,667	0,625	0,917	0,600	0,639
T15	1,000	0,333	0,455	0,600	0,664	0,333	0,776	0,667	0,800	0,333	0,667	0,833	0,917	0,750	0,652

According to the values in table 8, Supplier T14, has the best performance. T15 is second and T2 is the third. The supplier with minimum performance is chosen as supplier T5. The suppliers having relatively lower performance are determined. And the lower criteria of those suppliers are improved.

6. RESULTS AND SUGGESTIONS

In this study, fifteen certified suppliers of a food manufacturing company are evaluated based on the specialized criteria for that company. The result of the analysis gives the best performing supplier among fifteen suppliers of the company. The manufacturing company can get chance to improve its long term relationship with good performing suppliers to get higher performance. This study also helps the company to determine the poor performing suppliers and to improve their poor performing areas.

Grey relation analysis, is a mathematical multi criteria decision making model. In this method, the data is not necessarily fit to any statistical distribution. The grey relation analysis technique can give high performance in the solution of problems having multi criteria and multi alternative but limited data sequence. [31]

The grey relation analysis can help decision makers in finding optimum solutions to complex multi criteria decision making problems by evaluating all the alternatives in an easier manner. Grey relation analysis gives realistic results, since the weights of the criteria are included in the model. In the future studies, TOPSIS, ELECTRE, Analytic Network Process, PROMETHEE methods can be combined or compared with the results of this study.

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CORPORATE SUSTAINABILITY PERFORMANCE WITH USING AHP AND TOPSIS

Cigdem SOFYALIOGLU[138], Ebru SURUCU[139]

Corporate sustainability is a business approach that aims long-term value creation while preventing risks that arises from company's decision-making activities with unifying management standards and economic, environmental and social factors. Corporate sustainability performance measurement ensures the examination of sustainability's three dimensions, which are social, environmental and economic, on corporate level. However, while evaluating corporate sustainability performance, using multi-criteria creates problems since it is really hard to put all the criteria in one main criterion. Using multi-criteria decision-making (MCDM) modeling is an applicable approach to measure corporate sustainability. In this study, AHP (Analytic Hierarchy Process), which is one of the MCDM modeling, is used for weighting sustainability's three dimension and three dimensions' sub-factors. After that TOPSİS (Technique Ordered Preference by Similarity to the Ideal Solution) is used to measure Arcelik's supply chain sustainability performance. Arcelik is one of the best and well-known major appliance brands in Turkey. Data were acquired from Arcelik's annual and sustainability reports. Company's tendency in corporate sustainability performance will be monitored year by year, and answer of the question which is "why the slope of the tendency is whether positive or negative" will be revealed after the comprehensive examination of the reports. This study aims to bring light on the firms, which are adopted corporate sustainability approach while measuring the corporate sustainability performance.

Keywords - AHP, Corporate Sustainability in Supply Chain, MCDM, Sustainability Performance, TOPSIS.

INTRODUCTION

After the World War II, a fast growing industrialization process has started around the world. During this process, a fast settlement and unrestrained population increase occurred. While an unrestrained development process was started; nature includes atmosphere, hydrosphere and biosphere is polluted. In late 1960's scientists revealed that natural balance has been destroyed. This situation showed both environmentalists and economy world that development and environment must be examined together [13].

Because of these problems, threatens to environment and ecology has to come up with a wide perspective, and as a result of this perspective, sustainability concept arose. One of the classical sustainability definitions is "today's modern society, which is designated by classic capitalism model, defines sustainability increase of the income per capita" [18]. In this development model, unlimited production, unlimited consumption of resources and dividends got importance. However, biggest drawback of this model is, it ignores the future and consumes the resources unconsciously. Same situation occurs across the all countries and eventually this problem became global [11]. Sustainable development is a concept that includes society, environment and development, and complicated relations of them [17]. The most well-adopted and most often quoted definition of sustainability is that of the Brundtland Commission "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" [21].This definition focuses on need of both current and future generations. It qualifies to be a widely accepted definition of sustainable

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development in universal sense; however, it is required to define this concept in specific fields [16]. Sustainable development has three components: the natural environment, society and economic performance. Figure 1 shows a representation of these three components.

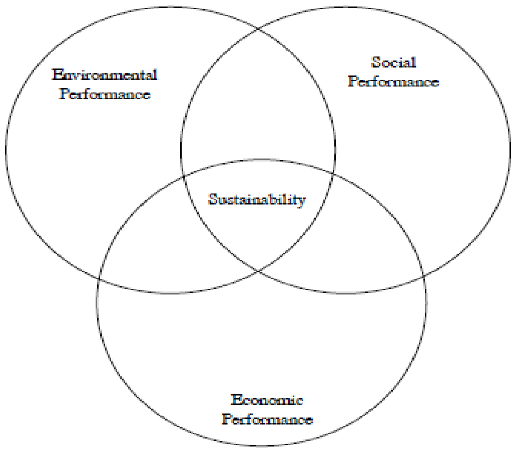

Figure 1. Three Components of Sustainable Development

This figure corresponds to the idea of the triple bottom line, a concept which is developed by Elkington; simultaneously considers and balances economic, environmental and social goals from a microeconomic standpoint. Triple bottom line suggests that at the intersection of social, environmental and economic performance, there are activities that organizations can engage in which not only positively affect the natural environment and society, but which also result in long-term economic benefits and competitive advantage for the firm [5].

Recently, there has been rising concern about sustainability both among managers and researchers. Growing importance has been mainly results of increased environmental concerns, such as environmental pollution accompanying industrial development, diminishing raw material resources, overflowing waste sites and increasing levels of pollution. Besides, other key factors like government regulations, changing consumer demands, and the development of international certifications standards have progressively led companies to look at sustainability initiatives with increasing attention [10]. 80 percent of the world's largest 250 companies report on their social and environmental performance [6]. The concept has also recently begun to appear in the literature of business disciplines such as operations and supply chain management [5].

CORPORATE SUSTAINABILITY PERFORMANCE

Corporate sustainability (CS) is adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting sustaining and enhancing the human and natural resources that will be needed in future [14].Corporate sustainability performance (CSP) is a newly emerging term about business, the environment and the social responsibility of firms, which aims to address the social, environmental and economic (performance) aspects of sustainable development [20].

However, while measuring corporate performance becomes very important today's world, there is no certain way of measuring it. Commonly used ways to measure corporate sustainability consists of three general categorization areas which are indicators and indices, product-related measurement tools and integrated measurement [12]. Method that used in this paper is one of the integrated assessment's sub-headings; multi-criteria decision modeling.

METHODOLOGY
DATA

In this study, Arcelik's corporate sustainability performance is researched by years. Data is gathered from Arcelik's annual sustainability reports. Each dimension for sustainability is examined in this study. To measure corporate sustainability performance AHP and TOPSIS methods used which are explained below.

In this study indicators, which Arcelik designated, are used as [9] used in their study. "Measurement of an indicator" and "accessibility to data" criteria was taking into consideration as it is implied in literature [7] - [8]. For the calculation Excel packaged software is used.

Each dimension of sustainability and their sub-factors examined in this study. For economic sustainability dimension 6 sub-factors examined. For environmental and social sustainability; 4 sub-factors examined for each dimension.

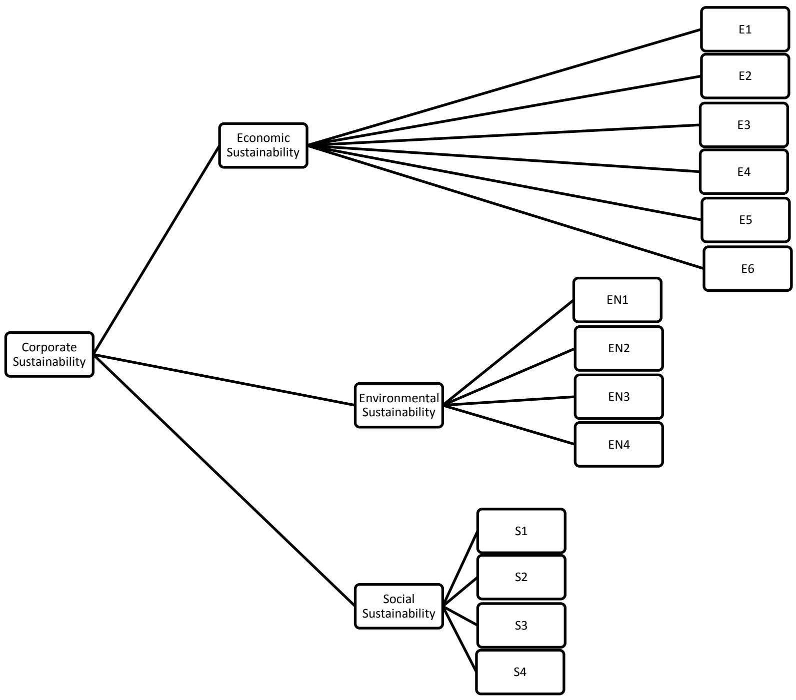

Figure 2. Corporate Sustainability Model

Indicators shown in Figure 2 explained in Table 1.

Table 1. Economic, Environmental and Social Indicators

Economic Indicator	Environmental Indicator	Social Indicator
E1: Net Sales **E2:** Operating Margin **E3:** Net Profit **E4:** Investment Expenditures **E5:** Corporate Governance Evaluation Score **E6:** End-year Market	**EN1:** Draft Survey of Headwaters **EN2:** Expenditures on Environment Protection and Investment **EN3:** Amount of Discharged Water **EN4:** Direct Energy Consumption	**S1:** Percentage of Woman Employee **S2:** Turnover Rate **S3:** Accident Frequency Rate **S4:** Accident Severity Rate

Value		

Mathematical Notation Of Ahp

While the criteria a_1, a_2,……., a_n and weights w_1, w_2,…..,w_n, pairwise comparison for *n* number criteria's weights will be compared in matrix as below [19].

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

Here, $a_{ij} = \frac{1}{aji}$ becomes $a_{ij} = \frac{aik}{ajk}$ according to the rule of opposing. In real problems $\frac{wi}{wj}$ results in not known, generally. This is why in AHP $a_{ij} \approx \frac{wi}{wj}$ equation is found in a_{ij} value [19]. General form of weight matrix is shown below.

$$W = \begin{array}{c} \\ w1 \\ \cdot \\ \cdot \\ \cdot \\ wi \\ \cdot \\ \cdot \\ \cdot \\ wn \end{array} \begin{array}{c} \begin{array}{ccccc} w1 & & Wj & & Wn \end{array} \\ \begin{bmatrix} w1/w1 & \cdots & w1/wj & \cdots & w1/wn \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ wi/w1 & \cdots & wi/wj & \cdots & wi/wn \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ wn/w1 & \cdots & wn/wj & \cdots & wn/wn \end{bmatrix} \end{array} \tag{2}$$

Value of W and *w* multiplied;

$$W.\, w = \begin{array}{c} \\ w1 \\ \cdot \\ \cdot \\ \cdot \\ wi \\ \cdot \\ \cdot \\ \cdot \\ wn \end{array} \begin{array}{c} \begin{array}{ccccc} w1 & & Wj & & Wn \end{array} \\ \begin{bmatrix} w1/w1 & \cdots & w1/wj & \cdots & w1/wn \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ wi/w1 & \cdots & wi/wj & \cdots & wi/wn \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ wn/w1 & \cdots & wn/wj & \cdots & wn/wn \end{bmatrix} \end{array} \begin{bmatrix} w1 \\ \cdot \\ \cdot \\ \cdot \\ wi \\ \cdot \\ \cdot \\ \cdot \\ wn \end{bmatrix} = \mathrm{n} \begin{bmatrix} w1 \\ \cdot \\ \cdot \\ \cdot \\ wi \\ \cdot \\ \cdot \\ \cdot \\ wn \end{bmatrix} \tag{3}$$

or can be shown as below

$$(W\text{-}nl)\, w = 0 \tag{4}$$

The result of equation above is the eigenvalue. λ_{Maks} provides the equation of relative weights $Aw = \lambda_{Maks}\ w$ is used for finding eigenvector w. λ_{Maks} is obtained by the equation of $(A - \lambda_{Maks}\, I)\, w = 0$. Also, two factors used to verify the subjective perceptions consistency and relative weights. These factors are Consistency Index (CI) and Consistency Rate (CR). To calculate Consistency Index (CI) the formula is shown at below.

$$CI = \frac{(\lambda\text{Maks} - \text{n})}{(n-1)} \tag{5}$$

λ_{Maks} is the biggest eigenvalue and *n* is the number of criteria. For a reliable result CI must be smaller than 0,1 [19].

For Consistency Rate (CR) the following formula is used.

$$CR = \frac{CI}{RI} \tag{6}$$

RI means Random Index. For different number of *n* RI values are show in Table 2 [19].

Table 2. Random Index

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

MATHEMATICAL NOTATION OF TOPSIS

First step of the TOPSIS is create an evaluation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria. The matrix is shown below.

$$\begin{array}{ccc} & \textbf{Factors} & \\ \mathbf{A_{ij}} = & \begin{bmatrix} a11 & a12 & \ldots & a1p \\ a21 & a22 & \ldots & a2p \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ am1 & am2 & \ldots & amp \end{bmatrix} & \textbf{Decision Criteria} \end{array}$$

Second step of TOPSIS is normalize the matrix with using the formula given below.

$$n_{ij} = \frac{aij}{\sqrt{\sum_{i=1}^{m} aij^2}} \quad (i=1,\ldots,m \text{ ve } j=1,\ldots,p) \tag{7}$$

Normalized matrix is shown as below.

$$N = \begin{bmatrix} n11 & n12 & \ldots & n1p \\ n21 & n22 & \ldots & n2p \\ \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ nm1 & nm2 & \ldots & nmp \end{bmatrix} \tag{8}$$

Third step of TOPSIS is calculation of the weighted- normalized decision matrix

$$V = \begin{bmatrix} W1N11 & W2N12 & \dots & WnN1p \\ W1N21 & W2N22 & \dots & WnN2p \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ W1Nm1 & W2Nm2 & \dots & WnNmp \end{bmatrix} = \begin{bmatrix} V11 & V12 & \dots & V1p \\ V21 & V22 & \dots & V2p \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ Vm1 & Vm2 & \dots & Vmp \end{bmatrix} \tag{9}$$

Fourth step is determination of the best (A^*) and worst alternatives (A^-) with given formula.

$$A^* = \{\max Vij \mid j = 1, \dots, p\ ; i = 1, \dots, m\}$$

$$\Rightarrow \quad A^* = \{V1*, V2*, \dots\dots, Vn*\} \quad \text{maximum value of each column} \tag{10}$$

$$A^- = \{\min Vij \mid j = 1, \dots, p\ ; i = 1, \dots, m\}$$

$$\Rightarrow \quad A^- = \{v1-, v2-, \dots, vn-\} \text{ minimum value of each column} \tag{11}$$

Fifth step of the TOPSIS is calculation of the L2-distance between the target alternative *i* and the best condition A^*

$$S_i^* = \sqrt{\textstyle\sum_{j=1}^{n}(Vij - Vj*)^2} \tag{12}$$

And the distance between the alternative *i* and the worst condition A^-

$$S_i^- = \sqrt{\textstyle\sum_{j=1}^{n}(Vij - Vj-)^2} \tag{13}$$

Last step is to calculate the similarity to worst condition

$$C_i^* = \frac{(Si-)}{(Si-)+(Si+)} \tag{14}$$

$C_i^* = 1$ if and only if the alternative solution has the best condition and;

$C_i^* = 0$ if and only if the alternative solution has the worst condition.

APPLICATION: CORPORATE SUSTAINABILITY PERFORMANCE MEASUREMENT

In this study, Turkey's one of the most well-known appliance brand, which is Arcelik, is used for corporate sustainability performance measurement [1] - [2] - [3] - [4]. For this aim, an assessment form is prepared according to Saaty's 1-9 scale. In this form, each dimension compared with each other [15]. After comparing dimensions, each dimensions sub-factors compared within. Prepared assessment form sent five expert, who are studying sustainability, environment, social issues and logistics. The AHP procedure is performed according to these five experts' assessments. Experts' assessments are evaluated in Excel packaged program with using formulas explained above. Results are shown in Figure 3. After the calculations, it is seen that the experts gave the most importance to social sustainability compared to other dimensions with 0, 3568 point. Second important dimension according to experts is environmental sustainability with 0, 3360 point. Economic dimension has 0, 3073 point and became third in the rank. End-year market value is on the top rank in economic sustainability with 0, 30 point; while expenditure on environmental performance and investment is on the top with 0, 55 point in environmental sustainability. Moreover, in social sustainability according to experts' assessment the most important sub-factor is accident severity rate with 0, 41 point.

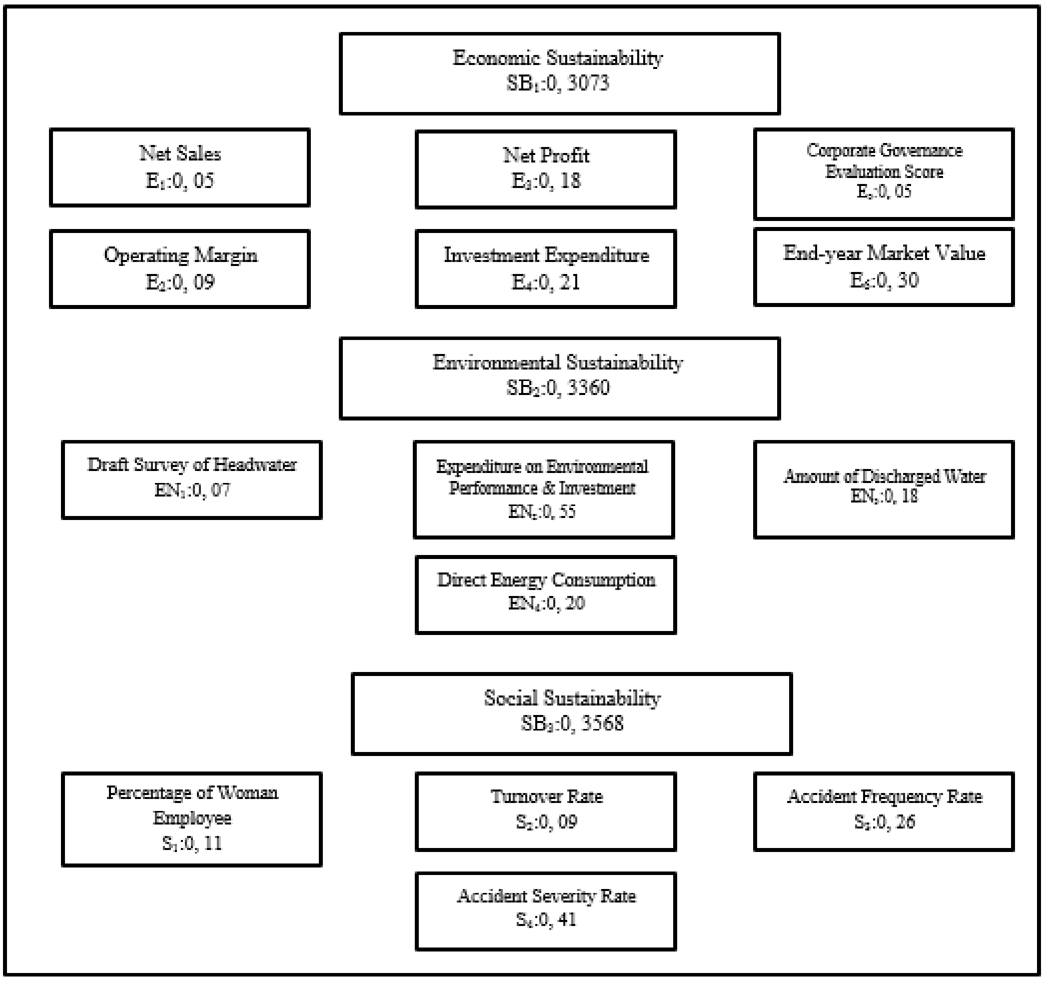

Figure 3. Hierarchical Structure of Performance Assessment Criteria

After finding weights of dimensions and sub-factors, TOPSIS procedure is obtained on weights and data gathered from Arcelik's sustainability reports [1] - [2] - [3] - [4] by using formulas explained above. Trend of Arcelik's corporate, economic, environment and social performance by years is shown in Figure 4. TOPSIS results are gathered from the AHP results and data, which are collected from Arcelik's sustainability reports. Since AHP results are leaned on experts' assessments, the same research can have different results with different expert election.

It is seen that corporate performance increased year by year. While in 2010, corporate sustainability was %68,8; it increased by %45 becomes %100 in 2013. For economic sustainability, it was %82,47 in 2010; while 94,85 in 2013. There is a huge improvement for environmental sustainability dimension when it is examined. While in 2010 environmental sustainability was % 33,55 and increased to % 91,5. This means that Arcelik has improved its environmental activates and this helped Arcelik to increase its environmental sustainability performance by %172,72. However, when it is examined, a small decrease in social sustainability can be noticed. While in 2010, Arcelik's social sustainability performance was %100; in 2013 it decreased to %99,11. Between the years of 2010 and 2013, social sustainability performance decreased by 32,98 percent but with the precautions against this decrease, this amount is shortened to 0,89 percent.

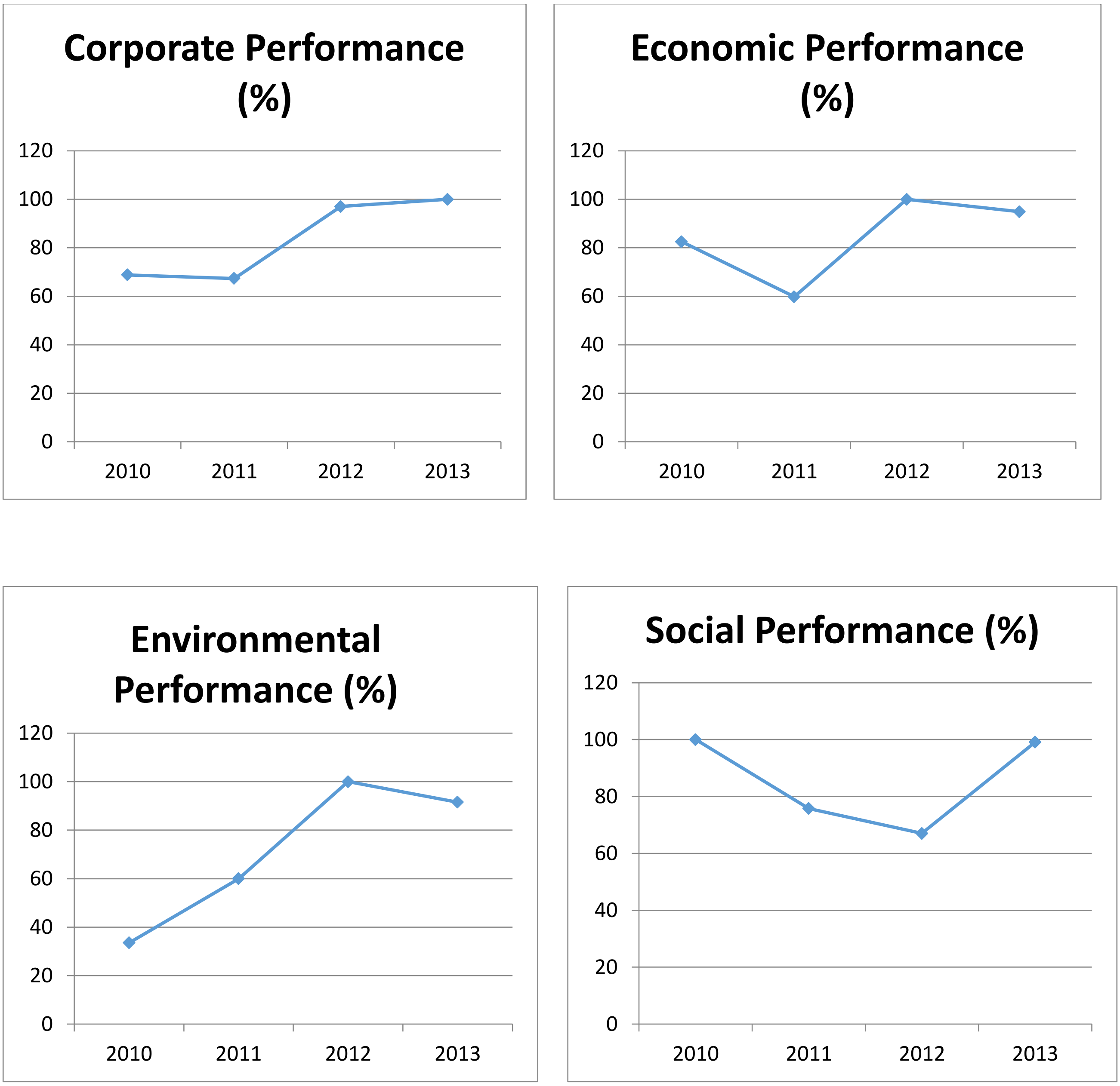

Figure 4. Corporate, Economic, Environmental and Social Performance by Years

RESULTS AND SUGGESTIONS

In this study, it is aimed to measure one of the Turkey's most well-known companies corporate sustainability performance with using AHP and TOPSIS. For this aim, first of all, indicators chose according to Arcelik's sustainability reports [1] - [2] - [3] - [4]. After that, order of importance for indicators is designated with AHP. Lastly, Arcelik's corporate sustainability performance is examined with TOPSIS method.

Results of analysis shows that Arcelik's corporate sustainability has an upward trend in generally. Especially increase in environmental sustainability performance is prominent. While economic sustainability performance has smoother upward trend; social sustainability performance has more volatile trend. It is seen that in 2012, while both economic and environmental sustainability performance reached top; social performance bottomed out. We assume that the most important reason for this situation is the recession period that world got through recession period. One of the main reason for increase in environmental performance measurement can be less production and less waste amount due to the recession period that affects production amount. During the same period, firm's turnover rate could get higher or the percentage of working woman could get lower and this could have affected performance as well.

In this study, objective and precise results achieved with using mathematical methods. Thus, this method can be a way of measuring corporate sustainability performance.

For future research, this study can be developed with including different appliance brands' sustainability reports and/or add more years to research.

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SUSTAINABILITY PERFORMANCE MEASUREMENT IN LOGISTICS SECTOR USING AHP AND TOPSIS

Dogan UYSAL[140], Ebru SURUCU[141]

Abstract - Logistics becomes leading sector in the world during globalization process; but also, it is a well-known fact that, logistics activities are not completely sustainable and causes too much CO2 emissions. Sustainability is an important concept that aims development includes economic, environmental and social dimensions together. To be able to achieve this development at the corporate level, it is highly recommended to release sustainability reports. One of the most common used sustainability reporting guides is Global Reporting Initiatives (GRI). This guide aims all sectors from all over the world to release sustainability reports. Releasing sustainability report is gradually new in Turkey and for Turkish companies. There are some reports related to sustainability in logistics sector; but these reports do not include qualitative data. Aim of this study is to overcome this problem and help companies to prepare reports coherent with GRI. Three international logistics companies which are UPS, FedEx and DHL used for this research. These companies' quantitative data gathered from their sustainability reports. Study covers the year of 2009-2013 periods. Sustainability's three dimension and each dimension's sub-factors will be used in analysis. Five sub-factors for economic; six sub-factors for environmental and seven sub-factors for social dimension are used. After the data gathered, multi-criteria decision-making (MCDM) modeling is used to rank companies. First, analytic hierarchical process (AHP) is used for weighting sustainability's three dimensions and dimension's sub-factors. After weighting, TOPSIS is used for ranking. Research ends with suggestions for Turkish logistics companies to be able to release sustainability reports.

Keywords - AHP, Logistics, MCDM, Performance Measurement, Sustainability, TOPSIS.

INTRODUCTION

Logistics is a concept that used to describe the transport, warehousing and handling of products as they move from raw material sources, through the production system to their final point of sale or consumption [16]. Logistics becomes one of the key determinants of the business performances in last years. However, logistics and transport activities are some of the main sources of emissions of greenhouse gases, mostly CO2. In addition, the transport sector represents the fastest-growing source of greenhouse gas emissions [1].

The concept of sustainability emerged in the 1960s in response to concern about environmental degradation resulting from poor resource management. As the environment became increasingly important as a world issue, sustainability was adopted as a common political goal [15]. Importance of sustainability has been gradually increasing, since raw material sources has been decreased, amount of waste and pollution have been increased. Other effects like government regulations, changed consumer demands and international certification standards had led companies to take consideration of sustainability more carefully [14].

These pressures lead companies to give more importance to sustainability and release sustainability reports. Elkington argued that due to the advance of information technology companies can no longer keep their practices secret from stakeholders. They have to report on their sustainability practices to inform them and to serve as a benchmark against competitors. It is also important that these report include measures or indicators

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that make the company's performance verifiable by external agencies and global standards [13]. However, sustainability reporting is a newly-emerging concept in Turkey and aim of this paper is helping Turkish logistics companies while they are started to releasing sustainability reports.

SUSTAINABILITY AND DIMENSIONS

Sustainability defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" [25]. This is the most quoted definition of this concept and its two central tenets are:"

- i "The concept of 'need' in particular the essential needs of the world's poor, to which overriding priority should be given" and
- ii "The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" [25].

At the core of sustainability is the interrelated relationship among the economic, environmental, and social dimensions [17]. Sustainability dimensions are shown in Figure 1.

Figure 1. Sustainability Dimensions

Environmental sustainability can be defined as the capacity to preserve over time the three basic functions of the environment: the resource supply function, the waste receiver function and that of direct usefulness. Economic sustainability can be defined as the capacity of an economic system to generate a constant and improving growth of its economic indicators. In particular, the capacity to generate incomes and employment in order to sustain the populations. Social sustainability can be defined as the ability to guarantee welfare (security, health, education), equitably distributed among social classes and gender [25].

METHODOLOGY

Data

In this study, three different global logistics firms' sustainability measurement is compared. Within the measurement of sustainability performance, sustainability's all dimensions is examined. The data used in this paper is gathered from three companies' sustainability reports. To measure all dimensions, five factors for economic dimension; six factors for environmental dimension and seven factors for social dimension are used as indicators.

This study aimed to be a roadmap for Turkish companies which are trying to be more sustainable and use sustainability activities in their business activities. However, Turkish logistics companies could not include. The biggest reason for this; corporate sustainability reporting is recently becoming popular and especially in logistics sector there are only few reports released for sustainability performance. Especially Ekol Logistics and Mars Logistics have studies about corporate sustainability and reports. However, Mars Logistics only has sustainability reports for 2012 and 2013. So, it is not suitable for this study. Also, Ekol Logistics has a sustainability report which covers the years 2007- 2014; but, this reports mostly includes qualitative date instead of quantitative data.

Since sustainability reporting initiatives has getting recently common in world, generally companies have sustainability reports for last ten years. However, most of the companies started to release sustainability reports since 2009 with meeting the requirements of GRI (Global Reporting Initiatives). To get precise results for academic concerns, the reports which are released after 2009 used for this research.

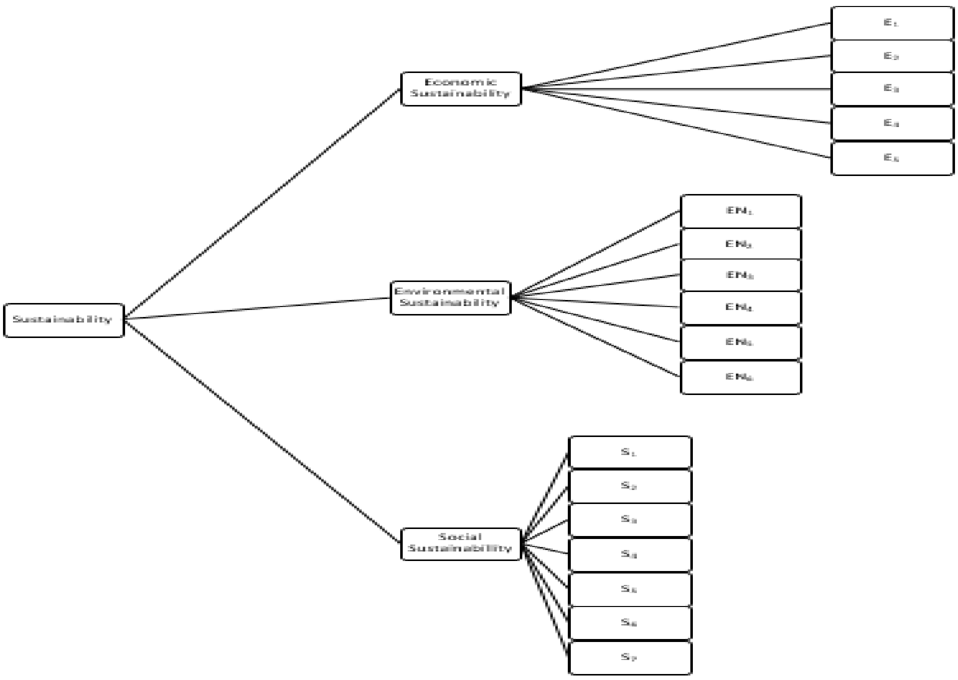

Figure 2. Sustainability Performance Measurement Model

With these indicators, first global logistics firms' sustainability performance is measured and then firms' will be evaluated by themselves. The search covers for 2009 – 2013 years. Indicators shown in Figure 2 explained in Table 1.

To make the assessment of MCDM, there is a need of expert opinion. To get the experts' opinion an assessment form is prepared. Experts, who gets the assessment forms, have to be well-informed or at least reasonably knowledgeable. Because results of AHP is completely predicated on experts' judgements [12] - [18]. After sub-factors a.k.a. indicators has been determined an assessment form has been sent 10 experts. Eight of them are working at Celal Bayar University and Dokuz Eylul University, who are well-informed about finance, logistics, management and environment. Rest of them are logistics sector employees. All the calculations are made with Excel packaged software.

Table 1. Economic, Environmental and Social Indicators

Economic Sustainability	**Environmental Sustainability**	**Social Sustainability**
E_1: Revenue **E_2:** Net Profit **E_3:** Retained Earnings **E_4:** Dividends **E_5:** Wages & Compensations	**EN_1:** Amount of CO_2 Emission **EN_2:** Amount of Deterred CO_2 Emission **EN_3:** Energy Consumption **EN_4:** Amount of Waste **EN_5:** Amount of Water Consumption **EN_6:** Amount of Recycled Waste	**S_1:** Percentage of Woman in Workforce **S_2:** Percentage of Woman on Top Level Management **S_3:** Average Hours that one Employee Spends on Training **S_4:** Average Money for one Employee's Training **S_5:** Amount of Money for Social Responsibility Project **S_6:** Accident Frequency Rate **S_7:** Organizational Engagement

MATHEMATICAL NOTATİON OF AHP

While the criteria $a_1, a_2, \ldots, a_n$ and weights $w_1, w_2, \ldots, w_n$, pairwise comparison for *n* number criteria's weights will be compared in matrix as below [19].

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n}\\ a_{21} & a_{22} & \cdots & a_{2n}\\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a_{n1} & a_{n2} & \cdots & a_{nn}\end{bmatrix} \tag{1}$$

Here, $a_{ij} = \frac{1}{aji}$ becomes $a_{ij} = \frac{aik}{ajk}$ according to the rule of opposing. In real problems $\frac{wi}{wj}$ results in not known, generally. This is why in AHP $a_{ij} \approx \frac{wi}{wj}$ equation is found in a_{ij} value [19]. General form of weight matrix is shown below.

$$W=\begin{array}{c} \\ w1\\ \vdots\\ wi\\ \vdots\\ wn\end{array} \quad \begin{array}{c} \begin{array}{ccccc} w1 & \quad & wj & \quad & wn\end{array}\\ \begin{bmatrix} w1/w1 & \cdots & w1/wj & \cdots & w1/wn\\ \vdots & & \vdots & & \vdots\\ wi/w1 & \cdots & wi/wj & \cdots & wi/wn\\ \vdots & & \vdots & & \vdots\\ wn/w1 & \cdots & wn/wj & \cdots & wn/wn \end{bmatrix}\end{array} \tag{2}$$

Value of W and *w* multiplied;

$$W.\,w = \begin{array}{c} w1 \\ \cdot \\ \cdot \\ wi \\ \cdot \\ \cdot \\ wn \end{array} \quad \begin{array}{c} \begin{array}{ccccc} w1 & & wj & & wn \end{array} \\ \begin{bmatrix} w1/w1 & \dots & w1/wj & \dots & w1/wn \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ wi/w1 & \dots & wi/wj & \dots & wi/wn \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ wn/w1 & \dots & wn/wj & \dots & wn/wn \end{bmatrix} \end{array} \begin{bmatrix} w1 \\ \cdot \\ \cdot \\ wi \\ \cdot \\ \cdot \\ wn \end{bmatrix} = n \begin{bmatrix} w1 \\ \cdot \\ \cdot \\ wi \\ \cdot \\ \cdot \\ wn \end{bmatrix} \tag{3}$$

or can be shown as below

$$(W-nl)\ w = 0 \tag{4}$$

The result of equation above is the eigenvalue. λ_{Maks} provides the equation of relative weights $Aw = \lambda_{Maks} w$ is used for finding eigen vector w. λ_{Maks} is obtained by the equation of $(A - \lambda_{Maks}\ I)\ w = 0$. Also, two factors used to verify the subjective perceptions consistency and relative weights. These factors are Consistency Index (CI) and Consistency Rate (CR). To calculate Consistency Index (CI) the formula is shown at below.

$$CI = \frac{(\lambda Maks - n)}{(n-1)} \tag{5}$$

λ_{Maks} is the biggest eigenvalue and n is the number of criteria. For a reliable result CI must be smaller than 0,1 [19].

For Consistency Rate (CR) the following formula is used.

$$CR = \frac{CI}{RI} \tag{6}$$

RI means Random Index. For different number of n RI values are show in Table 2 [19].

Table 2. Random Index

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

MATHEMATICAL NOTATION OF TOPSIS

First step of the TOPSIS is create an evaluation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria. The matrix is shown below.

Factors

$$\mathbf{A_{ij}} = \begin{bmatrix} a11 & a12 & \dots & a1p \\ a21 & a22 & \dots & a2p \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ am1 & am2 & \dots & amp \end{bmatrix} \quad \textbf{Decision Criteria}$$

Second step of TOPSIS is normalize the matrix with using the formula given below.

$$n_{ij} = \frac{aij}{\sqrt{\sum_{i=1}^{m} aij^2}} \quad (i=1,\dots,m \text{ ve } j=1,\dots,p) \tag{7}$$

Normalized matrix is shown as below.

$$N = \begin{bmatrix} n11 & n12 & \dots & n1p \\ n21 & n22 & \dots & n2p \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ nm1 & nm2 & \dots & nmp \end{bmatrix}$$

(8)

Third step of TOPSIS is calculation of the weighted- normalized decision matrix

$$V= \begin{bmatrix} W1N11 & W2N12 & \dots & WnN1p \\ W1N21 & W2N22 & \dots & WnN2p \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ W1Nm1 & W2Nm2 & \dots & WnNmp \end{bmatrix} = \begin{bmatrix} V11 & V12 & \dots & V1p \\ V21 & V22 & \dots & V2p \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ Vm1 & Vm2 & \dots & Vmp \end{bmatrix}$$

(9)

Fourth step is determination of the best (A^*) and worst alternatives (A^-) with given formula.

$\Rightarrow$ $A^* = \{\max Vij \mid j = 1, \dots, p \,;\, i = 1, \dots, m\}$

$A^* = \{V1*, V2*, \dots\dots, Vn*\}$ maximum value of each column

(10)

$\Rightarrow$ $A^- = \{\min Vij \mid j = 1, \dots, p \,;\, i = 1, \dots, m\}$

$A^- = \{v1-, v2-, \dots, vn-\}$ minimum value of each column

(11)

Fifth step of the TOPSIS is calculation of the L2-distance between the target alternative *i* and the best condition A^*

$$S_i^* = \sqrt{\sum_{j=1}^{n} (Vij - Vj*)^2}$$

(12)

And the distance between the alternative *i* and the worst condition A^-

$$S_i^- = \sqrt{\sum_{j=1}^{n} (Vij - Vj-)^2}$$

(13)

Last step is to calculate the similarity to worst condition

$$C_i^* = \frac{(Si-)}{(Si-)+(Si+)} \quad (14)$$

C_i^* = 1 if and only if the alternative solution has the best condition and;

C_i^*= 0 if and only if the alternative solution has the worst condition.

SUSTAINABILITY PERFORMANCE MEASUREMENT

Most important dimension according to experts' evaluation becomes economic dimension. Economic dimension gets 0.413 points. Environmental dimension becomes second important dimension in sustainability assessment structure with 0.327 points. Social dimension comes as third dimension with 0.260 points. Figure 3 shows the dimensions and sub-factors weights.

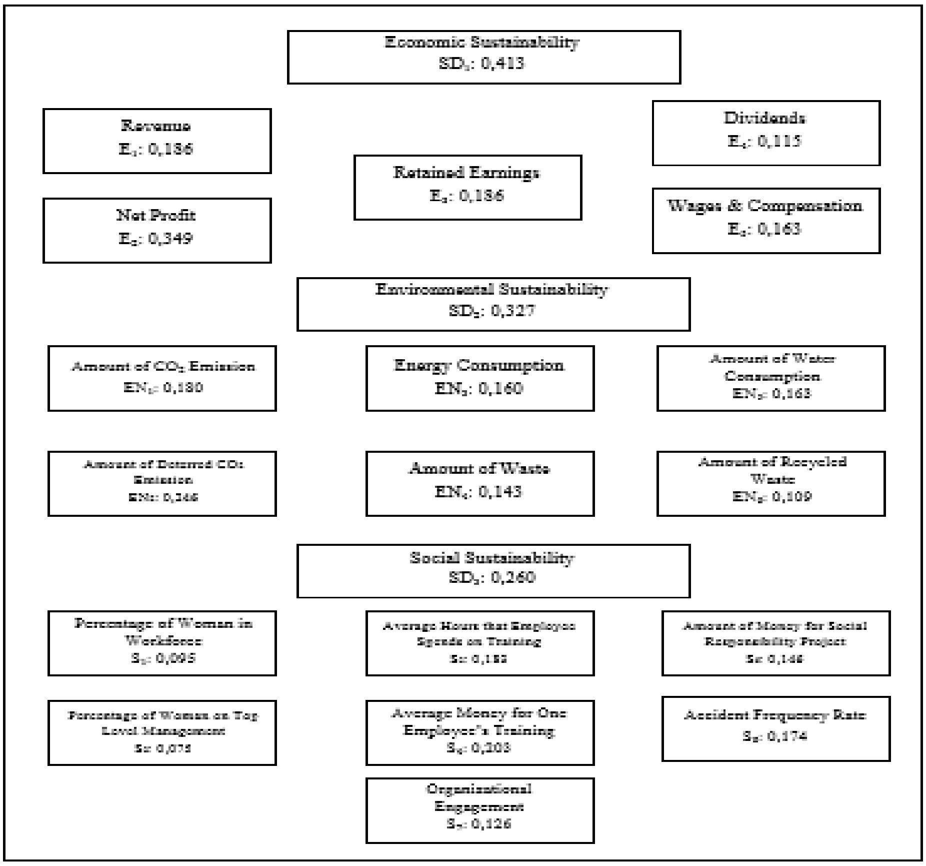

Figure 3. Hierarchical Structure of Performance Assessment Criteria

After determining weights, next step is finding best performing companies year by year. In Figure 3 economic sustainability performance is shown. According to Figure 4, FedEx and UPS have better performance than industry average; while, DHL has the worst economic performance within three companies.

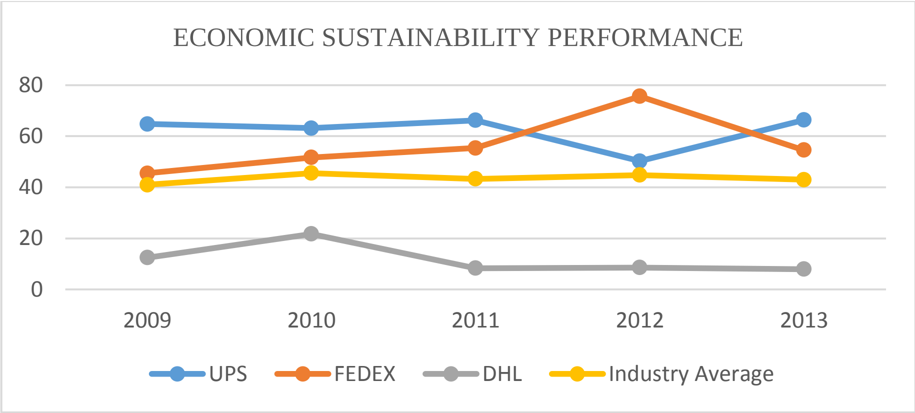

Figure 4. Economic Sustainability Performance of UPS, FedEx, DHL

In Figure 5 environmental sustainability performance is shown. According to Figure 5, DHL has the best environmental performance score compared to others. While, FedEx has the worst performance within three companies; UPS has decreasing trend especially in last two years.

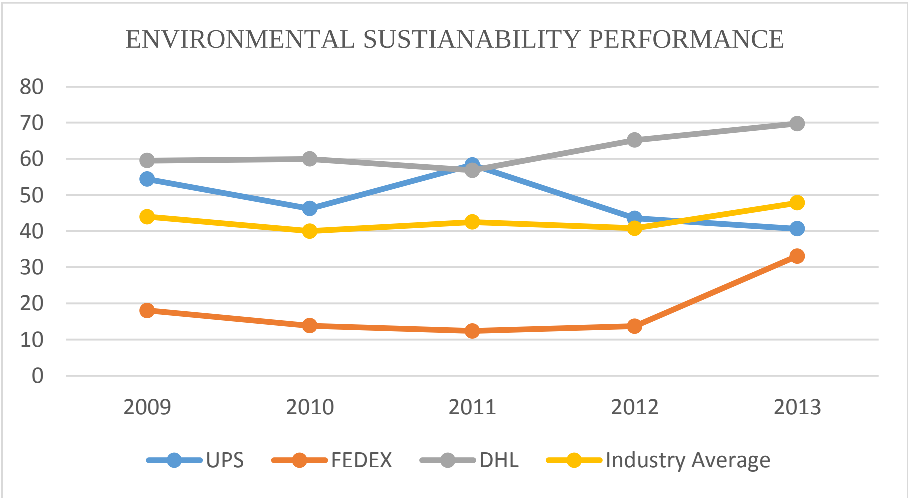

Figure 5. Environmental Sustainability Performance of UPS, FedEx, DHL

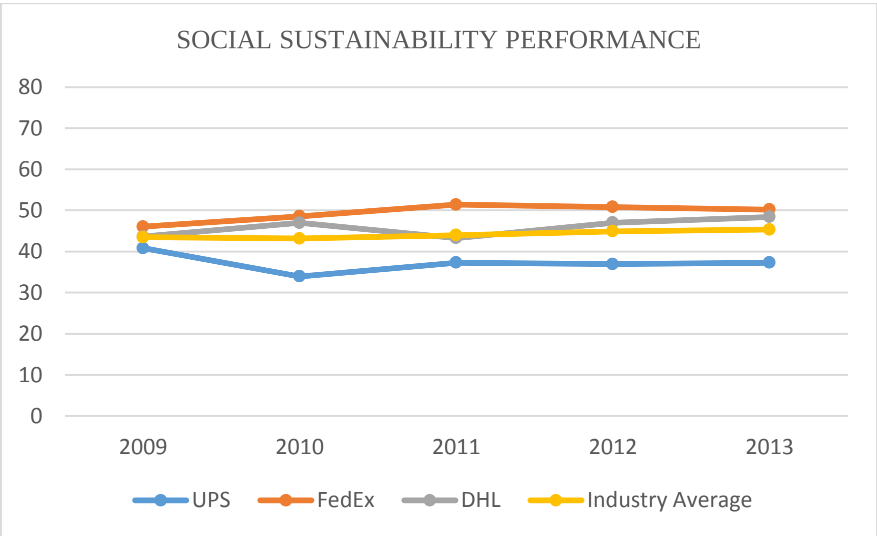

Figure 6. Social Sustainability Performance of UPS, FedEx, DHL

In Figure 6, social dimension performance results are shown. All firms and industry averages are pretty close. While UPS has lower performance than the industry average; both DHL and FedEx better performance than industry average.

RESULTS AND SUGGESTIONS

Firms can outsource raw materials, by-products and finished products from different countries to get cost and competitive advantage in globalizing world. But in all cases, raw materials, by-products and finished products still need to transport from produced country to delivery country. At this point, logistics steps in. However, logistics and transportation activities can be harmful for both humanity and environment. Thus, it is really important to obtain sustainability and infuse sustainability into logistics and transportation activities. Sustainability is known as “development which meets the needs of the present without compromising the ability of future generations to meet their own needs” [25]. Sustainability reporting systems are becoming widespread lately. Reports, that are convenient with GRI (Global Reporting Initiatives), has been released by a few different sectors. However, logistics sector could not be one of them. A few logistics brands have reports about sustainability. These brands are Ekol Logistics and Mars Logistics. When these reports is examined Mars Logistics’ reports covers only the period of 2012 and 2013; while Ekol logistics covers 2007-2014 period but only allows qualitative data. So, these two Turkish companies could not added to this study.
This study aims to be a roadmap for Turkish logistics brands for adopting sustainability activities. When Turkish logistics companies starts to prepare sustainability reports according to global initiatives that will bring global prestige. Logistics brands, which are active on both Turkey and abroad, are included in this study; UPS, FedEx and DHL’s sustainability reports used in this study. This paper covers the time period of 2009-2013. After gathering data from reports, dimensions and sub-factors is determined and assessment form was prepared according to these dimensions and sub-factors. Assessment form has been sent to well-informed people in their areas and AHP results were obtained according to these results. After that, TOPSIS results gathered with using AHP results.

According to experts’ answers most important dimension becomes economic dimension. So for Turkish companies, which want to be successful in economic dimension, should follow the suggestions written below.

- Turkish logistics companies should include economic performance variables in their sustainability reports.
- Turkish logistics companies should include market value and end-year values in their sustainability reports.
- Turkish logistics companies should include purchasing activities in their sustainability reports.

Second important dimension is environmental dimension according to experts’ results. To be successful in environmental dimension Turkish companies should follow the suggestions written below.

- Turkish logistics companies should determine the amount of CO_2 emission.
- Turkish logistics companies should determine the amount of energy consumption, and try to reduce the amount.
- Turkish logistics companies should determine the amount of waste, try to reduce it and try to increase the amount of recycling.
- Turkish logistics companies should determine the amount of used water and try to reduce it.

Third important dimension is social dimension according to experts' results. To be successful in social dimension, Turkish companies should follow the suggestions written below.

- Turkish logistics firms should keep record of demographic characteristics of their workers.
- Turkish logistics firms should keep record of their employees' self-improvement, training and volunteer activities data.
- Turkish logistics firms should keep record of their social responsibility projects data.
- Turkish logistics firms should keep record of accident frequency rate data.
- Turkish logistics firms should keep record of organizational engagement data.

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AN ANALYSIS OF LOGISTICS PERFORMANCE AND INTERNATIONAL TRADE INTERACTION

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Abstract – The interaction between the performances of logistics sector in a country with that of economic growth has long been investigated by different researchers. Since the transport and logistics sector affect production, consumption and trade in a country, it is clear that the performance of logistics sector has positive effect on economic growth. That is, if a country can obtain a competitive advantage in terms of logistics performance, this will increase its international trade, help to open new markets and encourage business. This study aims to investigate the relationship between logistic performance and export. For this purpose; a scenario analysis- based approach is used to analyze the relations between export and the six indicators of logistics performance index (LPI) indicators, namely; customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness. A new method is proposed in this study to select an eligible number of scenarios. Finally, Turkey is selected as a case study and possible scenarios are investigated for Turkey to suggest policy proposals.

Keywords – Logistics Performance, export, scenario analysis, Turkey

INTRODUCTION

The interaction between the logistics performance of a country and its economic growth and increased trade has been investigated by many researchers. In fact, the logistics industry plays an important role in the national development (Chen and Novy, 2011). Nguyen and Tongzon, (2010) underline that international trade, will affect the transport and logistics sector through higher demand for transport services and creating opportunities for business expansion. In fact, the growth of supply chain management is driven by external factors such as increasing globalization, reduced barriers to international trade, improvement in information availability and environmental concerns of the country in which the companies are operating. Higher economic growth leads to more government revenue and greater demand on good infrastructure, which stimulated the improvement in transport conditions (Hong et al., 2011; Gunasekaran, et al.; 2004, Röller and Waverman, 2001; Esfahani and Ramirez, 2003; Canning and Bennathan, 2000).

As can be seen from the literature survey, the previous researches on the logistics and growth interaction focus only on the effect of transportation infrastructure rather than the transport and logistics sector. Most of the studies use public infrastructure capital as a proxy for the transport infrastructure (Nguyen and Tongzon, 2010; Berechman et al.2006)) or they use roadway lengths but they do not capture the effect of infrastructure quality (Hong et al., 2011; Demurger, 2001). Futhermore; previous studies focuses on a certain type of infrastructure such as roadway (Gunasekera et al.2008) airport (Yamaguchi, 2007). Therefore, they do not compare the impacts of various types of infrastructure (Hong et al., 2011). However, despite its importance, transport infrastructure is only one of the key factors that can be used to measure the logistics performance of a country. The quality of door to door service, port efficiency, availability of transport modes etc. are among the key variables that should also be taken into account. In fact, Logistics Performance Index (LPI) is a very generally used index to evaluate the logistics performance of the among 155 countries based on six areas namely; customs, infrastructure, international shipments, logistics quality and competence, tracking & tracing and timeliness (Rantasila and Ojala, 2012; Arvis et al., 2014; http://lpi.worldbank.org/). LPI, published by the World Bank, compares these six logistics profiles among countries and rates them on a scale of 1 (worst) to 5

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(best) on their LPI Group. Therefore, one f the main contribution of this study is to analyze the logistics performance based on this wider perspective rather than taking only the infrastructure.

The development of logistics sector, in its turn, is also expected to have a positive impact on increasing production, consumption and trade and thus stimulating the economic growth. The improvement of logistics infrastructure will reduce the travel time and the resulting time savings will facilitate the access of the producers to distant markets and the drawing of inputs from distant markets. The better infrastructure will also contribute to attract foreign direct investment (Lean et al. 2014, Barnister and Berechman 2001, Berechman et al., 2006, Lall 2007, Gunasekera et al. ,2008) show a positive relationship between infrastructure and economic development in South Africa. Liu et al. (2006) found a unidirectional causality from logistics to economic growth. Chen and Novy (2011) underlines that the modern logistics industry plays an important role in the national economic development. They use econometric methods to establish the relation of logistics and GDP. Demurger (2001) provides an empirical evidence of the links between the infrastructure investment and economic growth in China. Esfahani and Ramirez (2003) develop a structural growth model of infrastructure and output growth. Their model indicates that infrastructure services have great contribution to GDP and that this contribution more than offset its cost. Fan and Chan-Kang (2008) uses an econometric model to estimate the impact of road investments on overall economic growth.

Although deterministic forecasting models are widely used to see the impact of logistics on the improvement of trade or economic development, the basic drawbacks of such models are that they typically provide a single prediction and they do not include qualitative system change. Developing a small number of scenarios which represent possible states of a system is an appealing alternative (Tietje, 2005). Scenario analysis provide an important tool in the strategic planning process. Scenarios are not forecasts but they give an internally consistent view of what the future might be. Scenario analysis has emerged as a useful tool for long term planning when the future is perceived to be subject to high degree of uncertainty and complexity (Nguyen and Dunn, 2009). The internal consistency of the scenarios is of primary importance. In fact, long term planning necessitates an understanding of multidisciplinary connections among several factors such as demographic, technological, economic and political developments. However, the human mind is limited to mentally processing these interdependencies (Weimer-Jehle, 2006). Therefore, different scenario analysis techniques are developed. Scenario analysis consists of problem analysis, system analysis and synthesis phases. Problem analysis helps the related experts and shareholders to have a common understanding of the problem on hand. System analysis define the problem as set of interrelated subsystems, identify relevant external influences on the investigated problem. Brainstorming, Brainwriting, the Delphi technique etc. can be used for this two stages. Finally; synthesis process is used to examine the interdependencies among the influencing factors and to develop scenarios. For this last stage two different groups of methods are generally proposed. Non-Bayesian methods (e.g. Morphological Analysis, Battelle Approach, Field Anomaly Relaxation) and Bayesian Methods (e.g Cross-Impact Analysis, Goal Programming. For a detailed overview of these techniques see Nguyen and Dunn (2009), Bishop et al. (2007), and Amer et al. (2013).

The aim of this study is to analyze the interaction between all aspects of logistics and export. A new scenario analysis approach is proposed to analyse these interactions. For this purpose LPI indicators are used to represent the aspects logistics.

In this research, Turkey is selected as a case study. One of the basic reason of selecting specifically Turkey is that Turkey, an important logistics center in Europe exhibiting high trade values with its regional partners, has a large population, diversified economy and strategic geographic location. It is considered a critical actor in the trade between Europe, the Commonwealth of Independent States (CIS) and the Middle East (ITF, 2015). Another reason of focusing especially on Turkey is that Turkish Exports Strategy for 2023 is initiated by the Ministry of Economy and Turkish Exporters Assembly in 2009 (TSV, 2015). The main purpose of this strategy is to reach 500 billion dollars of exports volume in 2023, the centenary anniversary of the Turkish Republic, with an average of 12% increase in exports annually. In this respect, the exports strategy of Turkey establishes a production plan towards export performance. Basic elements of this strategy are shifting production from low technology sectors to high value added areas and achieving new investments in high-tech sectors. In order to reach these goals of the strategy; some crucial actions have to be implemented, one of them being the improvement of logistics facilities.

Section 2 underlines the framework of the proposed methodology, section 3 applies the proposed methodology to Turkey as a case study and provides the interpretation of the results to highlight which key areas of logistics should be improved in the first run in order to get the highest increased in Turkey's export level. Finally, conclusions and suggestions are given.

FRAMEWORK OF THE PROPOSED METHODOLOGY

The basic aim of the current study is to analyze the interaction among the logistics and export. There is scarce research focusing on logistics performance evaluation from the perspective of nations as a whole. The existing literature on supply chain and logistics performance is generally static and provides cross-sectional analysis of performance rather than a dynamic picture of performance evolution (Töyli et al., 2008). In fact, the Logistics Performance Index (LPI) (Arvis et al. 2007, 2010, 2012, 2014) shows comparative performance of logistics in more than 150 countries and assesses performance flow of goods through each country. The World Bank and the Turku School of Economics have been making evaluations for the index every two years since 2007. The LPI takes into account customs, infrastructure, service quality, timeliness, international shipments, and tracking and tracing as the key elements of logistics and compares these logistics profiles between 166 countries, rating them on a scale of 1 (worst) to 5 (best) (Arvis et al., 2014).

In addition to the six LPI indicators export level of a country is added as the seventh variable in the system to find out the aimed interactions. Finally, the seven variables are reached as given in Table 1.

Table 19. Definitions of variables

Variables	Definition
Customs	The efficiency of customs and border clearance (LPI indicator)
Infrastructure	The quality of trade and transport infrastructure (LPI indicator)
Service Quality	The competence and quality of logistics services—trucking, forwarding, and customs brokerage (LPI indicator)
Timeliness	he frequency with which shipments reach consignees within scheduled or expected delivery times (LPI indicator)
International Shipments	he ease of arranging competitively priced shipments (LPI indicator)
Tracking and Tracing	The ability to track and trace consignments (LPI indicator)
Export	Exports as a percentage of GDP

In order to apply the scenario analysis, the data related to variables are converted to linguistic values. The scale used for the conversion is given in Table 2.

Table 20. Linguistic scale and data intervals for conversion

Linguistic variable	Data interval for LPI indicators	Data interval for export
Very Low (VL)	1.00 – 1.99	0.00 – 15.00
Low (L)	2.00 – 2.66	15.01 – 45.83
Medium (M)	2.67 – 3.33	45.84 – 78.56
High (H)	3.34 – 3.99	78.57 – 111.29
Very High (VH)	4.00 – 5.00	> 111.29

Proposed scenario analysis

Although deterministic forecasting models are widely used to see the impact of logistics on the improvement of trade or economic development, the basic drawbacks of such models are that they typically provide a single prediction and they do not include qualitative system change (Tietje, 2005). In fact, particularly for long-term planning, backcasting, scenario analysis and foresight techniques are accepted to be suitable to inform the logistics and transportation decision makers in highly uncertain future conditions (Schuckmann et al., 2012).

Backcasting is an approach for exploring long-term scenarios to reach a desirable future. It provides an opposite approach to forecasting which aims to predict the future from current conditions. Backcasting requires defining a future desired state first and then it goes backwards to find the path that leads to this desired system. In a sense, it is the opposite approach to forecasting which attempts to predict the future from the current conditions. However, due to the high variability in the set of identified backcasts, no specific policy recommendation could be made and the interrelation among the variables cannot be observed easily. On the other hand, as is underlined by Wangel (2011), few backcasting studies include the actors or governance

Foresight, in the other hand, is a participatory strategy processes in which different stakeholders such as research communities, industries and policy makers discuss different development policies to align them with anticipated social needs. However, the basic drawback of foresight processes is that they do not take into account some complication factors such as non-linearities and thresholds in the attempts to project the future.

Developing a small number of scenarios which represent possible states of a system is another appealing alternative. Scenario analysis provide an important tool in the strategic planning process. A scenario is a plausible description of some future state with no statement of probability. Scenarios are alternative pictures of how the future might develop. They are used to highlight the consequences and, thus, provide a basis for policies that might influence future developments or help the governments to deal with the future issues. Projections are sets of future conditions based on different scenarios. The key issue in projecting the future on the basis of a scenario is the consistency of the scenario (Pittock, 2009).

A scenario describes a possible future state of a system by means of impact variables. For each of the n impact variables yi, i=1..n, , possible different levels are defined and the combinatorial number of scenarios will be the product of all different levels. The consistency of a scenario is estimated by assessing the consistency of the levels of all pairs of impact factors (Tietje, 2005). The consistency analysis is the core part of a formative scenario analysis because the inconsistent scenarios do not draw any realistic image of the future. In the consistency analysis a scenario is taken as a set of system variables, each of which being allowed to take only a small number of different levels. However, the resulting combinatorial set of scenarios may be very large. Therefore, a scenario selection method which yields consistent, reliable, different and small number of scenarios is generally desirable (Tietje, 2005).

In the literature, the consistency is based on a specific scale, consistency indicator. However, the consistency rating of all pairs of impact variables is done by the experts. Subsequently these ratings are summarized in the consistency matrix is formed and different indicators such as overall consistency, multiplicative consistency, the number of inconsistencies and the minimum consistency level of a scenario can be calculated (see Tietje, 2005 for the calculation details as well as characteristics of these indicators)

After the consistency assessment, the set of all plausible scenarios which match specific criteria related to maximum number of inconsistencies or a minimum consistency level can be obtained. However, it is necessary to underline that even after this filtering, the number of scenario left may be hundred or in some cases even thousands. Therefore; it is necessary to use additional procedure for finding representative scenarios distinct from each other. One possible way is to use cluster analysis. However, this approach is criticized because it does not provide a good proposal for which scenario of a cluster to take as representative. Tietje (2005) proposes three different procedures to obtain a set of final scenarios, namely; Local efficiency, Distance-to-selected and Max-min selection (see Tietje, 2005 for details)

A scenario selection method, which yields consistent scenarios and which supports the quality of scenario analysis is desirable. In fact, inconsistent scenarios draw no realistic image of the future. The scenario selection should take into consideration the following rules (Tietje, 2005):

- *Significantly different scenarios*: The decision maker is interested in a set of principally possible cases and small differences between scenarios are not very relevant
- *A small number of scenarios*: the main reason of this is that decision makers can hardly compare many qualitatively different scenarios and a large number of scenarios may indicate a large redundancy
- *A reliable set of scenarios*: Different scenario analysts should arrive at the same results when they use different scenarios based on the same scenario selection procedure.
- *Efficient scenarios:* the most consistent scenarios within a group of similar scenarios,

In this study, in order to have a desirable scenario section method the following multiple objective mathematical program is proposed for scenario identification.

$$Max \sum_{k} C(S_k)\, x_k$$

$$Min \sum_{k} x_k$$

$$x_k + \sum_{l} N_{kl} x_l \leq 1 \qquad \forall k$$

$$x_k \in \{0, 1\} \qquad \forall k$$

where, $C(S_k)$ is the consistency of scenario S_k, N_{kl} is a binary parameter to indicate if scenario k and l are neighbors, x_k is binary variable to identify scenario k is selected or not.

This model is designed to have the properties of a quality scenario analysis such as consistent, significantly different, efficient, small number and reliable set of scenarios. The first objective maximizes the total consistency of the selected scenarios while the second one minimizes number of scenarios. Significantly different and efficient scenarios are gathered by the first constraint.

The explanations regarding the the parameters of the model, which are consistency and neighborhood are given in the following sub-sections.

Consistency assessment

The consistency of a scenario as a whole is estimated by assessing the consistency of the levels of all pairs of variables. To find the consistency of the levels of a pair of variables the following formula is used:

$$c\left(y_i^{m_i}, y_j^{m_j}\right) = \max\left(\frac{f\left(y_i^{m_i}, y_j^{m_j}\right)}{f\left(y_i^{m_i}\right)}; \frac{f\left(y_i^{m_i}, y_j^{m_j}\right)}{f\left(y_j^{m_i}\right)}\right)$$

i = 1,...,7. (1: customs, 2: Infrastructure, 3: International shipments, 4: Logistics quality and competence, 5: Tracking and tracing, 6: Timeliness, 7: export) , *m*= VL, L, M, H,VH

$f\left(y_i^{m_i}, y_j^{m_j}\right)$: number of scenarios where level of variable *i* is m_i and level of variable *j* is m_j

$f\left(y_i^{m_i}\right)$: number of scenarios where level of variable *i* is m_i .

Table 3. Frequency of scenarios for the variables "customs" and "infrastructure"

	Infrastructure					
Customs	**H**	**L**	**M**	**VH**	**VL**	**Grand Total**
H	55	0	24	0	0	79
L	0	190	18	0	14	222
M	3	35	83	0	0	121
VH	39	0	0	7	0	46
VL	0	19	0	0	15	34
Grand Total	**97**	**244**	**125**	**7**	**29**	**502**

For instance suppose frequency of the scenarios for the variables "customs" and "infrastructure" are as given in Table 3. The consistency of customs is H and Infrastructure is M is calculated as follows:

$$c(y_1^H, y_2^M) = \max\left(\frac{f(y_1^H, y_2^M)}{f(y_1^H)}; \frac{f(y_1^H, y_2^M)}{f(y_2^M)}\right) = \max\left(\frac{24}{79}; \frac{24}{125}\right) = 0.304$$

Consistency of a scenario $S_k = \left(y_1^{m_1}, y_2^{m_2}, \dots, y_n^{m_n}\right)$ is calculated based on the consistency of the levels of a pair of variables as follows:

$$C(S_k) = \min_{\substack{j=1,\dots n, \\ i=2,\dots n, \\ i>j}} c\left(y_i^{m_i}, y_j^{m_j}\right)$$

In the literature additive and multiplicative operator have been used for similar purposes. The reason of our using the minimum operator is to eliminate those scenarios the weakest possibility of occurrence in any pair of variables within the scenario.

For instance; $C(y_1^H, y_2^L, y_3^M) = Min\left(c(y_1^H, y_2^L), c(y_1^H, y_3^M), c(y_2^L, y_3^M)\right)$

Neighborhood identification

In order to find significantly different and efficient scenarios neighborhood relation between scenarios are defined according to the following neighborhood rules:

1) Two scenarios differ at most in two variables
2) The total linguistic variable difference is at most three
3) Linguistic variable difference in the export variable is at most one.

To apply these rules, distance between scenarios are calculated as follows:

$$d(S_k, S_l) = Max\left(\frac{\sum_{i=1}^{n}\begin{cases}1 & if \;\; y_i(S_k) \neq y_i(S_l) \\ 0 & otherwise\end{cases}}{2}, \frac{\sum_{i=1}^{n}|y_i(S_k) - y_i(S_l)|}{3}, |y_p(S_k) - y_p(S_l)|\right)$$

A scenario S_k is a neighbour of scenario S_l if $d(S_k, S_l) \leq 1$.

Solution of the proposed multiple objective mathematical program

A preemptive programming approach is used to solve the proposed multiple objective model. As the consistency of the scenarios is more important than the number of scenarios the following model is proposed:

$$Max \sum_k C(S_k)\, x_k - \lambda \sum_k x_k$$

$$x_k + \sum_l N_{kl} x_l \leq 1 \qquad \forall k$$

$$x_k \in \{0, 1\} \qquad \forall k$$

where λ is a significantly small coefficient.

APPLICATION OF THE PROPOSED SCENARIO ANALYSIS TO EVALUATE LOGISTICS PERFORMANCE COMPETITIVENESS OF COUNTRIES: TURKEY AS A CASE STUDY

The proposed scenario analysis is applied to analyze the integration between LPI indicators representing the logistics and exports. For this purpose; data provided from LPI Dataset (http://lpi.worldbank.org/) versions 2007, 2010, 2012, and 2014 and corresponding export data of the countries gathered from World Economic Forum's GCI dataset (http://reports.weforum.org/global-competitiveness-report-2014-2015/downloads/) are used. Initially, the data is converted to linguistic values according to the conversion scale given in Table 2.

Subsequently, consistency of each possible scenario is calculated according to proposed method given in Section 2.2. As a result, 1287 scenarios with non-zero consistency score are identified. Since the number of scenarios are very high to handle in the proposed mathematical program and most of the scenarios have very low consistency score we have eliminated the scenarios with a consistency score of 0.2. Finally 212 possible scenarios are found.

Furthermore; neighborhood relation between the 212 scenarios are identified based on the method given in section 2.3. At the end, the proposed multiple objective mathematical program is solved considering the 212 scenarios, their consistencies and neighborhood relations. Finally, 10 scenarios are selected as a result of the mathematical program that are presented in Table 4.

Table 4. Selected scenarios

ID	Consistency	Customs	Infrastructure	International shipments	Logistics quality and competence	Tracking and tracing	Timeliness	export
5	0.471	M	M	M	M	M	H	H
6	0.425	H	VH	H	H	VH	VH	VH
7	0.402	H	H	H	H	H	VH	L
14	0.353	L	VL	L	L	L	M	VL
19	0.329	L	L	M	M	M	M	L
31	0.287	VL	L	L	VL	VL	M	M
53	0.275	H	VH	VH	VH	VH	VH	M
120	0.222	VL	VL	VL	L	L	L	M
161	0.216	M	H	H	H	H	H	H
194	0.214	L	L	VL	VL	VL	L	L
Turkey		M	H	M	H	H	H	M

According to the LPI indicator values and export level of Turkey, the related performance can be seen in the last row of Table 4. As can be seen from this table, Turkey has a “medium” level performance in customs, international shipments and export levels while its performance is “high” in infrastructure, logistics quality and competence, tracking and tracing and timeliness. Since we are seeking a way to increase its export level, the aim has to be to find the scenario whose export level is “high”. The 9th scenario (ID 161), has a “high”level export performance and it is also the most resembling scenario to that of Turkey’s situation. When this scenario and Turkey’s current situation are analyzed in detail, it can be seen that if Turkey increases it “international shipments” performance, its export level can also increase from medium to high level.

International shipment indicator is defined as “The ease of arranging competitively priced shipments” in LPI report (Arvis et al., 2014). Turkey has a 3,18 score and its rank is 43th among 160 countries. It is the lowest score of Turkey among the 6 LPI indicators. One basic way to realize an improvement in international shipment can be realized through border procedures and time. In fact; LPI measures this factor through several indicators. Import and export time is a useful outcome measure of logistics performance that analyses the time taken to complete trade transactions. Lead time for port or airport supply chains should be improved, is nearly twice as long in low performance countries as in high performance ones. The geographic hurdles, and possibly internal transport markets, continue to pose substantial difficulties in the country. It is necessary to reduce time across all dimensions of the border process, make reforms to focus on the prevalence of physical inspection, proliferation of procedures and red tape. Although the time taken to clear goods through customs is a relatively small fraction of total import time, this time increases when the goods are physically inspected.

Export supply chain typically face fewer procedural burdens than imports evidenced by the shorter lead time to exports than imports. Customs is not the only agency involved in border management; collaboration among all border management agencies and the introduction of modern approaches to regulatory compliance are especially important. Indicators of red tape also illustrate a lack of coordination at the border and the burden it imposes on private logistics operators. Turkey has to reduce the number of government agencies as well as the document requirements. Turkey has also to improve its connectivity to the market through the hierarchical hub-and-spoke network of international trade. Another problem related to the international transportation of Turkey is the quotas and the transit procedures that make the movement of goods possible with payment of duties and excessive control.

CONCLUSION AND FURTHER SUGGESTIONS

In this study, a scenario analysis methodology is proposed. The most important part of scenario analysis is to generate a consistent, reliable, different and small set of scenarios. For this purpose, in this paper a multiple objective mathematical program is proposed for scenario identification. One of the objectives of the model is to maximize the total consistency of the selected scenarios while the second one is to minimize the number of scenarios. Constraints are added to the model in order to generate different and efficient scenarios.

The proposed methodology is used to analyze the interaction between logistics performance of a country with that of its export. Six LPI indicators as well as the export level of the country are used to find out the interactions between them. Subsequently 10 different and efficient scenarios are generated based on the proposed methodology explained in section 2.

After the identification of the scenario set, Turkey has been selected as a case study. Turkey, as an important logistics center in Europe, exhibits high trade values with its regional partners, has a large population, diversified economy and strategic geographic location. It is considered a critical actor in the trade between Europe, the Commonwealth of Independent States (CIS) and the Middle East (ITF, 2015). Turkey is ranked 30th out of 160 countries in the LPI 2014. With this current status, it is above the average of the upper middle income economies to which it belongs. Although Turkey's LPI score showed a significant increase of approximately 9% from 2010 to 2012, it showed almost no change between 2012 and 2014 resulting in a slight decrease in its ranking during this period (Arvis et al., 2014). After analyzing the selected scenarios, the scenario ID 161 is found to be the most resembling scenario to that of Turkey's situation. Therefore, it is suggested to Turkey that if they increase "international shipments" performance, export level can also be improved from medium to high level.

The proposed method can also be used to highlight the differentiated needs of different countries to improve their export level based on the improvement of different indicators of logistics performance.

Additionally; there is debate in the literature as to whether logistics and economic growth have two-way interaction (Nguyen & Tongzon, 2010). This study shows that improvement in some of the competitiveness indicators has an important positive impact on the logistics performance of a country. In fact, logistics improvement in its turn is expected to enhance economic growth because investments and infrastructure will increase demands for goods and services. Similarly, an improvement in logistics performance is expected to decrease the travel time which sets in train another series of economic consequences, such as enabling producers to gain access to more distant markets. Additionally, such an improvement will stimulate local production and attract foreign direct investment, which is itself an important engine for economic growth (Lean et al., 2014). It would therefore be a worthwhile goal of further study to analyze and ascertain to what extent this reverse relation is also true. Such an approach, as well as looking at effects on economic growth, would also highlight how improvement of a country's logistics performance can affect its trade level.

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THE IMPACT OF INFORMATION TECHNOLOGY APPLICATIONS ON THE SUPPLY CHAIN PERFORMANCE AND A CASE STUDY

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Abstract- In recent years, success factors plays a vital role in determining long term strategies thus they are considering directly related to the company's overall success among rivals so top management attaches much more importance to this issue. Especially in information technology (IT) era, success factors should be investigated in a more detailed way since every stage of product life is connected to new technologies. In this study, IT-based view is preferred while evaluating success factors of supply chain performance. It is a well-known fact that supply chain performance determines the company's place in marketplace and ensures competition achievement. From this point of view, measuring and enhancing the supply chain performance become one of the core requirements.

Aim of the study is mining of the success factors ranking according to the findings and expert opinions. Because of the fact that all factors are used in studies and have importance and usage; ranking of these remarkable factors is focused on instead of elimination. Ranking and prioritization of success factors are completed, analyzed and interpreted using DEMATEL (Decision Making Trial and Evaluating Laboratory) which is designed to evaluate criteria relationships and obtain a relationship diagram in order to interpret clearly and ANP (Analytical Network Process) which is designed to make optimum decisions for complex problems with considering cluster relationships. Combination of DEMATEL and ANP techniques is used as examination method. Matrixes from DEMATEL are used with the purpose of shortening ANP steps. It is intended to determine factor roles with DEMATEL and prioritize factors with ANP.

Keywords: *Information technology, decision making, analytical network process, supply chain success factors*

INTRODUCTION

Success factor studies are popular and preferred in recent years. Because of the fact that critical success factors plays a vital role in long term strategies and they directly related to company's success; top level management attaches importance to this issue. This leads researchers to go further investigation into the subject.

Information Technologies (IT) is one of the essential issues as a result of technology era. It is crystal clear that owners, managers or any other responsible people of the corporation should unconditionally have a technology based point of view. From designing to the customer services, every stage of product life cycle is related to new technologies. As well as production, all other inter / intra company related processes are being improved with the help of technological enhancements. Moreover, communication – which is considered as the keyword of new technologies – is possible with the assistance of IT. Even these limited headings show the significance and requirement of IT in companies.

Prasad (2008) aimed in his research to understand the businesses' perception of the nature of intangible benefits that they derive from their IT investments, and how these IT investments contribute to business value. The result of the study indicates that businesses indeed perceive to obtain intangible benefits from their IT

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investments, and that these investments contribute to organizational value creation. However, while they recognize that the IT investments may only provide intangible benefits, business does not treat their IT investments any different from any investments.

Information sharing, capacity, and reliability can be trade-offs on total cost and on-time delivery rate to a limited extent. The benefit of information sharing is the exchange of low cost real-time data for higher cost physical goods. Information sharing is low cost, but difficult to implement in dynamic or low trust supply chains. Cooperation, collaboration, and long term commitments are required. As capacity tightness moves from excess capacity to near-full capacity, total cost increases and on time delivery rate decreases. However, with appropriate level of information sharing within the supply chain, the adverse effects of near-full capacity on cost and delivery can be mitigated to a certain level [14].

SUPPLY CHAIN MANAGEMENT

Enterprises around the world are faced with intense competition. In the new economy, customers require business enterprises to offer better and cheaper products, shorter response times, more product lines, and higher service levels. Business executives and managers recognize that the ultimate success of any enterprise is no longer built around a firm's capability and capacity, but on a supply chain's capability and capacity. To respond to these challenges, it is important to integrate supply chain processes and listen to the voice of the customer. Supply Chain Management (SCM) is a holistic and strategic approach to demand, operations, procurement, and logistics process management [5] SCM is an integrated business model that takes a process-based view of how all of the business functions need to work together and how a business relates to its suppliers and customers [17].

The primary objective of SCM is to fulfill customer demands through the most efficient use of resources, including distribution capacity, inventory and labor. In theory, a supply chain seeks to match demand with supply and do so with the minimal inventory. Various aspects of optimizing the supply chain include liaising with suppliers to eliminate bottlenecks; sourcing strategically to strike a balance between lowest material cost and transportation, implementing Just In Time (JIT) techniques to optimize manufacturing flow; maintaining the right mix and location of factories and warehouses to serve customer markets, and using location/allocation, vehicle routing analysis, dynamic programming and, of course, traditional logistics optimization to maximize the efficiency of the distribution side [36]. These objectives are known as seven goals of supply chain: Delivering right product to the right customer at the right time, at the right place, in the right condition, in the right quantity and at the right cost [6].

Modern supply chains are expected to respond rapidly, effectively and efficiently to changes in the marketplace. Simultaneously there is the drive to achieve world class customer service levels coupled with minimum reasonable inventory (MRI). New concepts such as VMI – vendor managed inventory and CPFR – collaborative planning forecasting and replenishment are adapted to traditional supply chain to be more efficient response. As information sharing and collaboration becomes more predominant in industry, VMI is becoming a major development in supply chain management [23]. Under CPFR, both buyer and seller collaborate by correcting, adjusting, proposing prices and quantities to reach an agreement on a unique forecast, so that the buyer's purchases forecast and the seller's sales forecast coincide [3].

When companies view supply chain as a strategic asset, supply chain strategy is part of the overall business strategy, designed around a well-defined basis of competition (innovation, low cost, service, quality). It is integrated with marketing strategy and with customers’ needs, product strategy as well as power position. On the other hand, supply chain strategy must adapt as market conditions and competitive advantages change [18]. Supply chain management creates value for companies, customers and stakeholders interacting throughout a supply chain. The strategic dimension of supply chain makes it paramount that their performances are measured. In today’s performance evaluation processes, companies tend to refer to several models that will differ in terms of corporate organization, the distribution of responsibilities and supply chain maturity [10].

Fuzzy approaches are also preferred frequently by researchers. Yang and Jiang (2012) constructed an index system for evaluating the supply chains' overall performance by using SCOR model and used Analytic Hierarchical Model (AHM) to determine the weight of every index in the system. Another fuzzy approach used paper is published by Tsai et al (2009) which aims propose a fuzzy goal programming (FGP) approach that integrates activity-based costing (ABC) and performance evaluation in a value-chain structure for optimal Green Supply Chain supplier selection and flow allocation.

CASE STUDY

This case study is to determine most important and influential success factors of supply chain performance evaluation with an IT based point of view. With the help of the previous researches, articles, books and all kind of publications; most effective performance elements are selected for use in the case study. Success factors are departed into three categories, managerial, technical and business success factors.

Managerial Success Factors

Managerial success factors can be defined as partnership based relational elements. List of managerial elements and their references are shown below in Table 1.

Table 1: Managerial Success Factors

Factor Name	Description	References
Interaction, friendship and trust between partners	A willingness to rely on an exchange partner and characterized by the belief that the partner will not indulge in opportunistic behavior.	Yang, J. et al. (2010), Sayed, M. et al (2012), Pereira, J.V. (2009)
Relational commitment and loyalty between partners	An exchange partner's belief that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it; that is, the committed party believes the relationship endures indefinitely	Yang, J. et al. (2010), Sayed, M. et al (2012), Kongar, E. (2005), Papalexandris, A. et al (2004), Olson, E.M. et al (2002)
Relational stability	Consistency of the relationship between supply chain partners.	Yang, J. et al. (2010), Paulraj, A. et al (2008)
Strategic alliances and alliance performance	Strategic alliances enable buying and supplying firms to combine their individual strengths and work together to reduce non-value-adding activities and facilitate improved performance.	Yang, J. et al. (2010), Sayed, M. et al (2012)
Partner dependence	Dependence situation is described as a firm’s economic or social goal is mediated by another firm’s action	Seggie, S.H. et al (2006), Wu, K.J. et al (2011), Zhu, Q. et al (2008)
Intensity of information technology connection	The more companies use information technologies, the more they both collaborate with their partners and enhance inner information flow.	Prajogo, D. et al (2012), Kongar, E. (2005), Narasimhan, R. et al (2003)
Information sharing	Information sharing plays a role of paramount importance in modern supply chain environments.	Kocoglu, I. et al (2011), Flynn, B.B. et al (2010)
Top management support of IT	Top management support of information systems refers to the degree to which top management understands the importance of the Information Systems (IS) function and the extent to which it is involved in IS activities	Byrd, T.A. et al (2003)
Managerial IT knowledge	The union of IT-related and business-related knowledge possessed and exchanged among IT executives and functional managers.	Ranganathan, C.D. et al (2011)

Rapid customer response	Quick Response (QR) is both a management paradigm and a methodology that allows supply systems to react quickly to changes while improving their performance	Paulraj, A. et al (2008)
Flexibility of supplier	In a supply chain, the suppliers' flexibility is considered as a tool to cope with the environmental uncertainties	Paulraj, A. et al (2008)
Collaboration between firms and product designers	Collaborative product design is about business strategy, workflow and collection of software applications that facilitates different vendors to work together on development/design of a product.	Wu, K.J. et al (2011), Holt, D. et al (2009)
Satisfy customer needs	Customer satisfaction is the customer's reaction to the value received from the purchase or utilization of the offering.	Wu, K.J. et al (2011), Dreyer, B. et al (2004), Carr, A.S. et al (1999), Kongar, E. (2005), Papalexandris, A. et al (2004), Ittner, C.D. et al (2003)
Long term integration with suppliers	Innovative organizations seek to secure sustainable advantage and impact financial liquidity through an improved top line by fostering deep, long-term relationships with suppliers	Kongar, E. (2005), Narasimhan, R. et al (2003)

Technical Success Factors

Technical success factors are relevant to subjects such as information technologies facilities, inter-firm system effectiveness and infrastructure of the supply chain. List of managerial elements and their references are shown below in Table 2.

Table 2: Technical Success Factors

Factor Name	Description	References
Appropriability of information technologies, appropriate flow of information	The ability of the firm deploying IT to exploit the potential of the IT resource fully.	Seggie, S.H. et al (2006), Pereira, J.V. (2009)
IT alignment (the extent to which a firm's IT is compatible with that of its channel partners)	IT alignment is the extent to which a firm's information technology is compatible with that of its channel partners	Seggie, S.H. et al (2006), Wu, F. et al (2006)
Interfirm system integration	Interfirm systems integration is the extent a firm's supply chain communication system (SCCS) is integrated and prepared for collaborative activities with channel partners	Seggie, S.H. et al (2006), Flynn, B.B. et al (2010)
Brand equity	Brand equity has often been defined very broadly to include an extensive set of attributes that influence consumer choice	Seggie, S.H. et al (2006), Lemon, K.N. et al (2001)
IT advancement (the extent to which a firm adopts the most sophisticated technology)	It is defined as the extent to which a firm adopts the most sophisticated technology. It measures the degree of proactive adoption and implementation of advanced IT to find customer solutions ahead of competitors	Wu, F. et al (2006), Mukhopadhyay, T. et al (1997)
Information transparency, visibility, sensitivity	Supply chain transparency captures the extent to which information is readily available to end-users and other firms in the supply chain	Sayed, M. et al (2012), Pereira, J.V. (2009)
Logistics network design	Appropriate logistics strategies relating to transportation modes, warehousing, inventory management and order processing have to be implemented for moving the right materials efficiently to the right place, at the right time and at the right price across the supply chain	Sayed, M. et al (2012),
Effective use of mrp/erp systems in organization	Planning and optimization systems are not useful and improving unless they are used in an effective and full-capacity way.	Sayed, M. et al (2012), Dehning, B. et al (2007)

Effective use of internet	Principal applications of the internet usage in supply chain have been in the areas of procurement, transportation scheduling, vehicle tracking, and customer service.	Sayed, M. et al (2012), Bertscheck, I. et al (2012)
Effective inventory management	In traditional supply chain inventory management, orders are the only information firms exchange, but information technology now allows firms to share demand and inventory data quickly and inexpensively	Dehning, B. et al (2007)
Effective demand/production balance	Demand forecast accuracy is the ratio of the amount of orders delivered no later than the delivery day requested by the customer to total delivery amount	Dehning, B. et al (2007), Kongar, E. (2005), Gunasekaran, A. et al (2004)
Use of communication tools	The supply chain today is seen as being an important element in the value creation process and communication is seen as the “glue” that holds the relationships within that chain together.	Foster, T. (2007)
IT plan utilization	The content of IT plans includes distinctive competences of the firm, the dominant types of IT in the firm, and integrative concepts surrounding the firm’s IT infrastructure	Byrd, T.A. et al (2003)
IT technical quality and infrastructure	IT infrastructure refers to an arrangement of shared technical components and IT services: platforms, networks and telecommunications, data, and software applications	Byrd, T.A. et al (2003), Ranganathan, C.D. et al (2011), Liu, H. et al (2013)
Contextualization of information	Contextualization process helps to give the right information at the right time to the right person at the right place in the right format	Pereira, J.V. (2009)
IT assimilation	IT assimilation refers to the success achieved by firms in utilizing the capabilities of IT to enhance their business performance.	Liu, H. et al (2013)
Information intensity	Information intensity reflects the extent of potential interaction and information-exchange across buyer–supplier cohorts along the supply chain.	Ranganathan, C.D. et al (2011)
Degree of innovativeness of R&D products	The key challenge to companies is not so much the generation of innovative ideas at the R&D stage, but the effective transfer of technology from the discovery stage to the market	Wu, K.J. et al (2011), Damanpour, F. et al (2006)

Business Success Factors

Factors that are connected to business side of the supply chain are listed below in Table 3.

Table 3: Technical Success Factors

Factor Name	Description	References
Perceived ROI	ROI is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments	Ranganathan, C.D. et al (2011)
Work in process turnover	It is described as the ratio of cost of goods sold / work in process inventory	Dehning, B. et al (2007)
Finished goods inventory turnover	It is described as the ratio of cost of goods sold / finished goods inventory	Dehning, B. et al (2007)
Market share	It is described as the ratio of sales / median industry sales	Dehning, B. et al (2007), Kongar, E. (2005), Papalexandris, A. et al (2004), Olson, E.M. et al (2002)
Real time planning	IT-based SCM systems can sense changing conditions and respond with distribution, transportation, and logistics that are integrated with real-time planning	Dehning, B. et al (2007)

New product management	Technological achievements will undoubtedly impact the adoption of new products. Economic research into consumer behavior and the valuations associated with consumer adoption of new products are essential for market success	Dehning, B. et al (2007), Sanders, N.R. (2007)
Globalization (sourcing and selling)	A salient feature of globalization in recent decades is the emergence of 'global supply chains' in which different countries specialize in different stages of a sequential production process	Dehning, B. et al (2007)
Personalized solutions for customers	Customized solutions appear to be an effective way to build competitive advantages without the debilitating effects of price competition.	Dehning, B. et al (2007)
Cost improvement	According to Lida (2012); the manufacturer assembles components that are procured from the suppliers to produce a final product	Sanders, N.R. (2007)
Product quality	Product quality is one of the key competitive factors and an important dimension of operational performance in supply chain management	Sanders, N.R. (2007)
Delivery speed	The key characteristic of an agile supply chain is the lead time each player has to wait between receiving a demand from his customer and delivery from his supplier.	Paulraj, A. et al (2008), Sanders, N.R. (2007)
Increased revenue from new technologies	Companies are grappling with challenges such as learning how to enter new markets and attract new customers, identifying which new channels to tap in each segment and geography, and determining how to penetrate deeper and wider into the existing customer bases	Kongar, E. (2005), Papalexandris, A. et al (2004),
New customer sales	Without ignoring existing customers, getting new customers leads firms to increase their share in market.	Kongar, E. (2005), Olson, E.M. et al (2002)
Number of customers	Number of customers shows the size of the company which is an important image in order to be preferred.	Kongar, E. (2005), Reiner, G. (2005)
Total order cycle time	A shorter lead time implies better customer service, less inventory, and higher efficiency, and thus is more and more important for obtaining competitive advantage and increased market shares.	Kongar, E. (2005), Olson, E.M. et al (2002), Gunasekaran, A. et al (2004), Otto, A. et al (2003)
Supplier price compared with the market	Insightful and strategically oriented buyers and suppliers have taken a collaborative approach to achieving lower supplier prices	Kongar, E. (2005), Gunasekaran, A. et al (2004)
Supplier delivery performance	In the short term, delivery deviations—the earliness and lateness from the targeted delivery date—must be analyzed, as both early and late deliveries are disruptive to supply chains	Kongar, E. (2005), Gunasekaran, A. et al (2004)

METHODOLOGY

In this case study; an integrated Multi Criteria Decision Making (MCDM) Methodology is preferred. Decision Making Trial and Evaluation Laboratory (DEMATEL) method is used first in order to discover factor affect analysis. Microsoft Excel software is used as a calculation tool for DEMATEL.

The DEMATEL method, developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976, was used for researching and solving the complicated and intertwined problem group. DEMATEL was developed in the belief that pioneering and appropriate use of scientific research methods could improve understanding of the specific problematique, the cluster of intertwined problems, and contribute to identification of workable solutions by a hierarchical structure. The methodology, according to the concrete characteristics of objective affairs, can confirm the interdependence among the variables/attributes and restrict the relation that reflects the characteristic with an essential system and development trend [38].

After obtaining factor influences, ANP is used in order to sort the success factors. ANP Solver software is used as a calculation tool for matrix computations. ANP Solver is a free software for academic uses which is designed as a part of a dissertation (Development of software tool to support the ANP) for the evaluation of project portfolio) conducted by Elena Rokou. Both web based and downloadable versions of the software are available.

Model structure includes combination of two methods: DEMATEL and ANP. Elements of data set only contain success factors of supply chain. Figure 1 is represents the determined model structure.

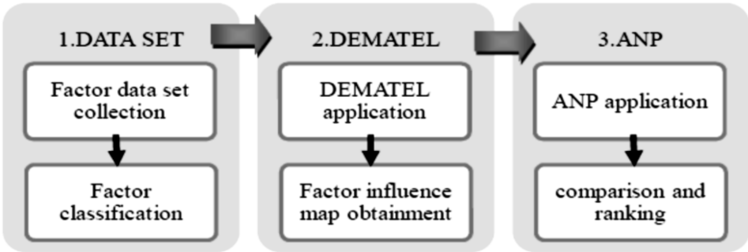

Figure 1: Model Structure

ANALYSIS

In the beginning DEMATEL analysis is used step by step. As first step of the DEMATEL technique, answer matrix (X) is obtained by using the 4 point likert scale Due to the number of case study success factors, answer matrix is obtained as a 49×49 matrix. Diagonal values of matrix is set as zero as the method purposes. Number of experts (H) is set as 1; thus, answer matrix (X) becomes equal to average matrix (A). Normalized initial direct-relation matrix (D) is obtained by normalizing the matrix A (found out from step 1). Form normalization; row and column totals are calculated. Maximum of row totals is found out 121, while maximum of column totals is found out 113. Total relation matrix (F) which contains both direct and indirect relations is obtained. Then, effect indexes are calculated with the help of the row and column totals of total relation matrix (F). D_i denotes the row sum and R_i denotes the column sum values. $D_i + R_i$ sum value shows the role of the factor in the problem. Factors and their roles are summarized in Table 4. The higher $D_i + R_i$ value, the more success factor takes part in the model. In our research, values are in the range of 0,535141808 - 3,242186179.

Table 4: Factor Role Indexes

Di + Ri Value Interval	Number of Factors
≤ 1	2
1 < Di + Ri ≤ 2	24
2 < Di + Ri ≤ 2,5	14
2,5 < Di + Ri ≤ 3	7
> 3	2

Although there are voluminous factors and their role weights are close to each other, certain factors differentiate from others. Significant factors are shown in Table 5 It is supposed that distribution is cut from the point of 2,5 in order to analyze clearly. Because of the fact that factor elimination is not included in the study; cut point level does not become a critical issue.

Table 5: Significant Factors in the Model

Value Interval	Factor No (i)	Factor Description	Role Value (Di + Ri)	Factor Cluster
Di + Ri > 3	14	Long term integration with suppliers	3,242186179	Managerial
	4	Strategic alliances and alliance performance	3,160151527	Managerial
2,5 < Di + Ri ≤ 3	13	Satisfy customer needs	2,942702163	Managerial
	22	Effective use of mrp/erp systems in organization	2,745567987	Technical
	7	Information sharing	2,632283294	Managerial
	10	Rapid confirmation of orders, rapid handling of customer complaints	2,600490014	Managerial
	25	Effective demand/production balance	2,545762784	Technical
	3	Relational stability, consistency	2,520420468	Managerial
	37	Real time planning	2,502776299	Business

Di - Ri values show the direction of the factor influences. If Di - Ri is positive; factor i is an affecting factor. If Di - Ri is negative, factor i is an affected factor. It is found out that; twenty-two factors have positive values (influencing other factors) while twenty-seven factors have negative values (influenced by other factors). There is not a positive correlation between the significance (Di + Ri) and influence direction (Di - Ri) of a factor. In other words; significance of a factor does not guarantee that it is an affecting/affected factor. In our data set, three affecting factors and six affected factors exist out of most significant nine factors.

Technical success factors mostly have a tendency to affect other factors. %72,22 of technical factors (13 factors out of 18) are in the affecting table. Meanwhile, %35,71 of managerial factors (5 factors out of 14) and %23,53 of business factors (4 factors out of 17) are found out affecting. Top three affecting factors are found as managerial IT knowledge, top management support of IT and flexibility of supplier.

Threshold value determination is done by research makers or obtained from expert decisions in recent literature studies. In this case study, threshold value is decided by researcher. After the examination of this forty nine - value graph; limit value p is obtained as 0,06. Setting the threshold value is vital in studies. If p is selected too low, influence network becomes complicated and hard to interpret. However, if p is selected too high, factor influences becomes invisible and some factors seem as independent factors even they are not. After cutting off the graph with value 0,06; eighteen factor values become selected.P-cut matrix (T) is obtained by changing the values to zero which are under the p limit value. Influence map is obtained with the help of limit value. Number of values higher than limit -eighteen factors- value lead the map to contain eighteen relationship arrows.

According to Di+Ri and Di-Ri values; Factor 8 (top management support of IT) is the most affecting factor in the model with the highest Di-Ri value. Factor 14 (long term integration with suppliers) is the most outstanding factor with the highest Di+Ri value.

According to the design of the ANP Solver software; there are nine different screens to be followed. Six of the screens are manipulated by the user and require input from researcher while three of the screens contain calculated results by software according to the input of previous screens. First steps require master data creations such as clusters and their nodes. Managerial, technical and business clusters are created in first tab. Elements of these clusters which are shown in the tables previous parts are created under the branches. Then, relations between factors are entered in the table. Average answer matrix A (obtained in Dematel step 1) is used as resource. If the value of $a_{ij} > 0$; checkbox is ticked in the matrix.

Comparison of the clusters is determined equal in the case study scenario. Each comparison matrix is evaluated according to each cluster’s point of view. With this method, three cluster comparison matrixes are obtained Cluster weights are supposed equal to each other in case study in order to analyze factors objectively. Result matrix of the comparisons is calculated by the software. Different ratio scenarios will be studied in sensitivity analysis.

Node comparison is the most complicated step of the analysis. Each comparison matrix is evaluated in managerial, technical and business point of views one by one. Software uses the factor relationships in order to propose row and column factors of the matrix. 9-point scale is used for the evaluation of the importance of factors. Diagonal values of the matrixes are always 1 as shown in Figure 2.

With Respect to Node 3 Relational stability consistency
Cluster technical

Nodes	16 IT alignment	20 Information transparency visibility sensitivity	21 Logistics network design	22 Effective use of mrp erp systems	24 Effective inventory management	25 Effective demand production balance	29 Contextualization of information	32 Degree of innovativeness of R&D products
16 IT alignment	1	0,2	1	1	0,333	0,333	0,2	1
20 Information tra...	5	1	5	5	3	3	1	5
21 Logistics netw...	1	0,2	1	1	0,333	0,333	0,2	1
22 Effective use ...	1	0,2	1	1	0,333	0,333	0,2	1
24 Effective inve...	3,003	0,333	3,003	3,003	1	1	0,333	3
25 Effective dem...	3,003	0,333	3,003	3,003	1	1	0,2	1
29 Contextualizati...	5	1	5	5	3,003	5	1	5
32 Degree of inn...	1	0,2	1	1	0,333	1	0,2	1

Figure 2: Compare Nodes Step Screen Display

Researchers prefer various methods and tools to collect data from experts. In this study; a decision making evaluation form is used as questionnaire. Pairwise comparisons of nodes are decided by participants with nine-point scale. Survey answer matrixes of these participants are calculated to obtain a single average matrix. In standard ANP methodology, alternatives are compared and best option is selected by evaluating the criteria. In this case, it considered like all factors are alternatives. For this reason, node comparisons are done for each factor point of view. This leads the model to have excessive number of matrix to fill. Participants are chosen from managers working in supply chain positions. After filling each matrix on ANP Solver and press “Save” button, system calculates the consistency index of the matrix. All consistency indexes are calculated lower than 0,1 which is appropriate to the limit consistency index value.

Limit matrix calculation is the last step of ANP. Importance values are obtained in this step. With the help of these importance values, ranking of the success factors is possible. Result of the limit matrix is shown in Table 6 in descending order.

Table 6: ANP Limit Matrix Results

Factor Definition	ANP Limit Matrix Value
Satisfy customer needs	0,072
Effective inventory management	0,067
Rapid confirmation of orders, customer complaints	0,063
Effective demand production balance	0,055
Real time planning	0,047
Delivery speed	0,043
Long term integration with suppliers	0,04
Total order cycle time	0,032
Strategic alliances and alliance performance	0,031
Information sharing	0,029
Effective use of MRP / ERP systems	0,029
Personalized solutions for customers	0,029
Logistics network design	0,025
Market share	0,023
Increased revenue from new technologies	0,022
Information transparency visibility sensitivity	0,021
Degree of innovativeness of R&D products	0,02
Supplier delivery performance	0,018
Contextualization of information	0,018
IT advancement	0,018
Relational stability consistency	0,017
The intensity of information technology connection	0,016
Perceived ROI	0,016
New customer sales	0,016
Managerial IT knowledge	0,015
Cost improvement	0,014
Top management support of IT	0,014
Collaboration between product designers	0,014
Interaction friendship trust between partners	0,013
Relational commitment loyalty between partners	0,012
Globalization (sourcing and selling)	0,011
IT alignment	0,011
# of customers	0,011
Inter-firm system integration	0,01
Information intensity (overall)	0,01
New product management	0,01
Supplier price compared with the market	0,01
Finished goods inventory turnover	0,01
Use of communication tools	0,01
Product quality	0,009
Work in process turnover and total asset turnover	0,009
Partner dependence	0,009
Flexibility of supplier	0,007
Effective use of internet	0,006
IT technical quality and infrastructure	0,005
Appropriability of information technologies	0,004
IT plan utilization	0,003
IT assimilation	0,003
Brand equity	0,001

RESULTS

According to DEMATEL findings, most outstanding factors belong to managerial cluster. Two major success factors, long term integration with suppliers and strategic alliances and alliance performance, have the biggest role in the model. Factor affection values can both have positive and negative values. Positive and negative values are distributed almost equally in our model. This finding shows that success factors have close values to each other. Even though there is not an absolute relationship between role and affection; nine most significant factors contain three affecting (positive) and six affected (negative) factors. Moreover, technical cluster has a tendency to affect other factors. %72,22 of technical factors (13 factors out of 18) have positive values. Managerial IT knowledge is the most influencing factor where strategic alliances and alliance performance is the most influenced factor in the model. It is found out that managerial elements such as skills, support or knowledge are the most important and outstanding subjects to be focused on for supply chain performance.

According to ANP findings, ranking of the success factors is done and “satisfy customer needs” is found out as the first factor with a weight of 0,072. Average weight of factors is calculated as 0,0203674. Managerial cluster has the major weight in the model with the value of 0,352. Business cluster has the weight 0,33 and technical cluster has the lowest weight with the value of 0,316. Weights of the clusters are very close to each other and success factors have close relationships due to the large number of factors and their importance.

Differentiation of clusters is not preferred although most outstanding factors belong to the managerial cluster. It proves that management issues are more dominant on supply chain performance. All elements of three clusters of model are significantly important and they are needed to be taken into consideration. Negligence of any cluster would cause various problems. Although technical quality or business success of a company is mostly focused on for performance analysis and enhancement, background and leading elements are included in managerial competencies. Without maintenance and support of management, in other words, with lack of management assets, performance of the entire supply chain cannot be analyzed, enhanced or reported effectively.

In this case study; two different ways are designated for sensitivity analysis. One of them uses DEMATEL analysis results in order to determine cluster importance values. Second sensitivity analysis observes the change of factor values affected by the change of cluster importance values.

In the basic case study calculation, importance values of three clusters in the model assumed equal. Sensitivity Analysis I is based on changing these values. Importance degrees of factors were valuated with a nine-point scale. For logical consistency, cluster importance degrees are valuated with the same scale. Lowest value (business cluster) assumed as 1. Meanwhile, Highest value (managerial) assumed as 9. In order to find out the scale point of middle value (technical), intervals are determined. Difference between lowest and highest divided to number of scale points and base difference value is obtained Results show a noticeable change in the ranking of the success factors. In original case study – which is done by considering factor importance values equal to each other – first ten success factors contain five managerial, two technical and three business elements. After changing the importance matrix of clusters to managerial > technical > business alignment; all of top ten factors become managerial factors.

In the case study calculations, weights of three clusters are assumed as equal. In order to apply a commonly preferred sensitivity analysis practice, managerial cluster weight is changed increasingly and factor weights are observed. According to the case study ANP results; sixteen of forty nine factors are above average. These factors are chosen by researcher to be observed during changes. With increasing values of managerial cluster; managerial factors are increased as it is expected. On the other hand; technical and business factors tend to decrease due to the changes. These interactions prove that model that is used in case study is sensitive to cluster importance changes.

CONCLUSION

Supply Chain Management plays a vital role in companies' lifespans. Dynamic nature of market leads firms to enhance their processes continuously. This enhancement cannot be successful without the help of information technology tools. IT tools have a wide range from small reporting software to comprehensive management systems.

Information technology point of view requires both managers and employees take part in the management process effectively. Similar to this, there are numerous factors that affect supply chain performance, effectiveness and success. Theoretical information about SCM, supply chain performance, information technologies and integration concept in supply chain are examined in the study. Success factors related to SC Performance are compiled from literature researches and
evaluated with the help of DEMATEL and ANP techniques. Factors are clustered into three categories: managerial, technical and business. Impact of factors on each other is evaluated and used in DEMATEL Affecting and affected factors are analyzed, factor alignments found out and influence map is drawn for better interpretation.

Cluster and node relationships are included in calculations by the help of ANP technique. ANP is mostly used for making decisions between alternatives. In this study, alternatives do not exist. Every node (criterion) is considered as an alternative success factor. Because of the fact that alternative evaluation is not preferred, elimination of alternatives (in this case: factors) is not required. ANP method is used for ranking factors and obtaining their weights from limit matrix. Cluster weights are considered equal for the case study. Sensitivity analysis is done with different cluster weights in order to check consistency and test the behavior of limit matrix according to weight change situations.

Limitation of the Study and Future Studies

Factor ranking and elimination are used in researches commonly. Qualitative or quantitative methods are used in order to eliminate some factors while excessive data makes interpretation complicated. In this study, factor ranking is used instead of factor elimination. Because of the fact that factors are obtained from previous researches – not obtained by questioning participant – elimination was not obligatory. For future research; it is recommended to broaden the survey area and found out more factors in order to make an elimination study. Moreover, sector or geographic area specification is also possible to focus on a specific subject. With the help of this limitation, more detailed interpretations can be acquired.

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EFFECTS OF PORT PRIVATIZATION PROCESS ON USERS: A CASE STUDY OF IZMIR PORT

Ismail Bilge Çetin[148], Gökçay Balcı[149], Soner Esmer[150]

Port privatization practices have been increasing worldwide including Turkey and governments started to undertake the roles of competition regulator, law legislator and controller rather than port operator. Private port enterprises operate the public ports through investments in infrastructure, superstructure, equipment, well-trained human resources and software which are necessitated by the competition environment in port industry. Port privatization process in Turkey started in the second half of 1990 particularly for small and medium size public ports. Privatization process of large sized public ports operated by Turkish State Railway started in 2000s and majority of these processes accomplished successfully. However, privatization process of Izmir Port was not finalized and necessary investments needed to fulfill requirements of port users were not performed since the privatization decision. This discusses the effects of port privatization process on users and touches upon the problems that Izmir Port users experience due to failure of privatization. In this sense, the purpose of this study is to evaluate port privatization applications in Turkey and investigate the results of accomplished and unaccomplished examples. The paper is a descriptive study that applies qualitative research methods. The application was performed in the sample of Izmir Port users.

Keywords: Port privatization, Izmir Port, container terminal, shipping lines

INTRODUCTION

The importance of ports for the development of a region is significant as it contributes to economic wealth by acceleration of international trade, exploiting economies of scale, creating jobs, providing more consumer choice and increasing foreign currency income. As the global competition continues to escalate, the role of ports have become even more important by not only playing as a node between the sea and land but also logistics centers where value is created for port users [1]. Thanks to containerization, ports also became a part of supply chain system and integrated with inland distribution centers [2].

Taking this vital role of ports into account, ports should be managed efficiently with contemporarily necessary investments not only because their own competitiveness but also competitiveness of their users [3]. Accordingly, governments have been privatizing the public ports for various reasons with different methods. Motivations and expected advantages of governments for port privatization vary but the most prevalent motivations, also indicated by Privatization Administration of Republic of Turkey (2015), are: minimizing state involvement in the industrial and commercial activities in the economy, creating an environment for free enterprise, decreasing financial burden of the state, generating revenue, strengthening the capital markets and providing efficiency. Baird [4] studied privatization trends of top 100 container ports by survey research and found the most common aims of privatization respectively: increasing efficiency and lowering costs, expanding trade, reducing the cost of public sector, obtaining management know-how and other reasons such as speed of developing new terminals, increasing port revenue and developing public-private relationship.

Several forms of port privatization exist that public and private bodies undertake different responsibilities. Understanding the type of ports and responsibilities of parties under each type prior to mention privatization forms is useful. Four types of port administration models exist and summary of Brooks [5] explains the responsibilities of public and private ports for each type of model as in Table 1 [3].

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Table 1 Allocation of responsibilities of ports

Responsibilities	Service	Tool	Landlord	Private
Infrastructure	Public	Public	Public	Private
Superstructure	Public	Public	Private	Private
Port labor	Public	Private	Private	Private
Other functions	Majority public	Mixed	Mixed	Majority private

Source: [5].

The responsibilities shift from public port administration to private administration as it goes from service to private ports. Baird [4] found that 63% of port believes public sector should create basic infrastructure, 46% believes regulation and safety should be provided by public while 42 % thinks public port authority should ensure fair competition and pricing.

As for privatization forms, several types exist in the literature but a recent comprehensive list was created by Pagano, Wang [6]. Pagano et al. described 6 privatization forms as shown in the Table 2.

Table 2 Privatization approaches

Type	Definition
Pure public	The public sector owns and operates the port
Landowner and regulator	The public sector owns the port and regulates the private sector. Private operator becomes the tenant of the port
Built-operate-transfer (BOT)	The port is built, operated, financed and the delivered to public after an agreed period. It is called as “Greenfield concession”.
Long lease of existing facility	It is the concession of existing facilities to a private company for agreed period. It is called as “Brownfield concession”.
Pure private	The private sector builds, owns and operates the port or public sector sells an existing port to private sector.
Publicization	Opposite of privatization. The public sector becomes involved in the facilities of private port.

Source: Adapted from [6].

Though existence of studies related to objectives, expected benefits and forms of port privatization, several authors investigated if port privatization is as beneficial as it is envisaged. Different opinions and research results appear in the literature. Cullinane, Song [7] found that supporting that shift of ownership from public to private sector improves economic efficiency of Asian ports. Cullinane and Song [8] indicated that private involvement in container terminals in Korea increases the productive efficiency. Results of Tongzon and Heng [9] stated that private sector participation in the port industry can partially improve port operation efficiency that increases port competitiveness. Wang, Knox [3] found that private sector participation in port industry positively affects port efficiency regarding its financial performance.

Despite the papers supporting positive sides of private participation in port industry, opponent researches appear as well. Saundry and Turnbull [10] argued that improvement regarding service to port users come from deregulation of employment rather than port privatization. They indicated only very little relation between privatization and competitiveness exists. They considered port privatization in the UK as private profit, public loss. Cullinane and Song [11] objected the argument that privatization of ports brings economic efficiency and improvement in financial and operational performance. They concluded that port privatization has little impact on port performance and efficiency but geographical location and deregulation instead has more impact while indicating the difficulty of measuring the benefits of port privatization. Cullinane, Ji [12] concluded in their study that there is no relation between private sector participation and improvement in efficiency of container ports.

In summary, governments might have different motives, methods and expected results from port privatization. Some of academics found port privatization applications to be rewarding while others questioned the benefits of privatization results. Port privatization process can be quite prolonged until the process is accomplished or, in some cases, failure of privatization. The purpose of this study is to investigate the effects of prolonging process of port privatization on port users. Unsuccessful privatization process of Izmir Port is used as a case study in this study.

PORT GOVERNENCE IN TURKEY

There are currently 178 ports in Turkey stretching along its coastal line of around 8,333 kilometers. 26 of them are governed by public bodies and 152 of them are operated by private companies Among the public ports 9 of them are operated by Turkish Maritime Organization (TMO), 2 of them are operated by Turkish State Railways (TSR) and 13 of them belong to municipalities and state affiliates [13].

From the historical point of view, port governance in Turkey can be classified into three main periods: a nationalization period, a period of both public and private port operations and most recently a privatization period during which the governments withdrawing from port operations. However, from the administrative point of view, the existing ports in Turkey are classified into four groups: public, municipal, affiliated and privately owned ports. Municipal ports in Turkey can be considered as negligible. They do not play an important role in the overall marine transportation of Turkey because of their low share of cargo throughput. Figure 1. shows the major ports and port areas in Turkey [14].

Figure 1. Location of the main ports in Turkey

Affiliated ports are owned and operated by either large state-owned or private industrial companies and these ports usually serve the tramp and bulk market. Privately owned ports; most of these primarily handle their own cargoes but serve other customers. Private ports have specialized terminal operations that usually serve the bulk and tramp market. Some are occupied with the liner market by serving containerized cargo. The private ports/terminals are in a rather competitive position compared with publicly operated ports. Generally, they prefer to specialize and operate more efficiently. The decision-making process in private ports is much quicker and more efficient at investing, especially in cargo handling equipment. The management style of private port sector has minimized internal bureaucracy.

PORT PRIVATIZATION IMPLEMENTATIONS IN TURKEY

In Turkey port privatization implementations started in 1994. The first privatized ports are operated by TMD (Turkish Maritime Directorate) that owns 20 ports. Since 1994, 13 ports have been privatized by transferring the operation rights to private enterprises, while Gulluk, Gokceada, Canakkale, Lapseki, Istanbul and Kabatepe Ports are further operated by TMD. TCDD (Turkish Republic State Railways) has 7 ports. Five of them are privatized by Privatization High Council.

Port Privatization Process at Izmir Port

The port was included in the process of privatization on December 30, 2004. Tender announcement was published on 04 January 2006 and the tender was completed in May 3, 2007. Privatization High Council had approved the tender on July 3, 2007. In accordance with the related laws (Constitution Law, Privatisation Law) the final draft of the Concession Agreement submitted to the opinion of the Council of State after being initialed by the parties.

In order to cancel the tender The Union of Ports and KIGEM (NGO) brought the tender to the Court. The Council of State 13th Department had rejected a motion for a stay of execution in February 2008. In 2009 Council of State is decided to the execution of the tender and sent its opinion about the Concession Agreement. After receiving the Council of State’s decision about Concession Agreement, The Consortium which consists of Global Investment Holding-Hutchison- Aegean Exporters Unions Port Services Inc. (LIMAŞ), was invited to sign a contract in November 2009. According to the Tender Specifications, 50 % of concession value which is USD. 1.275 billion would be paid at signing the contract. 25 % of the payment would be made latest 1 year from the contract date. Remaining 25 % would be made latest at the end of second year from the contract date. Unfortunately the Consortium is refrained from signing the agreement than his Bid Bonds is forfeited in favor of the Privatization Administration (PA) [15].

According to the Tender Specifications, the second bidder namely Celebi Holding which offered USD 1.270 billion has been invited to sign the agreement. However, due to the economical crises and difficulty in obtaining finance, second bidder also refrained from signing the agreement. Finally, since both first and second bidders refrained from signing the agreement, tender had been cancelled.

METHODOLOGY

Profile of Port of Izmir

Port of İzmir is located in the west coast of Turkey (See Figure 1). İzmir is the third largely populated city and the business centre of Turkey. The port has a wide agricultural and industrial hinterland. The port of İzmir, which is the agriculture and industry port of Aegean Region, has a vital importance for the exportation of Turkey. The port serves customers to handle every kind of cargoes and the port expansion studies are in progress. Also the port has connections to both rail and highway networks [16].

The port in Izmir was constracted in 1875 and the right to operate the port was exclusively granted to M.R. Gifre, a French company. The break water construction was completed by this same company in 1877. The construction of Port of Izmir was started in 1995, and the first part was completed in 1959. Various means of sub constructions at the port were then carried on. The port can offer port services to dry and liquid bulk cargoes, general cargoes, containers and passengers. Port of Izmir is both owned and operated by TSR (Turkish State Railways) [16].

Capacity of the container mole is 11.000 TEUs. The depth of the port changes from -7m. to -13m. The potential capacity of the port is 11,000,000 tons/year [16]. Container handling operations at the port are carried such TSR owned equipments as 5 gantry cranes of 40 tons, 2 mobile cranes of 100 tons, 10 rubber tired transtrainer of 40 tons, 15 full container forklifts of 25-42 tons, 14 empty container forklifts of 8-10 tons. Besides, such other equipments are also available at the port as 7 berth cranes of 3-25 tons, 12 mobile cranes of 5-25 tons, 21 short masted forklifts and 35 tractor trucks. Furthermore, the port has got proper reefer panels for for reefered containers. The capacity of the container washing structure is 20 TEU/day. Moreover, there are two mobile gantry cranes owned by a private company and one floating crane with 100 tons of capacity. The port also has got two concreted silos with a total capacity of 70.000 tons, which belong to TMO, and a conveyor system connected with the berth [16]; [17].

Primary Data Collection Method

The paper is a descriptive study that applies qualitative research methods. The application was performed in the sample of Izmir Port users. Semi-structured interviews were carried out with industry experts for data collection since it is ideal to have deeper insight of a situation [18]. The interviewees include liner agents, representatives of Chamber of Shipping, one port manager and one academician. The interviews have been realized at the offices of interviewees. The Interviews with each interviewee took approximately 1 hour and all speeches got type- recorded. After interviewing with 14 participants, the interview got stopped since similar answers were taken from them. The details of the interviewees are given at Table 1.

Table 1. The Details of the Interviewees

Title of Interviewees	**Company**	**Representative of :**
Vice Manager	Port of Izmir	Representative of Port of Izmir
General manager	Liner Agency 1	Representative of 1 Liner Shipping Company
Manager of the company	Liner Agency 2	Representative of 3 Liner Shipping Companies
Export Department Manager Import Department Manager Operation Department Manager	Liner Agency 3	Representative of 1 Liner Shipping Company
Export Department Manager	Liner Agency 4	Representative of 1 Liner Shipping Company
General manager Export Department Manager Import Department Manager	Liner Agency 5	Representative of 1 Liner Shipping Company
Export Department Manager	Liner Agency 6	Representative of 1 Liner Shipping Company
President	Chamber of Shipping Izmir Branch	Chamber of Shipping Turkey
Consultant (Ex-General Manager Turkish Maritime Organization for Aegean Region)	Chamber of Shipping Izmir Branch	Chamber of Shipping Turkey
Academician	Dokuz Eylul University Maritime Faculty	Dokuz Eylul University

RESEARCH FINDINGS

In this study, the effects of the privatization process on the port users are analyzed in two parts. The first part covers the period from the point of involving the port within the privatization process and holding an auction to the point of the failure encountered on the auction. The second part comprises the period beginning with the date of auction upto the present situation.

Pre Auction Period at the Port of Izmir

At the pre-auction period, the globalization has led to an increase in the trade volume all over the world. This increase has brought about a rise in the quantity of the cargoes handled at the Port. Such a rise in the quantity has resulted in that the infrastructure and the equipments available at the port have gone short, which has eventually caused the problem of congestion.

Management and Personnel

Since the port is state-owned, the port managers are appointed by the state. The managers try to carry out their duties dictated by and in compliance with the relevant regulations. Bureaucratic structure of state prevents the managers from being elastic in their actions, making independent decisions and acting as a businessman. Their authoritative power of acting on their initiative has been restricted, which in return makes it difficult for the managers to act professionally and work customer-oriented. As a consequence, the problems are not handled in time, which lengthens the time for solutions.

Before starting the settlement process, approvals from several authorities are required. Not responding to the port related problems in due time negatively affects the productivity of the port. For instance, in case of crane defects, the required spare parts are not provided on due time, because auctions are to be held prior to purchasing them. This obligation lengthens the ship operation periods. Besides, being stated owned prevents the port from putting forward reflex actions to correct itself. Moreover, the fact that the financial sources devoted to the port is rather inadequate, delays investments for repairs and maintenance, such delays, of course, do limit the performance of the managers.

Due to the failure in privatization, the state has decided to invest in the port and allocate certain amount of sources for this investment, which has enabled the managers to work in a more idealistic manner. Regarding to the daily operations, the level of bureaucracy at the Port was not found to be significant.

A shortage of personnel is suffered at the port. There is a shortage of port machine operators, particularly for cranes. This shortage makes certain operations that the port itself is supposed to carry out to get transferred to certain ship agents. In order to compensate the gap in number required, some of the personnel working at the privatized ports have been transferred to the Port of İzmir. The fact, however, that these newly transferred staff is not familiar with and experienced in the cranes operated at the Port makes it difficult to get the desired efficiency from this transfer.

There is some staff qualified and trained for repair and maintenance. These are, however, very few in number and cannot afford to cover all tasks required. As the repair-maintenance requirements are not responded to on due time, such delays bring about certain serious defects on the cranes. Besides, due to the deficiency/shortage of the required staff, the gangs cannot be provided.

There are three shifts for loading and discharging but there are two shifts for container stuffing operations within the port? The latter must be raised to three. Besides, the shifts do not have enough number of employees. When the port was operated by TDI, It was possible to employ workers for temporary terms. This system is not used now. The workers from the privatized ports are transferred but the personnel is not productive. The shifts are started late and ended early. The management has been taking measures to start and end the shifts on due time.

The port tariffs are relatively high, compared to those of the Nemrut ports. The tariffs are unchangeable. Nemrut ports and other private ports have a chance of bargaining. They have longer storage periods, lower storage fees and certain demurrage advantages. Besides, the free time for stowage of containers is high.

Infrastructure and Superstructure

The most important problem related with the infrastructure is the drafts. The insufficient drafts prevent big ships from entering the port. The call of the large scaled ships gets restricted, which hinders the port from being a hub port in the region. Those ships with drafts of over 10 m. are not able to enter the port. It is impossible for ships 3500-4000 TEU to enter the port. The ports at Nemrut Bay, on the other hand, have no draft problems, and they can host big ships.

The port started operations in 1954 with general cargo handling, and since 1980 container handling has accelerated. The berths previously devoted the general cargo handling were later converted to be container berths. Then, the capacities of the cranes thought to be used at these berths were considered, but the weights of the container gantry cranes were found too much for the berths, and consequently the berths were strengthened and 2 light type cranes were bought. The number of gantry cranes has, now, reached to 5. In addition to 5 cranes; there are other 2 mobile cranes, which belongs to a shipping agency, used in container handling at the Port.

The port area is not sufficient, but it is possible to enlarge the area. The existing area is 500,000 sqm., which could be enlarged up to 1,000,000 sqm. It is one of the largest ports in Turkey. But there exists a problem of concreteness of container yards. The insufficient container stock yard has now set a serious problem. The concern is the same with container stuffing areas as well as the CFS. The fact that the container stocking areas are inadequate, has often being causing the containers to get moved within the container stock yard, which has been resulting in even the loss of containers within the port. Finding the lost containers are costly and time consuming. A sort of confusion has been suffered at the storage operations at container stock yard.

The lengths of the berths are not satisfactory. There are 3 gantry cranes at one berth; however only 2 ships can berth due to the large sizes of the ships, and third gantry has to stay idle. The state (government) has decided to lengthen and thus convert the bulk cargo berths into container handling berths. The insufficient berth number for container ships has caused these ships to wait at anchorage.

The approach channel is to be dredged. In order to offer effective services, the port has to have a draft of around -14,5 m. the ships with a draft over 11m. are not able to call the port or they call it half empty. That is why mother ships have shifted their call to Nemrut ports, which has caused Izmir to lose 240,000 TEU per year. Some liner companies do want to bring their ships to the port, which is however, impossible.The capacity, which is 1.6 mil. TEU, is satisfactory and now 900.000 TEU is handled. The capacity could be raised to to 2.5 mil TEU. When dreging is carried out, the capacity will stay short.The port has no serious problems regarding to superstructure, but the existing structures are old and not well maintained.

Equipment

At present, the port has got 5 gantry cranes and 2 agent-owned mobile cranes. The container handling equipments; however, are old and insufficient. Certain difficulties have been encountered in container loading and discharging operations. The operations are restricted by the height and the access capacity of the cranes, It is impossible to handle the containers of big ships. Rather often crane breakdown problems are suffered at the port. The gantry cranes are taken to maintenance one by one in turn. When the repairs and maintenance are not provided in due time because of the heavy load of work (operations), serious breakdown problems are suffered with cranes. Delays in purchasing the repair and maintenance related separe parts urgently required are suffered due to the strict bureaucratic stages at state owned industries.

Since some shipping lines abandoned İzmir Port due the problems encountered at the port and started calling newly opened Nemrut Bay based two container terminals which are privately owned and only 60 miles away from Izmir Port, the number of the ships calling the port has decreased and at present no serious gantry crane related problems are encountered. Besides, following the failure of privatization movements, the state has decided to to buy 2 new mobile cranes. There are certain problems with transtrainers as well. Forklifts and toplifts are not effective enough. The agents are using their own equipments in handling their cargoes in container yards.

Port Operations

Because the cargo handling equipments are over aged and there is a shortage of personnel, productivity at the ports is rather low. For example, in terms of container handling, the productivity at Port of İzmir is 15 TEU/hour whereas it is 40 TEU/hour at Nemrut Bay.

One of the lines that have abandoned Port of Izmir states that an operation of their 400 containers is now completed in 8 hours at Nemrut based ports and that the same operation used to take 24 hours at Port of İzmir. Such a low productivity has caused congestion at the port and some lines shifted to Nemrut Bay. Thanks to this shift, the congestion has lessened.

In terms of stowing and stuffing, productivity at CFS is not at the desired level. The equipments are over aged, but no new equipments are bought. The container stuffing areas are not sufficient; which has caused the CFS to have shifted to the private container depots outside the port. There is an intense vehicle traffic within the port. Certain problems are encountered at port entry and exit gates. There is no traffic design at the port. The truck and vehicle traffic within the port is rather too densed. This intensity has been worsened by the vehicles both at the berth and the container stuffing stations. There is no parking area at the port for long vehicles.

As some of the container stuffing activities has been moved out of the port and some of the lines have shifted to Nemrut Bay, the traffic within the port has relatively lessened. When the independent highway connections, exclusively for port entries and exits are completed, the traffic within the port is expected to get relatively lessened.There is no insurance for the damages made on cargoes. In the past there used to be such an insurance which is no more available. Certain small scale damages given to the containers are corrected at the port, but big scale ones corrections can not be made at the port. The shipowner himself has such corrections made. Damages given to the cargoes at the port are not covered by the port. In case of cargo damages, the port does not get any storage fee for the damaged cargoes.

The effects of delays suffered at customs. Customs declarations are not issued on time, which delays the relevant ship operations. No problems related with police, customs security and sanitary offices services have been encountered. No problems exist with concerning the auxiliary port services in such port services as providing procurement and spare parts and etc. The cheapest water is offered at this port. No gas oil, but fuel oil can be supplied. Gas oil is provided at Nemrut Bay.

Hinterland connection

The port has a connection with the hinterland through railway, but is not used effectively. Only 2 % of the containers handled at the port are transported via railway. Using the railway at present is rather costly and difficult to utilize. Besides, container loading and discharging area at the port is not sufficient.The highway connection with the hinterland is quite good and with further highway connections to the port, the overall highway connections are thought to get smooter. These connections will help both the port traffic and city traffic get further smooth and at ease. In terms of being close to the hinterland, Port of Izmir’s location is more convenient than of Nemrut Bay ports, but it creates traffic congestion.

Automation

There is a lack of automation system and software which could accelerate the operations. Tracking and tracing containers within the port carried out manually. An automation system for such operations is not available yet. Hence, this process is inefficient and the speed is too low. There is no chance at the port for tracking containers. Problems at locating containers are encountered, which causes loss of containers within the port and hence the time consuming search for the lost containers. Planned stowage of containers get difficult; containers movements increase and the land can not be utilized effectively.All the discharged containers are to be reported to the customs office at the port. An automation system would do this reporting quite rapidly. Therefore, the demurrage and stowage cost would decrease and the importer would release his/her cargoes in a short time rapidly. It should be noted that at the entrance of the port, there exists a car/vehicle tracking system.

Failure of the first Auction and the Post Auction Period Investment Plans of the State for the Port of Izmir

In the post-privatization period, the government will realize an investment of USD. 300 – 350 millions. With this investment, certain new equipments will be provided and 2 new mobile will be bought. Besides, the old cranes available at the port will be revised and the total number of the cranes will reach at 9.

There are new berth plans aiming to increase the capacity of the port. The berth which is used to serve bulk cargoes will be converted into a container berth. Furthermore, the idle warehouses within the port have been removed and will be used as open container stock yard. Moreover, the old stabilized lands will be concreted and a land of 50,000 sqm. will be gained. Besides, the highway connections will be activated and hence the trucks will not get involved in the city traffic while exiting the port.

The port will be parted into two, one of which for cruise and the other for container terminals. Certain new regulations/reforming will be realized within the port and some new stocking areas will be gained. A new container terminal automation system will be established. The traffic flow and the container tracking operations will get more effective. Even if the port is not privatized.it will get more effective.

The overall contents of the strategic plan drawn for the port as follows:

Urgent plan
A process of reprojects will get set (initiated)

- The broken down cranes will get repaired
- Two new cranes will get bought
- The personnel will get supported by the transfer of new qualified personnel from the ports of Bandırma and Samsun
- Liquid and bulk cargoes handling operations will disappear
- The areas needed will get concreted and lauded with asphalt
- The lightening system will get revised
- Petrol station, bilge water and water purification will be moved

Short term plan
The incomplete highway connections will get completed to the access the port

- The roads within the port will get rearranged
- The existing filled terminal area which is not concreted will get concreted
- All the departments /units will provide on-line services/ get computerized
- The computer infrastructure will get managed from one top center

Midterm plan

- The sea bed will get dredged to deepen the Gulf
- New cruise pier, passenger hall and berths will get established/built through auctioning and build-operate-transfer system.
- Two new cruise piers will get built

Post Auction period at the Port of Izmir

The process of privatization

Since the failure of first auction attempt which is in 2010, the port has still been subject to the process of privatization. The process has been planned to privatize the port in two distinct parts as cargoes and cruise shipping rather than privatizing it as a whole at once. There has been held no auction so far regarding this privatization. The state seems to be unwilling to make investments due to this privatization process unless some urgent needs are unavoidable. For example, the request from the port management for converting the warehouses at cruise ships berths into a passenger lounge with certain decent shopping centers has been declined. Attributing this decline to the process of privatization.

Infrastructure and superstructure

The quays and the approaching channels at the port have not been dredged, for which the results of the Environmental Impact Assessment reports have not been released yet. When the results are released, the approaching channels will get dredged up to a width 250 m. and depth of 14 m. The quays will get pushed away of 40 m. so that they could have further depths. In addition to dredging, the gulf will get provided with a water – circulation channel. No new quays have been constructed at the port. But a dry bulk cargo quay, which had been partially constructed with piles driven, has been completed. This newly completed quay has been used for dry bulkers as well as containerships when needed. Additionally, the fenders at the quays where general cargo ships approach are being renewed. The port has been linked directly to the highways through interrects.

The container stocking area has been enlarged and concreted. The staffing activities have been shifted to the cement covered areas. There has been no increase in the CFS areas but a decrease of around 4000 m2. A center has been established where the solid and liquid wastes taken from ships are stored.

Cargo Handling Equipment

There mobile cranes have been bought to serve at the port. All of the five existing gantry cranes have been revised. Two mobile cranes have been hired. 8 tractors and 4 RTG have been purchased.

Port Automation

Automation at port is about to have been completed. Nevertheless, some physical and operational problems are suffered. Hence, some of the modules at the automation system have been cancelled.

Problems faced by the port users

At post auction period some problems are suffered by the port users. The congestion problem was solved but in this period the first problem container lines encountered was the insufficient draft and second problem was the low amount of container handling at the quay. The average number of containers handled by one crane is 15. This low capacity is attributed to such basic factors; despite the enough number of cranes available at the port, there has been a shortage of the number of the crane operators; the cranes can not be operated effectively enough; and the number truck available between apron and the container yard is not enough; which results in unnecessary increase in the time of operations and causing ships to wait the port for long periods; and as a result of all problems, ships waste time and ship operating costs increase. On the other hand, however certain efforts are observed that aim to compensate this loss through increasing the number of gangs at the ports.

As a consequence of the problems highlighted above, 14 container lines shifted to the ports at the Nemrut Bay, being encourage to do so by such basic reasons as deep drafts, high handling capacities, relatively appropriate tariffs, distance and bunker cost advantages (these ports are located at a 50 km away from Port of Izmir), cost advantages due to relatively fast handling and the lower time ships wait at the ports.

The overall picture at present reveals that 55% of the Aegean cargoes are handled at Port of Izmir and 45% to are handled at the Ports of Nemrut. The exporters are willing to pay for the transport costs from Izmir to Nemrut, but the importers at present encounter some customs-related problems, which results in longer period of import releases and higher costs.

CONCLUSIONS

Port privatization practices have been increasing worldwide including Turkey and governments started to undertake the roles of competition regulator, law legislator and controller rather than port operator. Governments have been privatizing the public ports for various reasons with different methods. Motivations and expected advantages of governments for port privatization vary but the most prevalent motivations are: minimizing state involvement in the industrial and commercial activities in the economy, creating an environment for free enterprise, decreasing financial burden of the state, generating revenue, strengthening the capital markets and providing efficiency. Private port enterprises operate the public ports through investments in infrastructure, superstructure, equipment, well-trained human resources and software which are necessitated by the competition environment in port industry.

Port privatization process in Turkey started in the second half of 1990 particularly for small and medium size public ports. Privatization process of large sized public ports operated by Turkish State Railway started in 2000s and majority of these processes accomplished successfully. Port of Izmir operated by Turkish State Railway was included in the process of privatization on December 30. Although the first auction was not successful, the port is still under privatization process. Since the port has been placed under privatization process, the port users have been effected negatively from the process. The Ministry of Transport, Maritime Affairs and Communications has adopted the required regulations and not included the port within the state investment plan. Until recently no investments have been made. The financial loss of the TCDD has been met from the profits of the port, but due to the expectations concerning the privatization movements, the required investments have been delayed. The government thus set reactive approaches rather than proactive actions. As a result, The state did not dredged the approach channel, did not buy new cranes or repaired the broken ones on time, did not buy new trucks, did not enlarge the container stock yard, did not build new berths and the efficiency of gantry cranes is rather low. As a result, congestion occurred at the port. Several container ships waited at anchor for several days. They lost time, customer and money and they decided to quit Port of Izmir and start calling Nemrut Bay container terminals.

After the failure of the first auction, the port is still under privatization process and the state has made some investment related with infrastructure, equipment and container yard but 14 container lines and 45 % of Izmir Port's Cargo has shifted to Nemrut Bay by such basic reasons as deep drafts, high handling capacities, relatively appropriate tariffs, distance and bunker cost advantages.

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CONTAINER TERMINAL PRODUCTIVITY AND AN APPLICATION WITH OBJECTIVE MATRIX METHOD

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Abstract − *In a supply chain or logistic system ports are one of the important places that connects sea route transportation to other modes. Ports main aim is handling by the best possible way and in the shortest time and providing service to all other customers completely. Nowadays, most of the transportation is done by containers, because of convenience at loading and unloading phases, ease of transportation, and cost advantage. Within a port specific facilities, technic and operating models for specific cargo traffic exist and these sup parts of ports are called terminals. Container terminals have an important position at ports performance assessment. Objective matrix method evaluates weights of different performance indicators to get an overall performance indicator. This approach is based on some fundamentals which are study conductors have the knowledge of factors that influence performance and mostly conductors determine performance indicators. Objective Matrix method is used to determine Antalya Port which is located at Mediterranean Sea container terminals productivity.*

Key Words - *Container Terminal, Productivity, Objective Matrix Method*

INTRODUCTION

Today at all around the World and in Turkey nearly 90 percent of the trade is done by sea route. One of reason of this situation is world's three out of four surface is awash by water. Another reason is maritime transport 6-7 times cheaper than road transport, 3-4 times cheaper than railway transport. In addition, maritime transport is suitable to transport at a tremendous rate of loads at one time in a secure way [1]. When it is take into consideration that maritime transportation dominates world trade, ports importance emerge. Because, ports are the start and finish points of maritime transportation. Ports are found where sea, land and railways' crucial intersection points. At these points large scale of goods and/or humans are distributed from maritime transportation vehicles with the help of land transportation means in smaller scales and vice versa is used for maritime distribution [2].

Whole transportation services will be affected positively when the services at ports are run efficiently; and vice versa when the services are not run well enough, whole system will affected negatively. With regard to this situation, it is clear that port services can be offered smoothly by using port facilities efficiently [3]. In ports some areas are separated for specific loads to serve particular load traffic purpose, these sub segments have technic and business models and they are called terminals. At ports terminals consist of some sub stations like;

- Vessel unloading; vessel loading docks,
- Areas that load traffic is keep waited for a while,
- Land docks that are unloading and loading areas for land vehicles
- Areas of handling of container traffic, movement and areas for transportation of containers [4].

Today because of easiness of loading/unloading, great ease of transportation and minimization of port transportation costs, most of transportation is done by containers. In this circumstances, at ports for container

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terminals according to necessities of particular load traffic specific facilities in other words ports or ports with sub divisions with technic and business models are arise. Simply, container terminals can be defined as terminals where handling operations of containers which are came with vessels or came to be loaded to vessels [5].
Since major amount of sea way loads are transported by containers, it is revealed that how much important that the container terminals are. Because of this reason, ports' container handling efficiency evaluation and determining low efficient ports in order to provide effective solution are vital.

Container Terminal Productivity

Productivity is one of the key terms which can solve the most major problem, economic problems. It stands for sources usage to what extend effective and efficient. In the most general sense productivity is defined as produced products/services (outputs) are divided by consumed goods or services (inputs) that are used for the purpose of producing the outputs during a given time. Output and input can be defined differently according to purpose of productivity measurement as well as production process of produced product/service [6].
The basic function of a container terminal is the transfer and storage of containers. Terminal operators are accordingly concerned with maximizing operational productivity as containers are handled at the berth and in the marshalling yards, and with efficiently utilizing available ground space. Container handling productivity is directly related to the transfer functions of a container terminal, including the number and movement rate of quayside container cranes, the use of yard equipment, and the productivity of workers employed in waterside, landside, and gate operations.The efficient use of available ground space relates to the number of containers stored in a given area of the terminal. Improving the utilization of ground space typically reduces the operational accessibility to containers; that is, ground space utilization and container accessibility are inversely related. The challenge is therefore to define container accessibility in relation to ground space utilization based on a terminal's operational targets and unique physical characteristics [7].

Table 1. Common Productivity Measures of Container Terminals

Element of Terminal	Productivity Measurement	Measure
Crane	Crane Utilization Crane Productivity	TEUs/year per Crane Moves per Crane-Hour
Berth	Berth Utilization Service Time	Vessels/year per Berth Vessel Service time (hrs.)
Yard	Land Utilization Storage Productivity	TEUs/per Gross Acre TEUs/Storage Acre
Gate	Gate Throughput Truck Turnaround Time	Containers/hour/lane Truck Time in Terminal
Gang	Labor Productivity	Number of Moves/Man-hour

Source: [7]
Container terminals productivity measurements van be seen at Table 1.

Objective Matrix Method

Numerous original applications of OMAX in a variety of contexts are associated with the work of the late James L. Riggs, founder and first director of the Oregon Productivity Center in the early 1980s. Since then, additional applications have been carried out or suggested by others, including Carl Thor at the American Productivity and Quality Center, John Parsons at the National Productivity Institute in South Africa, and elsewhere [8].
Different names, such as objectives matrix (OMAX), productivity matrix, multi-criteria performance measurement technique (MCP/PMT), importance-performance matrix and interpretations of matrix method have been used in the past. An early application of the matrix method was carried out by Riggs (1986). Measurement framework has been applied in manufacturing industries, services and public organizations [8].
According to Rantanen and Holtari (1999), the matrix method of performance measurement is one of the most popularly used alongside balanced performance measurement frameworks such as the Balanced Scorecard [9].
Determination of measurement objectives is the first step like the general productivity analysis approach. Then, it is necessary to determine appropriate criteria for each objective. After determining the two main stages, it is important to get managers' idea about objectives and criteria. Because the part of computation will be started after this stage of the model. After approval of management, scale and weights of these criteria will

be determined. Then, as a result of the calculations, the total productivity index can be obtained. Flow chart for the model is shown in Table 2 [10].

Table 2. OMAX (Objective Matrix) Model

1.	Determination of Measurement of Objectives
2.	Determination of Appropriate Criteria for Each Objective
3.	Presentation of Criteria to Managers
4.	Determination of Scale Related to the Criteria
5.	Determination of Weights Related to the Criteria
6	Calculation of Performance Results Related to the Criteria
7.	Finding the Scores from the Scale
8.	Determination of Weighted Values
9.	Calculation of the Total Productivity Index

APPLICATION

The Objective Matrix method is used in this study to measure the productivity of Antalya Port. In addition to measures which are available in literature four new criteria are determined. These criteria are:

Dock Productivity:
Criteria 1

$$\frac{\text{Going and coming containers from vessels number (Shifting containers inclusive)}}{\text{Total time period of the vessel at dock}}$$

Crane Productivity:
Criteria 2

$$\frac{\text{Going and coming containers from vessels number (Shifting containers inclusive)}}{\text{Gross crane working time}}$$

Total Field Capacity
Criteria 3

$$\begin{array}{c} \text{Total crossing time X Stowage layer height mean X 365} \\ \hline \text{Mean time of containers life cycle at port X Seasonal production peak factor} \\ \hline \text{Weekly inventory peak factor} \end{array}$$

Mean Time of a Veichle At Port
Criteria 4

Total time of vehicles that came to port to take containers or came to discharge containers. It is the mean time between the entrance to terminal borders and leave of the vehicle.

Common objectives of carrier and terminal operator during the container handling processes for Criteria 1 and Criteria 2.

Carrier	**Terminal Operator**
During arrival berthing	Coordinated and scheduled arrivals
Maximizing the productivity of vessels	Maximizing port productivity
Minimizing the time that spend at ports	Minimizing dock occupancy

Carrier demands vessels to spend minimum time at ports as much as possible. Same aim is also shared by the terminal operators, so that they can serve more handling capacity to other vessels too. In this context, increased capacity of dock and cranes will result in decreases of vessels' demurrage. Lower demurrage will result in both higher customer satisfaction and at the same time increased productivity. With the help of this situation container terminal will be more competitive than competitors.

Antalya Port's 2012, 2013 and 2014 data are used for the application of this method for these criteria. Results are shown at Table 3, Table 4, and Table 5.

Table 3. Antalya Port's 2012 Container Productivity

2012	**Berth Productivity**	**Crane Productivity**	**Yard Productivity (CY Capacity)**	**Gate Productivity (Truck Turnover Around Time)**	Productivity Criteria
	27,23	14,90	187.055	20,00	Performance
					Performance Scale
Scores	46,00	20,00	350.000	16,00	10
	43,50	19,30	325.000	17,00	9
	41,00	18,60	300.000	18,00	8
	38,50	17,90	275.000	19,00	7
	36,00	17,20	250.000	20,00	6
	46,00	20,00	350.000	16,00	5
	43,50	19,30	325.000	17,00	4
	41,00	18,60	300.000	18,00	3
	38,50	17,90	275.000	19,00	2
	36,00	17,20	250.000	20,00	1
	33,50	16,50	225.000	21,00	0
	2	3	3	6	Score
	25	25	40	10	Weight
	50	75	120	60	Value
				305	Total Productivity Index

Table 4. Antalya Port's 2013 Container Productivity

2013	**Berth Productivity**	**Crane Productivity**	**Yard Productivity (CY Capacity)**	**Gate Productivity (Truck Turnover Around Time)**	Productivity Criteria
	28,61	15,90	222.296	22,00	Performance
					Performance Scale
Scores	47,50	22,20	350.000	15,00	10
	45,00	21,38	325.000	16,00	9
	42,50	20,56	300.000	17,00	8
	40,00	19,74	275.000	18,00	7
	37,50	18,92	250.000	19,00	6
	35,00	18,10	225.000	20,00	5
	32,50	17,28	200.000	21,00	4
	30,00	16,46	175.000	22,00	3
	27,50	15,64	150.000	23,00	2
	25,00	14,82	125.000	24,00	1
	22,50	14,00	100.000	25,00	0
	2	2	5	3	Score
	25	25	40	10	Weight
	50	50	200	30	Value
				330	Total Productivity Index

Table 5. Antalya Port's 2014 Container Productivity

2014	**Berth Productivity**	**Crane Productivity**	**Yard Productivity (CY Capacity)**	**Gate Productivity (Truck Turnover Around Time)**	Productivity Criteria
	37,79	18,90	199.450	23,00	Performance
					Performance Scale
Scores	60,00	25,10	350.000	16,00	10
	57,00	24,28	325.000	17,00	9
	54,00	23,46	300.000	18,00	8
	51,00	22,64	275.000	19,00	7
	48,00	21,82	250.000	20,00	6
	45,00	21,00	225.000	21,00	5
	42,00	20,18	200.000	22,00	4
	39,00	19,36	175.000	23,00	3
	36,00	18,54	150.000	24,00	2
	33,00	17,72	125.000	25,00	1
	30,00	16,90	100.000	26,00	0
	3	2	4	3	Score
	25	25	40	10	Weight
	75	50	160	30	Value
				315	Total Productivity Index

The results that obtained from objective matrix are 2012 productivity index is 305, for 2013 is 330 and for 2014 is 315.

RESULTS

In this study, the productivity of container terminal of Antalya Port which is within container terminal has been measured by using OMAX method. The method is to measure performance with weighting determined criteria. One of the results of this study is year 2013 was more productive than 2012 and 2014 and this was mainly caused by efficient usage of yard capacity. On the other hand, the year 2013 was the highest volume of TEUs transshipment operations. In addition, at this particular year yard capacity was used at the amount of water capacity. 2013 index is higher because of waterside outgoing was 218.423 TEUs and yard outgoing was 222.296 TEUs. Despite the fact increasing adjustments at infrastructure of port and cranes (this increment is mainly was the field cementation works) in 2014, waterside outgoing amount was 189.346 TEUs and yard outgoing TEUs was 199.450, because of yard outgoing TEUs' volume outweigh waterside outgoing TEUs and 2014's increased port and crane production capacity resulted in better results for 2013 than 2014. In conclusion this study reveals that the method can be used usefully to measure container productivity and to make comparisons with other pots.

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OPTIMIZATION OF SAFE MARINE TERMINAL OPERATIONS

Ali Cem Kuzu[153], *Özcan Arslan*[154]

Abstract – Demand for energy is increasing every day all around the world. The most common method for transportation of energy sources is carried out via ships. Most of energy sources are flammable, explosive and dangerous for health and environment. Especially, during tanker-terminal operations, lots of hazards are available related to dangerous goods. For this reason, it is appropriate that attention should be concentrated on the port facilities and the activities of ship and shore employees involved in cargo operations. Tankers are inspected by port state, flag state, classification societies and independent surveyors according to international safety rules at regular intervals and safety standards ensured, but there is flaw about terminal inspections and safety standards. In this study, existence of unsafe tanker-terminal operations investigated by both field study and questionnaire. With this study, existence of unsafe tanker terminal operations investigated and root cause analyze and corrective actions discussed.

Keywords – maritime, inspection, tanker, terminal, safety,

INTRODUCTION

In this study, unsafe tanker-terminal operations and root causes of these operations were researched. A questionnaire was carried out for determining safety shortcomings. Findings of the questionnaire were discussed and what to do for eliminating safety defects was studied. In addition to the questionnaire, field study was carried out at tanker-terminal for defining safety defects at tanker-terminal operations.

METHODS

In this study, a questionnaire applied to employees that have professions at tanker-terminal operations. For defining tanker-terminal operation safety defects, the questionnaire was applied to 50 participants that captain, chief officer, chief engineer, loading master, port facility security officer and other related employees that working at tanker-terminals. And the results of the questionnaire analyzed thoroughly by using SPSS 19 (Statistical Package for the Social Sciences) program. The questionnaire incorporates ship-shore safety check list items and terminal regions. Ship-shore safety check list cited from International Safety Guide for Tanker and Terminals Code. Terminal Regions in all around of the world are territorialized seven regions according to OCIMF Tanker Terminal Maps. [3]-[16]

Field study was carried out at a tanker-terminal. During tanker-terminal operations, safety defects and hazardous conditions were determined. Both questionnaire results and field study observations demonstrated that safety shortcomings and hazardous conditions were available.

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FIELD STUDY

Unsafe Conditions Found at Marine Terminals

Use Of Hand Tools At Tanker Terminals: The use of hand tools such as chipping hammers and scrapers for steel preparation and maintenance may be permitted without a hot work permit. Their use must be restricted to the actual deck areas and fittings not connected to the cargo system. The work area should be gas-free and clear of combustible materials. The ship must not be engaged in any cargo, bunker, ballasting, tank cleaning, gas-freeing, purging or inerting operations. [3]

Figure 18. Unsafe Use of Hand Tools

Hazardous Areas at Tanker Terminal: At a terminal, account is taken of the probability of a flammable gas mixture being present by grading hazardous areas into three zones: Zone 0 An area in which a flammable gas mixture is continuously present or is present for long periods. Zone 1 An area in which there is likely to be a flammable gas mixture under normal operating conditions. Zone 2 An area in which the presence of a flammable gas mixture is unlikely, but if such a mixture is present it is likely to persist for only a short period. During tanker-terminal operations, any sparks shouldn't be occurred near tanker berths. [3]

Figure 2. Scrap Metal Handling Near Tanker Terminal

Access Between Ship And Shore: Personnel should use only the designated means of access between ship and shore. Gangways or other means of access should be provided with an effective safety net where appropriate. Lifebuoys with lifelines should be available in the vicinity of the gangway or other means of access. In addition, suitable life-saving equipment should be available near the access point ashore. Means of access should be placed as close as possible to crew accommodation and as far away as possible from the manifold. [3]

Figure 3. Unsafe Ship-Shore Access

Earthing and Insulating: Earthing and insulating minimises the dangers arising from faults between electrically live conductors and non-current-carrying metal work, atmospheric discharges (lightning) and accumulations of electrostatic charge. Earthing is achieved by the establishment of an electrically continuous low resistance path between a conducting body and the general mass of the earth. Earthing may occur inherently through intimate contact with the ground or water, or it may be provided deliberately by means of an electrical connection between the body and the ground. [3]

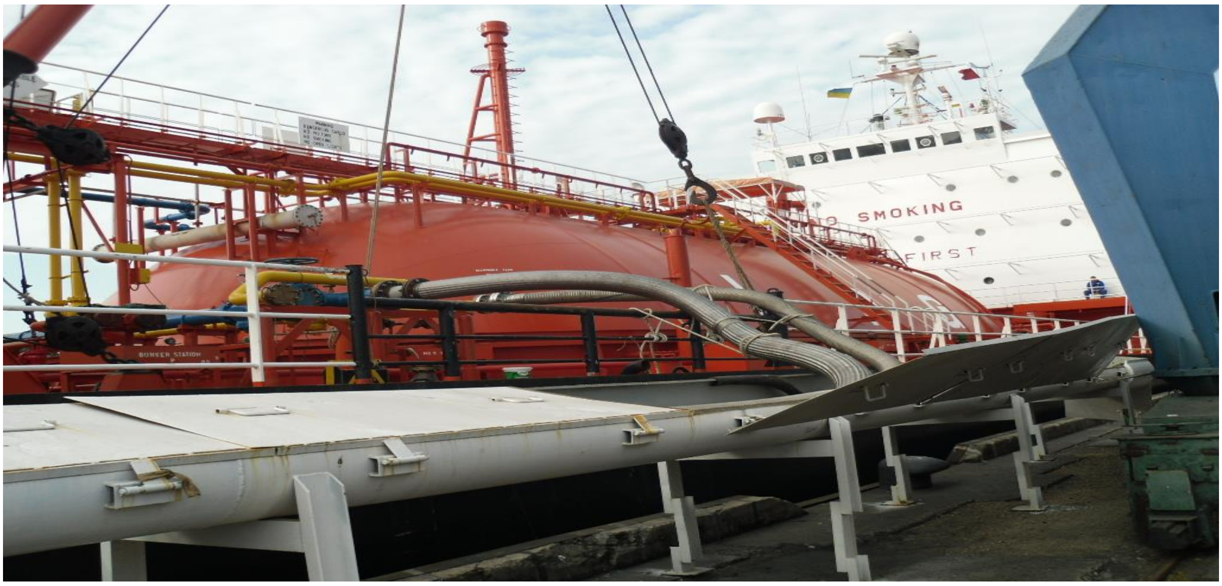

Figure 4. Non-insulated Cargo Manifold

Competency and Training of Terminal Staff: Terminal staff should have safety awareness and competency about his or her job. They should be trained according to marine terminal operator competence guide.

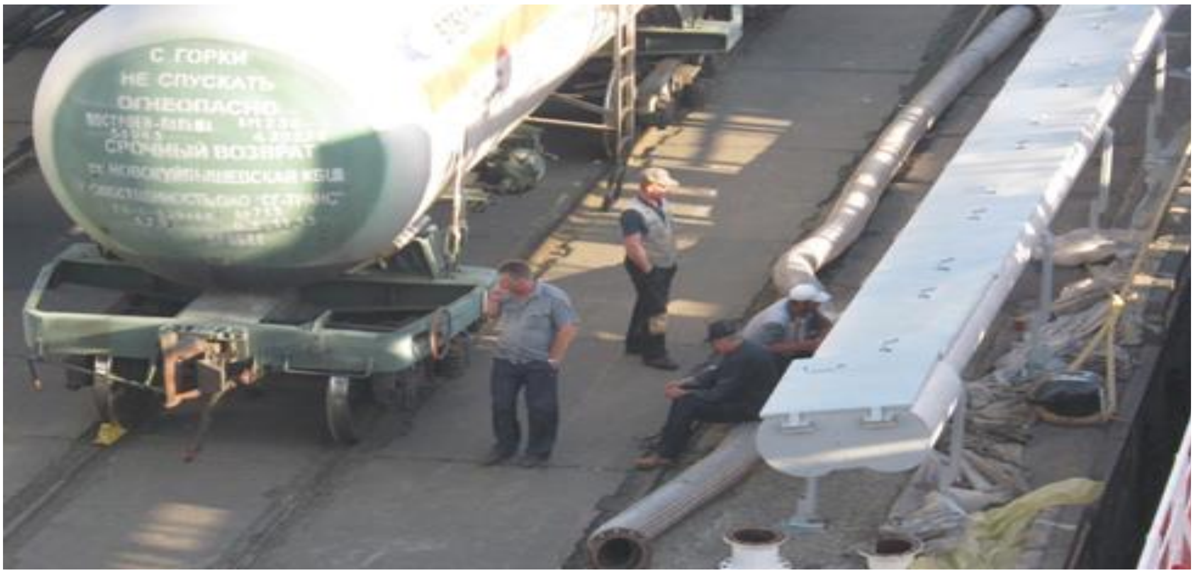

Figure 5. Incompetent and Untrained Terminal Staff

Marine Terminal Information System

Over the past 3 years, OCIMF has developed the marine terminal information system with the aim of filling the gaps that exist in the international standards for terminals and also that would complement the similar work already being done by OCIMF and its members to improve ship safety and environmental protection. Marine terminal information system enables operational efficiency through better matching of terminals and ships, better dissemination of terminal information, continuous improvement of safety management, better trained and motivated staff and promotes safety. Marine Terminal Information System aims to enable safety standards for tanker-terminal operations all around the world. And also, aims to prevent marine pollution by sea. Specifically, the consolidated system embraces Marine Terminal Particulars Questionnaire (MTPQ), Marine Terminal Management and Self-Assessment (MTMSA) Marine Terminal Operator Competence & Training (MTOCT). [16]

Marine Terminal Operator Competencies and Training (MTOCT) aims to identify key competences and knowledge requirements, together with appropriate verification processes, to help members develop or commission their own terminal operator training programs to ensure that personnel working on the ship/shore interface have the required skills and competence. [16]

Marine Terminal Management and Self-Assessment (MTMSA): A tool to assist terminal operators to assess, measure and improve the effectiveness of their management systems with regard to berth operations and the management of the ship/shore interface. MTMSA provides the best practice and key performance indicators against which terminal operators can assess the effectiveness of their management systems for berth operations and the ship to shore interface. With a self-assessment culture at the heart of OCIMF’s approach, members can use the MTMSA guide to develop their own internal review methodology. They can then use the internal review results to continuously improve their safety and environmental performance and to identify and share best practice around their terminal network. [16]

Marine Terminal Particulars Questionnaire (MTPQ): An accurate repository of marine particulars data. Data needed for assessing suitability of the ship/shore interface. Accurate and comprehensive terminal information is an essential element in ensuring the compatibility of ships and terminals, the safety of operations and the protection of the environment. MTPQ provides a standard format for the collection of information that can be shared with terminal users, improved operational efficiency through better matching of terminals and tankers and improved effectiveness and efficiency, with better dissemination of terminal information. [11]**-** [16]

QUESTIONNAIRE

The questionnaire was applied to 50 participants that captain, chief officer, chief engineer, loading master, port facility security officer and other related employees that have duties on tanker-terminal operations. And the results of the questionnaire analyzed thoroughly by using SPSS 19 (Statistical Package for the Social Sciences) program. The questionnaire incorporates ship-shore safety check list items and terminal regions. Ship-shore safety check list cited from International Safety Guide for Tanker and Terminals Code. Terminal Regions in all around of the world are territorialized seven regions according to OCIMF Tanker Terminal Maps. The first three questions of the questionnaire are definitive questions that incorporate professions, profession experiences and type of tanker-terminals at which participants work. The second part of the questionnaire comprises of 30 statements in likert scale. The statements are cited from International Safety Guide of Tanker and Terminals. In the last part of the questionnaire is prepared using again likert scale for determining the safety level at seven terminal regions that are territorialized according to OCIMF Tanker Terminals Maps. For the second part at 30 expression, evaluation is defined as; "Strongly disagree = 1", "disagree = 2," "undecided = 3", "agree = 4" and "strongly agree = 5". And the last part incorporates an open ended question and safety conditions at 7 terminal region by defining the safety levels as "absolutely unsafe = 1 ", " unsafe = 2 ", " I'm not sure = 3 ',' safe = 4 ", " absolutely safe = 5 '.

Analysis Program: The questionnaire was applied to 50 participants within a period of four months between October 2014and February 2015. SPSS 19 (Statistical Package for the Social Sciences) software program was used for analyzing the questionnaire results. Factor analysis, examination of correlation tables, the frequency statistics responses to questions applied and reliability coefficient was calculated.

Definitive Information of Participants: Profession, experience, and working field information of participants given in Table.1

Table 1. Definitive Information of Participants

Definitive Information	Number	Percentage
Experience		
2 years	6	12
2-5 years	13	26
5-10 years	13	26
More than 10 years	16	32
Profession		
Captain	14	28
Chief Officer	17	34
Chief Engineer	4	8
Loading Master	3	6
PFSO	4	8
Other Relevants	7	14
Working Field		
Oil Tanker/Terminal	27	54

Chemical Tanker/ Terminal	11	22
LPG-LNG Tanker/Terminal	11	22

Reliability Analysis of Questionnaire: Reliability value that is indicative of the degree, gives the same result in repeated measurements of a measuring instrument. Statements that can be interpreted differently by different people reduce the reliability of the measurement results. Cronbach's alpha value determined as 0.93 for 38 items. This value is sufficiently acceptable.

CONCLUSION AND RECOMMENDATIONS

The questionnaire results and field study indicated that there are safety defects on tanker terminal operations. And also safety conditions are variable according to terminal regions.

Open ended question, the non-conformities that are often encountered during terminal operations, answered mostly similar. When the answers were analyzed according to participants' professions; Captains' answers to the open-ended question were untrained, inexperienced and incompetent terminal staff, lack of communication because of inadequate foreign language. Chief Officers' answers were similar to captains' answers. In addition to these, insufficient pre-arrival information about weather and environment conditions, improper ship-shore access, naked lights such as smoking at terminals. Chief Engineers' answers were communication troubles and lack of waste receiving facility of terminals. Loading Masters' answers were lack of terminal operation staff on duty, incompetent cargo watch keeping officers and not to be carried out regular checks during tanker-terminal operations. PFSO (Port Facility Security Officer)'s answers were security gap at entrance of terminals and not to be kept closed prohibited areas at tankers. Last part of the questionnaire was safety level evaluation of terminal regions. For evaluation of safety level of terminal regions, likert scale was used as "absolutely unsafe = 1 ", " unsafe = 2 ", " I'm not sure = 3 ',' safe = 4 ", " absolutely safe = 5 '. According to the results, average value of terminal region 1 (Brazil, Colombia, Peru, Paraguay) was 3,36, terminal region 2 (Germany, Denmark, England, Holland, Belgium) was 4,54 terminal region 3 (South Kore, Japan, East China) was 3,97, terminal region 4 (USA, Gulf of Mexico, Venezuela) was 3,85, terminal region 5 (Indonesia, Vietnam, Singapore) was 3,39 ‘’terminal region 6 (Turkey, Russia, Ukraine, Romania, Bulgaria, Greece, Georgia)’’ was 3,33, terminal region 7 (UAE, India, Iran, Egypt, African Countries)’’ was 3,04. Results showed that the safest terminal region in the world was terminal region 2 that incorporated developed countries. Terminal region 7 that incorporated undeveloped countries had the lowest safety level. These results were expected because developed countries can make investments for constructing safer terminals. They can also enable safety awareness and well training opportunities to their staff.

The questionnaire results and field study indicated that there are safety defects on tanker terminal operations. And also safety conditions are variable according to terminal regions. Answers viewed bearing in the mind that professions and experiences. When root cause analyze of safety defects on tanker terminals are carried out according to the results of the questionnaire, it is determined that existing conditions of safety are at different level, at different terminal regions. There are lots of reasons for this difference of safety level. Most of important reasons are difference of safety awareness, safety perception, safety culture, priorities, and educational level in different countries. In addition to this, it can be said that profession experience is an effective factor for safety and emergency response at tanker-terminal operations. On the other hand, professional experience may come up with casualization of the operations carried out by its cockiness. Changing technological opportunities of tanker terminals come up with new technological training requirements. That's why; required trainings should be supplied for employees by tanker terminal management. According to the results of the questionnaire, the safest terminals are in the second terminal region that covers Germany, Denmark, England, the Netherlands and Belgium, with the grades of 4,54 (between safe and absolutely safe). When this region is examined, it is seen that all of the countries at the region are developed countries.

If a system like ''Marine Terminal Information System'' that has database particulars and safety defects of registered tanker terminals, is established, employees of tanker-terminal and the other operation relevant will be able to report safety defects about a terminal with online reporting system and be able to access all information and safety defects about the terminal. After reporting, the terminal will be inspected according to defined safety standards by an independent surveyor who will define the failures of terminal and inform relevant about the failures. And then, if the terminal failures aren't removed in a determined period of time the terminal will be registered as unsafe terminal. And unsafe terminals will be promulgated to the relevant by the authorities via online system. As soon as the reported failures are removed, the terminal will demand an inspection from authorities. If authority experts approve removal of failures and safety of terminal the terminal will be able to carry on its routine activities and be changed as safe terminal. When enforcements like restraining and punishments are implemented to the terminals that don't meet safety standards terminal responsible try to ensure safe operations at their terminals much more than before. [11]-[12]

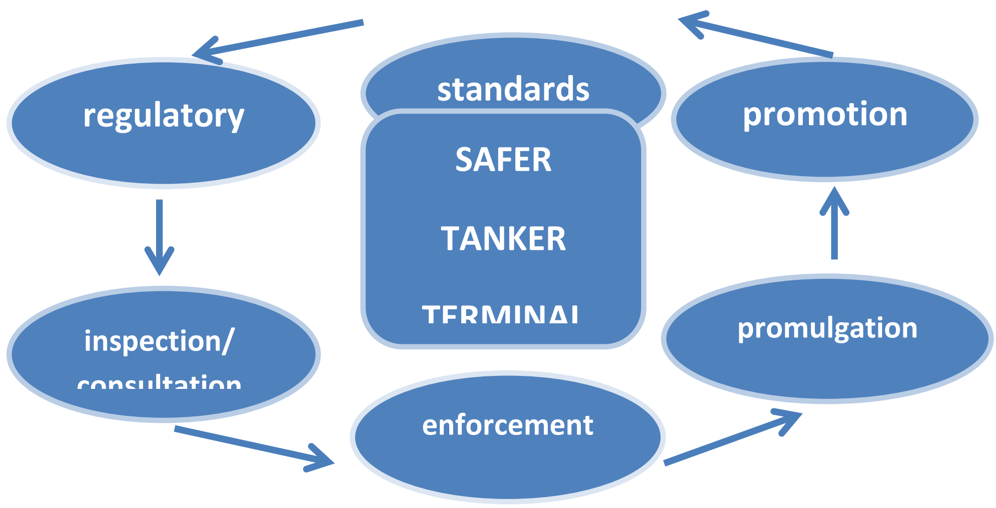

Figure 6. Safer Tanker Terminal Management Process

Safer tanker-terminal operations, cleaner seas, more trained employees, more livable environment are on the mind and with this study, tanker terminals are aimed to enable safety standards for tanker-terminal operations all around the world.

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SERVICE QUALITY DIMENSIONS IN CONTAINER SHIPPING: AN APPLICATION ON THE FREIGHT FORWARDERS IN TURKEY

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Abstract_The role of container shipping lines has changed and evolved in recent years. Container shipping lines are required to give more attention to managing relationships with their customers. They need to achieve service excellence by constantly improving their service performance. Therefore, it is important to determine dimensions and components of container shipping service quality. The main aim of this study is to explore the dimensions of service quality and propose a model for measuring service quality in container shipping service. In order to reach this aim a questionnaire was developed based on the ROPMIS Model and applied on the freight forwarders in Turkey. As a result of the study, a reliable and valid scale consisting of 6 dimensions with 24 variables was developed for measuring container shipping service quality.

Keywords_Service Quality, Container Shipping, Container Shipping Service, Turkey

INTRODUCTION

The structure of global markets has changed and as a natural result of this change demands of shippers have also changed. This development has forced container shipping lines to restructure their business processes to better satisfy shippers' needs [1]. Container shipping lines can differentiate their services by offering high quality services to shippers. Shippers expect high quality service at a fair price from container shipping lines. They also expect close attention to their requirements as well as improved scheduling.

This study primarily aims to explore service quality dimensions in container shipping. The study analyzes the service quality perceptions of freight forwarders who are considered as shippers against carriers and act as an important intermediary between shippers and carriers in container shipping.

LITERATURE REVIEW

Service Quality

The qualities of products and services have essential importance in terms of company's business strategy and the national economy [2]. Customers evaluate service quality by comparing their perceptions of what they receive with their expectations of what they should receive. Expectations and perceptions occur experimentally rather than necessarily being real. Therefore, in the context of the service, it is necessary to satisfy customer expectations and requirements [3]. According to Frankel [4] service quality is largely an attitude which influences all aspects of the operations. It considers customer and user needs and expectations both internal to the services provided and to external factors of concern. Lewis and Booms [5] define service quality as the measure of how well the service level delivered matches customer expectations. Delivering quality service means conforming to customer expectations on a consistent basis.

Major benefits of successful service quality can be classified as follows [6];

- Satisfied and retained customers and employees
- Opportunities for cross-selling
- The attraction of new customers
- Development of customer relationships

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- Increased sales and market shares
- Enhanced corporate image
- Reduced costs and increased profit margins and business performance.

In the literature, scholars have focused on the dimensionality of the service quality. They proposed a number of models including Gronroos' model [7], SERVQUAL [8-9], SERVPERF [10]. The aims of these models were to find a better scale to measure service quality from service specific perspectives. Among these models, the SERVQUAL has been widely used and mostly criticized by scholars especially in consumer services [11].

The first attempt to develop service quality model was made by Gronroos in 1982. He suggested two service quality dimensions; the technical aspect (what the service provides) and the functional aspect (how the service is provided). Later he added the "corporate image" dimension as an important component in the model. Parasuraman et al., in 1985, first described 10 components of service quality consisting of tangibles, reliability, responsiveness, communication, credibility, security, competence, courtesy, understanding/knowing the customer and access. Later, the SERVQUAL scale was reduced into main five dimensions. Reliability, tangibles and responsiveness remained constant, but the other seven components categorized into two components, assurance and empathy (see Table 1).

Table 1: Perceived Dimensions of Service Quality[9]

Reliability	The ability to perform the promised services accurately and dependably
Responsiveness	The willingness to help customers and provide prompt service
Assurance	The knowledge and courtesy of employees and their ability to convey trust and confidence
Tangibles	The physical facilities, equipment, and appearance of personnel and communication materials
Empathy	The caring, individualized attention provided to the customer

Cronin and Taylor (1992) were the first researchers to propose a theoretical justification for rejecting the expectations portion of SERVQUAL in favor of just the performance measures included in the scale and named the scale as SERVPERF. The term ''performance-only measures'' refers to service quality measures that depend on consumers' perceptions of the performance of a service provider, as adverse to the gap between the consumers' performance perceptions and their performance expectations.

While SERVQUAL scale directly measures both consumer's expectations and performance perceptions, SERVPERF measures only performance perceptions of counsumer. SERVPERF uses only data from service performance because it considers that respondents provide their ratings by comparing performance perceptions with performance expectations. Therefore, SERVPERF suppose that directly measuring performance expectations is inessential [12].

Container Shipping Services and Service Quality

''Product (service)" in the container liner industry means that the transport services provided by container lines. It is obvious that the transport service cannot be stored; because once a particular voyage is undertaken, all unutilized slots on board will be wasted [13]. Container shipping service that provides regularly scheduled maritime transportation service on fixed routes has a number of attributes, such as speed, reliability, competitive level of rates, and completeness of service to shippers. For customers of container shipping service, some of these attributes can be expected to be more important than other service attributes and not all shippers will attach the same importance to any particular attribute. To develop a liner service responsive to shippers' needs, container shipping lines need to determine the attributes of that service, give individual importance, and know how customer segments differ on the importance of that service attributes [14]. Table 2 presents the literature review related to service quality dimensions in container shipping.

Table 2: Summary of the Literature Review Related to Service Quality Dimensions in Container Shipping

Author	Resources	Output	Process	Management	Image	Social Responsibility
Pearson (1980)		-speed of transit -reliability -regularity	-flexibility -first on the quay			
Collison (1984)		-transit time -schedule reliability -frequency of sailing	-flexibility			
Suthiwartnarueput (1988)		-frequency of sailing -cost of service -punctuality -transit times -directness of sailings			-past loss and damage experience	
Frankel (1993)	–availability of capacity –cargo flow control and tracking	-service reliability -service time and delivery time -cargo safety, security and maintenance -timeliness and accuracy -cost control, billing and management		-service status control and projection -intermodal management		
Matear and Gray (1993)		-on-time collection and delivery	-fast response to problems		-good relationship with carriers	
Jamaluddin and Shah (1995)		-freight rates -punctuality -transit time -service frequency	-cargo care and handling	-knowledge ability		
Chui (1996)		-transit time -reliability -documentation services -assistance with loss/damage claims	-fast response to problems -notice of delay			

Note: The dimensions and factors of container shipping quality placed in table according to dimensions of ROPMIS Model

Table2: Summary of Literature Review Related to Service Quality Dimensions in Container Shipping (Continued)

Author	Resources	Output	Process	Management	Image	Social Responsibility
Durvasula et al. (1999)	-tangibles	-reliability	-responsiveness -assurance -empathy			
Tuna (1999)	-equipment availability -equipment condition	-documentation quality -reliability -transit time	-courtesy of employee -knowledge of employee			
Chen et al. (2009)	-tangibles	-reliability	-responsiveness -assurance -empathy			
Kannan et al. (2010, 2012)	-infrastructure	-rate -customer service -scheduling	-operations -information technology orientation and communication		-reputation	

Note: The dimensions and factors of container shipping quality placed in table according to dimensions of ROPMIS Model

Collison (1984) determined the importance of service attributes to a container shipping line's customers both in aggregate and by market segment. He found that the transit time, schedule reliability, frequency of sailing and flexibility are the most important criteria that effect container shipping service quality. Suthiwartnarueput (1988) investigated the efficiency of the shipping industry in Thailand and indicated that the most important service attribute was found to be the cost of service, followed by punctuality, transit times, frequency of sailings, directness of sailings, as well as past loss and damage experience. The information nature of advertising was noted as the least important item in this research [15].

Matear and Gray (1993) investigated freight transport services in Ireland. According to shippers the most important service attributes were fast response to problems, on-time collection and delivery, value for money and good relationship with carriers. Carriers defined the most important service attributes as punctuality of sea transport service, availability of freight space, high frequency of sea transport service and fast response to problems encountered [16].

Frankel (1993) determined the quality criteria that indicate the major quality concerns with regard to liner shipping services. These criteria consists of reliability of service, time of service and maintenance of delivery time, availability of promised or advertised capacity, cargo safety, security and maintenance, cargo flow control and tracking, documentation and information flows effectiveness (timeliness and accuracy), cost control, billing and cost management, service status control and projection, intermodal management [4]. Jamaluddin and Shah (1995) examined the marketing of liner shipping services with reference to the Far East/Europe trade. Freight rates, cargo care and handling, knowledge ability, punctuality, transit time and service frequency were the most important service factors that shippers considered. The six service factors considered important by carriers were: knowledge ability, freight rates, cargo care and handling, punctuality, transit time and service frequency [17].

Chiu (1996) analyzed the logistics performance of liner shipping, assessing carriers’ performance from the shipper’s perspective. He described six most important service attributes for shippers as prompt response from carrier to any problem, transit time, reliability, documentation services, notice of delay and assistance with loss/damage claims [18].

Durvasula et al. (1999) presented an application of SERVQUAL as a measurement of service quality in ocean freight services. The results of their study indicated that while five-dimensional factor of SERVQUAL measurement is reasonable, the measurements may be better represented by a more parsimonious (i.e. three-dimensional) factor structure where responsiveness, assurance, and empathy are combined into a single dimension [19]. Tuna (1999) investigated the service quality, the relationship between the perceived service quality and behavioral intentions of shippers in container transportation. Documentation quality and shipment safety and security (loss and damage) were determined as the most important criteria from the perspective of shippers in his research [20].

Chen et al. (2010) examined the validity of applying SERVQUAL to the shipping industry of Taiwan and the service quality gaps between business customer types and between employee statuses of business customers by using the data of perceived service quality of the forwarders and the shippers in the shipping industry of Taiwan. Their results of the study do not support the validity of applying SERVQUAL to the shipping industry of Taiwan due to the failures of discriminant and nomological validity [21].

Kannan (2010) offered a framework based on an analytic hierarchy process to ocean container carriers operating in India, with a view to assist them in benchmarking their service quality. His study presented a framework for benchmarking the service quality of container carriers. According to Kannan’s study (2010) Indian shippers use 48 attributes in the carrier evaluation process and they aggregate these service attributes under seven significant criteria, namely rate, customer service, operations, reputation, infrastructure, scheduling and information technology orientation and communication. Rate is considered as the most important service attributes dimensions in this research [22].

Kannan et al. (2012) assisted ocean container carriers operating in India in their service quality improvement process. They selected seven container carriers and investigated their service capabilities. They determined the list of criteria in order to assess the service quality of ocean container carriers in the Indian market and then attempted to measure the service quality of the selected container carriers. After that, they carried out gap analysis to find out the comparative strengths and weaknesses of the selected container shipping lines [23].

Thai (2008) found that the service quality in maritime transport is a six-dimensional construct composed of resources, outcomes, process, management, image, and social responsibility (ROPMIS). Each dimension is measured by a number of explaining factors making up a total of 24 factors. The results of the study revealed that factors involving the outcomes and process of service provision, as well as the management factors, which all focus on satisfying the customers, received high ranking. He also indicated process and management-related factors which involve the center of all quality systems: the human element.

METHODOLOGY OF THE RESEARCH

This study aims to explore and determine the service quality dimensions in container shipping and proposes a model to measure service quality in container shipping. The study also reveals service quality perceptions of freight forwarders who are considered as shippers of container lines and act as an important intermediary between the shippers and carriers in container shipping.

In the study, managers and personnel of the freight forwarders active in the field of sea transportation in Turkey were selected as sample. A list of 168 freight forwarder companies from Association of International Forwarding and Logistics Service Providers (UTIKAD) was used as sample in the study.

The questionnaire form was used as data collection instrument. The questionnaire was sent to each freight forwarder by requesting three sets of responses from senior manager, department manager and the other staff (sales representative, customer representative etc.). By the cut-off date of survey, totally 112 questionnaires were returned from 62 freight forwarder companies. 28 of the questionnaire were taken from general managers, regional managers and branch managers. 36 of the questionnaire were taken from the department managers (sales and marketing managers, operation managers, business development managers, accounting managers etc.). 48 of the questionnaires were taken from sales and marketing representatives.

FINDINGS

Profile of the Respondents and the Freight Forwarder Companies Involved in the Study

Table 3 shows the profiles of the respondents participated in the study. 57.1 percent of the respondents are managers including general manager, regional manager, branch manager, sales and marketing manager, operation manager, business development manager and accounting manager. 55.4 percent of the respondents have experience of 10 or more years in the maritime industry. Majority of the respondents have Bachelor's degree (79.5 percent). 44.6 percent of the respondents work in sales and marketing department.

Table 3: Profile of the Respondents [24]

Job title	**N=112**	**%**	**Experience**	**N=112**	**%**
General managers, regional managers, branch managers	28	25	1-4	26	23.2
Department manager	36	32.1	5-9	24	21.4
Marketing and sales representatives	48	42.9	10-14	34	30.4
			15 and more	28	25
Education level	**N=112**	**%**	**Department**	**N=112**	**%**
High school	3	2,7	Sales and marketing department	50	44,6
Associate degree	6	5,4	Operation department	34	30,4
Bachelor degree	89	79,5	Business development department	4	3,6
Master degree	14	12,5	General management	22	19,6
			Accounting department	2	1,8

Table 4 shows the profiles of the freight forwarder companies involved in the study. 46.8 of the freight forwarders were established after 2000. 48.4 of the freight forwarder companies employ more than 50 employees. Most of the freight forwarding companies has between 5,001 and 30,000 TEU annual shipments (43.5 percent). 37.1 percent of the companies have annual shipments between 1 and 5,000 TEU. When the partnership/ownership structures of freight forwarder companies are analyzed, it is observed that most of the companies are purely local owned companies (61.3 percent). 77.4 percent of the companies have long-term agreements with container shipping lines. 80.6 percent of the companies are members to forwarder networks. 51.6 percent of the companies don't have the supplier evaluation systems.

Table 4: Profile of the Companies Involved in the Study [24]

Establishment Years	**N=62**	**%**	**Employee Numbers**	**N=62**	**%**
1990 and before	16	25,8	1-9	14	22,6
1991-2000	13	21,0	10-49	18	29,0
2001-2010	13	21,0	50-250	18	29,0
2011-2015	16	25,8	More than 250	12	19,4
No response	4	6,5			
Annual Shipment (TEU)	**N=62**	**%**	**Partnership/Ownership**	**N=62**	**%**
1-5,000	23	37,1	Purely local	38	61,3
5,001-30,000	27	43,5	Purely foreign	13	21,0
more than 30,000	12	19,4	Local-foreign partners	11	17,7
Long-term Agreements	**N=62**	**%**	**Membership to Forwarder Network**	**N=62**	**%**
Yes	48	77,4	Yes	50	80,6
No	14	22,6	No	12	19,4
Supplier Evaluation System					
Yes	30	48,4			
No	32	51,6			

Descriptive Statistics

The most important variable for freight forwarder managers and staff is shipment safety and security (loss and damage). 72.3 percent of the respondents marked this variable as "very important" and mean score has value of 4.69. Reliability of documentation (error-free processes) is the other variable that freight forwarder personnel stated as important criteria (mean=4.64). The other important variables are respectively "quick response to customers' inquiries and requests" (mean=4.61), "competitive price of freight" (mean=4.49), and "equipment (container) availability" (mean=4.49). The Cronbach alpha (α) coefficient of the scale has a value of 0.911, which indicates the reliability (high internal consistency) of the Container Shipping Service Quality Scale.

Factor Analysis

Exploratory Factor Analysis was used to minimize the large set of container shipping service quality variables to a smaller set of basic factors. Table 5 presents the factor analysis results of the container shipping service quality. Principal components analysis with “varimax” rotation was employed to identify the key dimensions in container shipping service quality. Accounted KMO has the value of 0.835. This means that the sampling size is adequate to do reliable factor analysis. Barlett’s sphericity test value is less than 0.05 and significant (p=0,000). The tests findings show that the data is adequate to employ factor analysis for container shipping service quality scale. As a result of factor analysis, container shipping service quality variables are grouped under six factors. These 6 factors account for 65.238 percent of the total variance. Container shipping service quality factors are labeled as follows;

(1) Management and responsiveness
(2) Physical facilities and reliability
(3) Outcomes
(4) Technology and social responsibility
(5) Resources
(6) Image and process

Table 5: Factor Analysis Results of the Container Shipping Service Quality Scales [24]

Quality Attributes of Container Shipping	Alpha(α)	TVE %	Factor Groups and Factor Loading Value					
			I	II	III	IV	V	VI
Factor 1-Management and Responsiveness	0,813	14,774						
Knowledge of customers' needs and requirements			,840					
Efficiency in operations and management			,668					
Knowledge and specialized skills of management and operators			,627					
Feedback from customers			,546					
Quick response to customers' inquiries and requests			,542					
Understanding customers' needs and requirements			,517					
Factor 2-Physical Facilities and Reliability	0,742	12,709						
Equipment (container) condition (e.g. old or new, specialized or not)				,797				
Equipment (container) availability				,754				
Reliability of documentation (error-free processes)				,636				
Shipment safety and security (loss and damage)				,600				
Factor 3-Outcomes	0,444	12,401						
Competitive price of freight					,896			
Transit time (Speed of service performance)					,453			
Factor 4-Technology and Social Responsibility	0,839	9,664						
Application of IT and EDI in customer services						,824		
Application of IT and EDI in operations						,778		
Socially responsible behavior and concerns for human safety						,605		
Environmentally safe operations						,567		
Factor 5-Resources	0,714	9,185						
Financial stability of carrier							,800	
Staff's attitude and behavior in meeting customers' requirements (e.g. changing customers' needs)							,502	
Availability of ship capacity (Physical infrastructures)							,490	
Shipment tracing capability							,416	
Factor 6-Image and Process	0,782	6,504						
Reliability of service performance (timeliness of shipment pickup and delivery)								-,667
Company's reputation for reliability in the market								-,627
Continuous improvement of customer-oriented operation processes								-,539
Providing service in a consistent manner (maintaining service quality in any situation)								-,396
Eigenvalue			**8,359**	**1,961**	**1,691**	**1,405**	**1,236**	**1,006**

Scale; 1=Not at all important; 3=Neutral; 5=Very important

CONCLUSION

This study has explored the service quality dimensions in container shipping. The study has also evaluated the importance of container shipping service quality dimensions from freight forwarders' perspectives. A valid and reliable container shipping service quality scale has been proposed in order to measure the service quality in container shipping.

"Management and responsiveness" factor is the most important factor in container shipping service quality from the freight forwarders' perspective. Container shipping lines' relationship with customer and responsiveness seems most important for freight forwarders as shippers in container transportation. The results of the study have also indicated that "efficiency in operations and management" is important factor in container shipping. Container shipping lines must consider their management capabilities and responsiveness in order to improve their container services to meet shippers' expectation. Managers can use the container shipping service quality scale designed and explored in this study to develop a research instrument, such as questionnaire, to survey their customers' evaluation of quality of service provided.

This study presents only the viewpoints of freight forwarders on container shipping service quality. Other parties of container shipping such as shippers (exporters and importers) can be taken as sample in the future studies. This study is mainly based on the ROPMIS scale. Other service quality models or approaches can be also applied to the container shipping service quality studies. The similar study with a same questionnaire can be applied on other countries' shippers or freight forwarders in the future researches.

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USING RFID (RADIO FREQUENCY IDENTIFICATION) TECHNOLOGIES ON HOSPITALS: A LITERATURE REVIEW

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Abstract- Health expenditure is a significant item of national budgets and it is regarded as a sector that targets to maximize benefits, efficiency and effectiveness through cost minimization instead of reduction of budget because of its vitality. Global Budget System implemented in Turkey defines an upper budget limit for hospitals' income in order to keep under control the health expenditure, and benefits of hospitals increase in terms of their efficiency. As a result, organizational structure, business processes and service quality have changed and transformed significantly by the Turkish Ministry of Health by the Legislative Decree No. 663. The key areas of change are associated with organizational, hospital and materials management systems. Radio Frequency Identification (RFID) technologies have been used in diverse fields in healthcare for improving process efficiency and cost effectiveness. RFID technology have the potential to facilitate new value creation in healthcare service innovation and these technologies are offering several contributions of application areas such as medication tracking, asset management, patient safety management and personnel tracking. In the light of this information, the aim of the study is reviewing Radio Frequency Identification literature and finding the cross-sections between healthcare and logistics regarding Radio Frequency Identification technologies. The result of this study will contribute to literature by showing the big picture of RFID applications in healthcare.

Keywords: *Literature review, Hospital, RFID, Health Services, Supply Chain*

1. INTRODUCTION

The healthcare industry is one of the largest sectors in many economies. In the United States (US) it represents a "multi trillion dollar industry". The sector created approximately 14.3 million jobs in 2008, and has the potential to create an additional 3.2 million jobs by 2018 [1]. In 2009, general healthcare cost was over 38 billion dollars in Turkey [2]. As the healthcare sector becomes increasingly complex, a key driver of cost and quality become more critical than before. It needs more sophisticated and integrated solutions to controlling all critical performance indicators of healthcare services. Hospital and healthcare value chain are required a holistic approach to control of all units alignment of same page. It involves multiple stakeholders and organizational units numerous requirements, including patient safety, the ability to track and trace pharmaceuticals, medical devices and the flow of products from manufacturers to patients.

Supply Chain Management (SCM) is designed to include best practices of the industry to streamline entire processes from the ordering to supply through delivery processes. These processes include efficient management and distribution for the flow of products/services for on time delivery of high-quality medical care. Logistics management is the part of SCM that plans, implements and controls the efficient and effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements [3].

In the current IT era, through the use of suitable identification technologies such as 2D barcodes and RFID tags can recognize physical objects automatically to speed-up processes and reduce costs, such as the automatic identification of incoming and outgoing goods in warehouse operations or asset tracking in closed-loop applications. Recently, RFID technology has begun to use to track and identify people, equipments and products in healthcare sector. Despite the rising implementation of RFID technology based upon production and services sectors few cross-sectional studies have been conducted to assess the potential of this technology

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such as supply chain management and logistics' within healthcare sector. The purpose of this research study is to first, determine the benefits of implementing current RFID technology into the healthcare sector. Second, determine which areas of the healthcare and logistics would benefit the most from these implementations. This paper proceeds as follows. Section 2 discusses RFID technology, in general. RFID applications are reviewed and classified in Section 3. In section 4 findings are summarized and future study opportunities are proposed in the conclusions.

2. LITERATURE REVIEW

Radio frequency identification (RFID) has been identified as one of the ten greatest contributory technologies of the twenty-first century. The first prototype of RFID technology was developed by the United Kingdom in World War II to distinguish between enemy and friendly aircraft [4]. More recently, radio frequency identification technologies are defined as wireless automatic data identification and capture technology. RFID is method for remotely retrieving and storing data from devices that are called RFID *tags* or transponders. RFID system is designed with three main parts. RFID tags, RFID reader and computer hosted specific software or middleware [5]. A general representation of RFID technology can be demonstrated as in Figure 1.

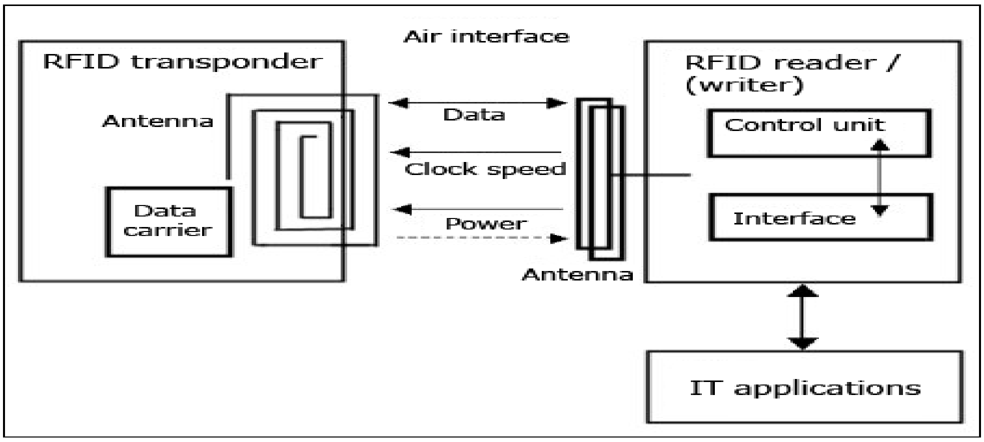

Figure 1.Schematic representation of RFID technology

As there can be seen in Figure 1, there are three main components such as transponder, antenna and reader. Final point is reached to deployed IT applications that can be mobile, desktop or middleware. RFID is based on electromagnetic waves with frequency ranges from long wave through to microwave. Unlike with barcodes, RFID transfers data between for instance a package (equipped with a transponder) and a data capture unit (reader) with no need for contact or a direct line of sight. The RFID middleware filters which is demonstrated in Figure 1 as interface; processes, manages and aggregates the vast amounts of data collected by the readers from the embedded RFID tags. It then routes the required data to enterprise applications.

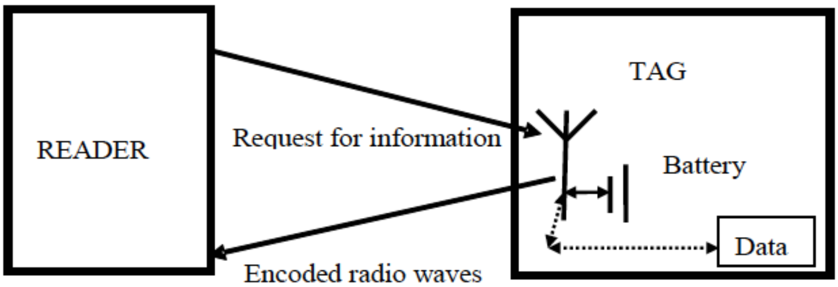

Figure 2. Active RFID tag

An RFID tag is most critical and operational part of RFID system. It includes an antenna and a chip for computation and transmission of data that are captured from object that are moving or retrieving desirable information. RFID tags come in various formats, including badges, pendants, labels, wristbands, cards and even implants and they can be classified based on a wide array of features such as memory type (i.e. RO, WORM and RW), operating frequency (i.e. LF, HF, UHF, and μWave), power source (active or passive tags), design, etc. [6]. The active tag's schematic representation can be seen in Figure 2. Active tag includes internal battery and rewritable chip that can be used many times with much variable kind of data. Active tags can be rewritten and RFID reader can read or write tags within active operation range. It does not need hand held scanner to retrieving data.

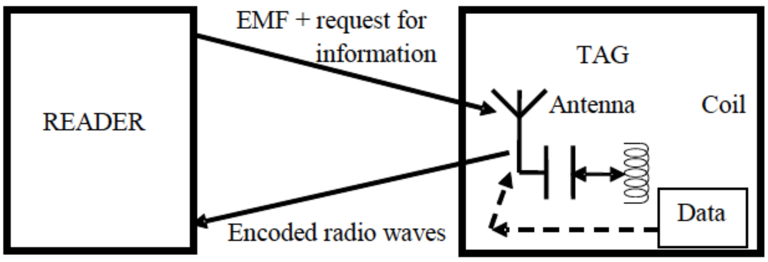

Figure 3.Passive RFID tag

As seen in Figure 3. Passive tag is designed for to carrying specific data that is not able to overwrite or rewritten. Passive tags only contain internal antenna and wire coil which induce with electromagnetic fields to keep specific data with one-way usage and contain no independent source of power. Passive tags are widely used low cost solutions [7].

While most attention has focused on adopting RFID in retail and manufacturing, healthcare should be considered the next room of RFID. To improve certain situation, numerous researchers have discussed and provided useful insights for successful deployment, however, the currently available critical success factors and lessons learnt are in the fields of retail, manufacturing and in the logistics industry and they cannot be transferred to the medical environment without modification [8]. In this study, healthcare sector is focused and the literature is reviewed with this point of view.

3. RFID APPLICATIONS IN HEALTHCARE

Healthcare services are complex and life-critical. One mistake in any procedure may lead to irremediable consequences. Medical operations are associated with several types of task and operations. In addition, there is high level of uncertainty and process since human lives are involved. Due to fact that it needs focused systems that are enabling the higher system visibility. To improve quality of services and enhance patient safety by reducing the medical errors, Radio frequency identification (RFID) is considered as one of the emerging tool assist in meeting the challenges of the present situation [8].

Although RFID technology has obvious advantages over other identification technologies such as barcode, its adaptation lags behind the optimistic expectation of early years. In USA, over 25 million RFID tags are supplied into healthcare institutions in 2008. But growth rate for RFID hardware slowed from over 2005 through 2008 [9]. The adaptation of healthcare industry has been lingering since diffusion of other sectors. RFID based applications provide better visibility that leads significant increases in-patient care, equipment usage efficiency and medication safety. In the existing literature, RFID applications can be classified into three mainstream disciplines in medical area, such are *medication management*, *personnel management* and *asset management* respectively [1].

3.1 Medication Management

Increasing of the expected life period, human life has been extended with complex prescribed medication. Aging society causes frequently taking wrong pill issues or waste medicine due to neglect of taking medications. Children and infants are in risk group of wrong medication dosage. Most observed medication error type is dose calculation errors in pediatric services. These errors are caused by nonexistence of medicine forms for children [10]. Using RFID in healthcare service area reduces human errors and enhances tracking of drug inventory levels. As medication dispensed with automated dispensing boxes inventory levels can be monitoring easily. A new system has been offered as a design of smart pillboxes that consist of one master panel and seven portable panels. It can remind the user to take medicines at specified times. Smart pillboxes are considered to mobile indoor units and can be used in most active services in hospital [11].

The RFID-based intelligent medication error and compliance monitoring system is designed as medical cabinet. A system consists of a computer, an RFID reader, a WLAN access point and some tags were attached to user's medical packages. User wears a wristband tag for identification by the reader installed in the medical cabinet while taking the tag-attached medical packet at home [12]. Visual and voice alarms would be triggered if either user ID or medical packet ID did not match to that stored in database beforehand. In addition, a SMS message would be sent to user's caregiver or families if user forgot to take medicine 30 minutes later than schedule. It would provide more accurate monitoring outside of hospital and useful for doctor diagnosis with integrated health records.

RFID tags decrease unnecessary steps and facilitate lean process in inpatient process. A new medication safety management with RFID technology that called WARD (Wise Aware RFID Dosage) has been facilitated a new solution for hospital environment. The system contains specific medication barcode as the index of patient’s medical order. Each patients need to carry a wristband embedded with RFID tag. System is integrated with pharmacy delivery mechanism; the pharmacist staff can be monitoring the packing and dispatch process to prevent the errors that may occur [13].

Counterfeit drugs are notably growing problem in pharmaceutical supply chain. Pharmaceutical tracking system has been put into practice since 2010 in Turkey. The main aim of this system is tracking movements of drug packs at national pharmacy system. With integration of the RFID system into Hospital Information System (HIS) enhances in-patient safety against counterfeit drugs. To prevent any medication errors a hybrid system ensures the validation of original drugs with Data Matrix barcode and RFID tags. Drug packs are labeled with Data Matrix barcode and pallets or containers are tagged with RFID tags that provide double check the integrity of drug data [14].

3.2 Personnel Management

Another significant category in healthcare is the access and control of healthcare staff especially nurses and physicians. Several studies analyzed the performance of healthcare staff is related with accurate and timely workflow and services. Implementing RFID applications such as Wi-Fi based real time location systems increases high availability of medical personnel in needed places [15].

Hospitals struggle to improve health care personnel behavior and for assessing the accuracy of staff behavior RFID tracking system can be used. A commercial RFID tracking system was assessed to improving hand hygiene as part of infection prevention control [16]. Another preventative RFID application was proposed that called as Contact History Inference Model (CHISM) is developed to prevent health care personnel from superbugs contact behavior can be monitoring with proximity sensing approach by aid of RFID tags and readers [17].

The observed hygiene compliance rates among healthcare workers (HCWs) have been regarded unacceptably poor by public health authorities. Several methods for monitoring hand hygiene have been proposed; among them is the direct observational survey. However, direct observational surveys suffer from several limitations. They are time-consuming and costly; they do not allow continuous monitoring; and they only provide information about a very low percentage of all hand hygiene opportunities. Due to fact that a new patented radio frequency identification (RFID)/location-based device coupled with an alcohol dispenser sensor

(MediHandTrace®) system results have been compared with direct observational [18]. Still video recording as a gold standard, MediHandTrace® offers real-time continuous automatic hand hygiene compliance recorder to understanding non-compliance and evaluating innovative techniques.

Nurse and patient interactions are critical to improve service quality of hospital. Many advances have happened in both hardware and software side of nurse call system. Most common nurse errors are caused by communication problems and tiredness [19]. To prevent medical errors that are caused by nurses offering an innovative solution is mobile nurse whiteboard system. System allows nurses to construct and route messages through system [20]. It also allows redirecting workload of overloading personnel thorough whiteboard control system.

3.3 Asset Management

RFID-enabled asset management is considered tracking mobile hospitals assets and increases the utilization of these that can be transferred between services in facility. In managing mobile clinical assets there are three main occurrences. The hiding and hoarding by hospital staff. The hiders will find assets as needed other staff are unable to locate and use the item when it is not in use. Staff fails to clean used assets appropriately, maintain them and place them back into rotation for use of mobile devices. Fixed or stationary objects can be tracked with portable RFID scanners [15].

MRI machines, X-Ray equipment are large and expensive assets. They never meant to move and fastened in place. Defibrillator and emergency beds are small and less expensive assets that can be placed under lock and key. High mobility of those items requires precise tracking process to reducing operation time. For example, RFID tagged operation room supplies reduces the likelihood of tool or sponge inside patient. Tagging wheelchair allows patients to be transported and discharge more quickly [21].

Thousands of mobile assets are circulating in hospitals, representing millions of dollars in capital and operating expenditures. The availability of mobile assets is critical, especially in life-threatening situations. Medical equipment is used daily for a wide variety of diagnostic and therapeutic services to patients. A research was conducted at Duke tertiary care hospital and according to their research findings, the efficiency of infusion pump utilization notably improved with application of RFID tracking system [22]. In another study, the management of IV pumps with RFID system has been criticized and also offered new standard operation procedures in the light of new findings. The personnel cannot track IV pumps as they move through the hospital, neither when being used by clinical staff for patient care nor when being handled across the hospital by non-clinical staff such as warehouse clerks or biomedical engineers. The lack of real time visibility is increased by a new proposed RFID tracking system [6].

4. CONCLUSION

This paper presents a comprehensive review of articles dealing with RFID applications in the healthcare. Cross section fields of health care and supply chain management had been investigated with context of RFID-enabled applications. With respect to improving direct patient-care processes, RFIDs can dramatically reduce unnecessary steps and facilitate lean processes. RFIDs have a potential to use all along the medical supply chain particularly, medication and equipment location, inventory control.

These areas will be come out in with the re-designation of Turkey's health system the Legislative Decree No. 663. Because of changes in the health system, hospital information systems have also changed under the establishment of Public Private Partnership integrated health camp uses (city hospitals). In the new system, establishment of general secretary singles hospital information management system changed and multiple integrated hospital information management system has begun to move. New system may have caused multi deployment of many local developments of in-house tracking systems. For example, at the second region general secretariat in Ankara there are 24 and in Konya 20 hospitals are located. These new integrated structure has made an already complex enough to manage the health care system even more insurmountable. The Ministry of Health was shown an interest of RFID technology with deployment of national drug tracking system since 2010. Although patient monitoring and inventory tracking system that are widely used RFID applications has been limited to local hospitals. In the light of best practices, integral information of reviewed studies to be integrated into the new administrative structure will emerge as an effective method in terms of time and cost control. Research in RFID technology valuation is needed to show the benefits and savings of technology. Healthcare institutions are limited resources can begin to find simple application areas along with hospital information system. The impact of such changes could be the subject of future research.

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MANAGING THE TRAFFIC OF COMPONENT PACKAGING BETWEEN A MAJOR AUTOMOTIVE MANUFACTURER AND ITS SUPPLIERS: THE PROCESS OF MOVING TO THE RFID PRACTICE

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Abstract − In a supply chain, the circulation of component packaging between major manufacturers and their suppliers is a process that must be properly managed. Some misuses such as transferring the component packaging to unauthorized companies or holding it for internal use in an unrelated area of the supplier plant cause big burdens on the annual budget of a manufacturer due to replacement costs. This work includes the investment analysis for a system that will identify the whereabouts of component packaging and the selection of the most qualified supplier of the intended system. At the beginning, we studied the barcoding and RFID (radio-frequency identification) methods which were technologically feasible among all the automatic identification (auto ID) alternatives. We determined that the RFID option was applicable after performing the steps of an economical evaluation and an execution of Analytical Hierarchy Process. In the second stage, we applied two integrated approaches each comprising of two steps. The first step provided relative ratings of the supplier alternatives by either TOPSIS or PROMETHEE which are common methods of multi-objective decision making. The second step finalized the supplier selection by using a 0-1 Goal Programming model that aims to reach the expectations on total cost and system accuracy while considering the overall ratings of the supplier alternatives. We also compared the results obtained by alternative approaches. As a result, we suggested a framework to select a supplier which will install a monitoring system for the movements of component packaging with the highest possible benefit throughout its lifetime.

Keywords − Goal programming, Multi-objective decision making, RFID, Supply chain, Supplier selection.

INTRODUCTION

Over the last three decades, the concept of supply chain has been a key issue focused by many successful companies. A supply chain includes all parties which directly or indirectly contribute to fulfillment of customer demand. The supply chain consists of not only the manufacturers and suppliers but also transporters, warehouses, retailers and even customers. In a supply chain, there a number of geographically dispersed facilities in which raw materials, intermediate products, or finished goods are acquired, transformed, stored or sold. The facilities which may be operated by vendors, customers or third-party providers need to be efficiently connected by transportation links throughout the supply chain. Within each company, all functions may be organized based on their primary contributions to the supply chain [1, 2].

In order to better serve the customer with growing expectations, an increasing number of companies prefer to concentrate on their stronger areas while getting support from their suppliers in other cycles of the supply process. Meanwhile, choosing the right suppliers and coordinating all efforts towards a better customer satisfaction remain as a very challenging task for the key player in the supply chain environment [3, 4]. Some of the processes that are increasingly delegated to a supplier are component fabrication, logistics operations including transportation and warehousing, and even information technology. Since the operations of a process

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are scattered over geographically dispersed facilities, transportation of the material becomes one of the support activities that must be carefully tracked so that the smooth flow of the end product towards the customer can still be maintained. It is mostly the job of the major company in the network to provide the returnable cases or containers for the material during the inbound and outbound transportation. The investment for these cases and containers occupy a considerable portion in the budget of a company including the originals and replacements required in the progress. Most of the firms need to set up a method to trace the returnable containers because of extreme costs to replace missing containers. Therefore, returnable transport units and adequate tracking technology complement each other [5].

This study was motivated by the project initiated by one of the major automobile manufacturers of Turkey to track the returnable containers used during the two-way transportation from and to its suppliers. This automobile manufacturer estimates that a viable method will quickly pay back the replacement costs for the lost and unreturned containers. A tracking system is supposed to provide the information on the whereabouts of each individual containers so that it can be used when necessary.

This paper is organized as follows. Literature Review provides a brief literature survey on returnable container tracking and supplier selection. Problem Definition defines the content of the problem under study. Proposed Method and Application provides details on the phases of this specific project, such as selection of the proper technology and selection of the competent supplier for the particular technology and also summarizes the results obtained in the content of this study. Conclusion closes the paper explaining the contributions of the current work and possible extensions of the integrated method in the future.

LITERATURE REVIEW

The concept of supply chain became concrete with the era of globalization in the 1980s. However, the conscious collaboration of companies under the definition of "supply chain" in order to compete with other supply chains started in the 1990s. After discovering the necessity for integrated solutions, academic studies on supply chain management accelerated at the beginning of 2000s [6]. However, there are still some differences in the definition of "supply chain management". A study done among the members of Council of Supply Chain Management Professionals indicates that the following definition is more preferred: "Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities" [7].

Supply chain management is based on the principle that a major manufacturer coordinates the efforts of a manageable number of companies called suppliers or vendors in order to provide the best value to the customer. Meanwhile, some news terms were coined such as supply chain collaboration (SCC), which is viewed as a business process whereby two or more supply chain partners work together toward common goals. SCC has also been defined as the formation of close, longterm partnerships where supply chain members work together and share information, resources, and risk to accomplish mutual objectives [8]. When some manufacturing steps of the supply process are outsourced to competent suppliers, it is the responsibility of the major manufacturer to track the material traffic. Since these material tracking duties may result in a tremendous amount of efforts when everything is done manually, it is wise to implement some technological methods to preserve the savings obtained by outsourcing [5].

In order to speed up the logistics processes between the major manufacturer and its suppliers, automatization of the information sharing becomes a necessity. It is generally deliberated that automatic information sharing requires some advanced technology. However, there are some examples that were made possible even when the technology was in its infancy. Automatic identification of an object and its features has been the subject of many research studies and commercial and governmental applications since the World War II. The earliest application was the *identity friend or foe system* (IFF) used by the British Air Force to identify their aircrafts by using radio frequency identification (RFID). In 1960s, some commercial applications took place to protect the department stores against theft. In 1970s, several research projects were initiated in commercial, governmental and academic institutions in order to develop solutions for the future [9]. Over the years, many automated data collection methods were developed, each coming with different technological and economical aspects, such as barcodes, biometrics, machine vision, magnetic stripe, optical card readers, voice recognition, and smart cards [10].

There are several academic studies that exemplify the current and future applications of RFID and similar technologies in the supply chain as remedies to a wide range of problems, such as continuous replenishment in vendor-managed inventory, information exchange to improve the coordination and reducing the supply chain costs, etc. Meanwhile, the same studies also point to the fact that the lack of adequate planning and careful analysis may lead to certain failures because of unforeseen risks. A short list of these risks are as follows: “scarcity of qualified suppliers”, “dominance of the major company on how to implement RFID” and “lack of standardization in the technology”. When it comes to the economics, it is not cost-efficient to implement these technologies to every echelon of the supply chain. Therefore, these investment for promising technologies which are surrounded by hidden costs must be analyzed properly by some approaches with broader perspective [9, 11, 12].

Technology adoption and supplier selection problems fall in the wide class of multi-objective and/or multi-criteria decision making problem. In the literature, there are several studies that suggested various methods to obtain well-balanced solutions to these challenging problems, such as Analytical Hierarchy Process (AHP), TOPSIS, PROMETHEE and engineering economy. Since there are occasions where some of these methods may fail to obtain a sustainable solution, it is wise to check the consistency by using another method(s). In order to further improve the robustness of the solution, it is common to apply some integrated techniques including powerful methods in their intended stages [3, 9, 12, 13, 14].

PROBLEM DEFINITION

The objective of this study is to analyze the investment for the container tracking system between a major automotive company and its suppliers and to contribute in the purchasing decision processes. The automotive company works with 37 local suppliers and uses 149 different types of containers to provide the material flow from and to the suppliers.

Currently, the company uses some shipping documents that accompany the material containers to identify the whereabouts of each container when necessary. The material flow in the plant is controlled by two departments, such as the managerial acceptance warehouse and the assembly line supply department. In the managerial acceptance warehouse, the containers are unloaded from the trucks coming from the suppliers and a quantitative inspection is done to compare the real amount and the specified amount in the document. If the real amount and the specified amount are not consistent, this information is sent to the supplier and the purchasing department through the computer system. If the real amount is more than the specified amount, the purchasing department pays the cost of the additional amount to the supplier. If the real amount is less than the specified amount, inventory levels are checked. If the current inventory is enough to cover the production cycle, it is not necessary to request an extra shipment from the supplier. The supplier will not be paid for the missing material and this information is sent to the supplier. If the current inventory is not enough to cover the entire production run, an urgent shipment is requested from the supplier and the material comes in carton boxes.

After the inspection, the material is carried to the proper locations in the warehouse by forklift trucks. It was already planned which assembly line will be supplied by which components and how long. The component are packed according to these lists and loaded to the carts. The operators of the assembly supply department take the material carts and pull them to the proper locations near the assembly line. When the component containers become empty, they are taken by the operators to the empty container park. The production planning department has already determined the number of components to be used for production and this information is saved in the computer system. Empty containers which are enough to cover the production plan are loaded to the trucks leaving to the suppliers. Numbers of containers that leave the company are documented and this information is sent to the supplier. Similarly, the containers coming from the suppliers are also checked in the managerial acceptance department.

Since there are more than one check-points in the company, there are some disruptions in the system, such as inconsistency in the number of containers, risk of production stoppage due to missing containers and cost of additional carton boxes. It is not quite possible to perform a simultaneous and coordinated container counting covering all suppliers. It is also not possible to know the exact number of containers since the information on the damaged containers is not sent to the company. Since the containers are sent to various companies with the same code number, it is not rare to observe that a supplier receives the improper container. In this case, the intended supplier receives an inadequate number of containers which necessitates the use of carton boxes with an additional cost due to single use.

In order to solve these problems, it is necessary to implement a tracking system to efficiently identify the location and condition of the containers in circulation. This study was done to analyze the investment and to support the purchasing decision processes. There are two major decision processes that the company uses to analyze this investment: Stage I – Investment alternatives evaluation process: Deciding on which technology to be used for tracking system, and Stage II – Supplier selection process: Selecting the supplier from which the technology to be purchased.

PROPOSED METHOD AND APPLICATION

In this study, we use a two-stage method. In the first stage, in order to support the technology investment analysis process of the company, the most suitable technology will be identified by using economic analysis and Analytical Hierarchy Process (AHP). In the second stage, in order to determine the best supplier from which this technology to be purchased, two integrated methods comprising of TOPSIS and PROMETHEE accompanied by 0-1 Goal Programming (GP) will be used comparatively. Later on, a final cost analysis will be performed at the end of the purchasing process. The proposed solution approaches are sketched in Figure 1.

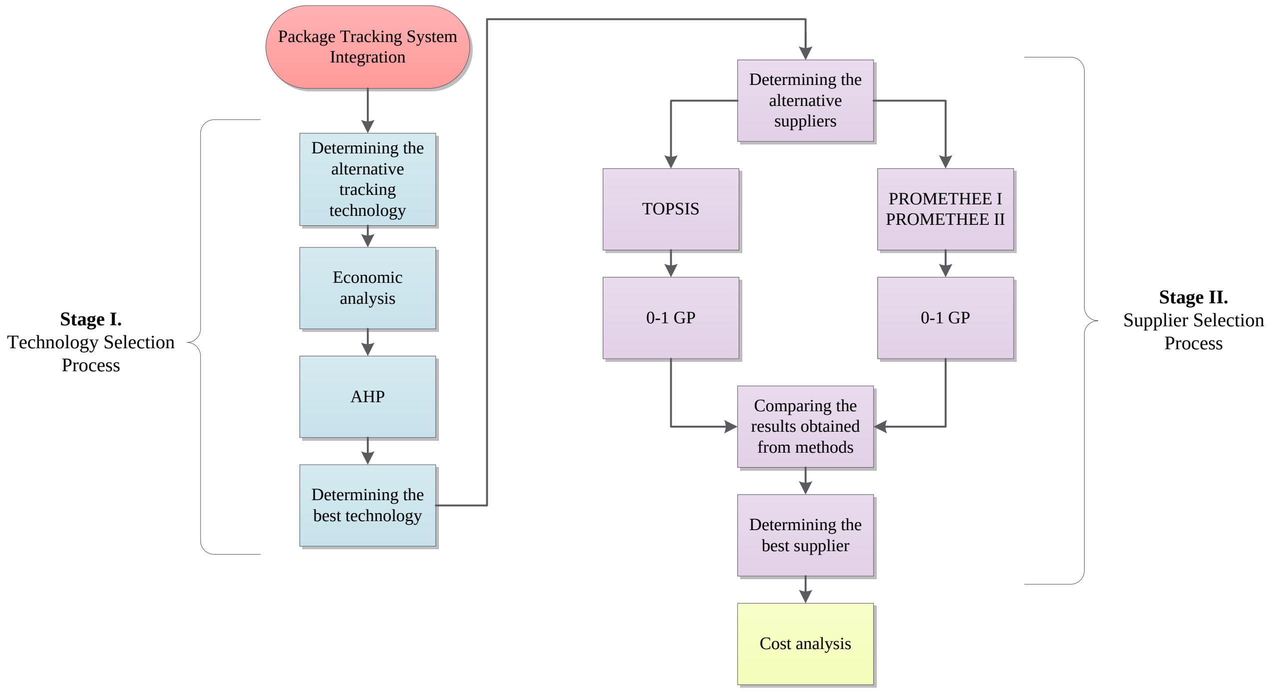

Figure 1. The flow chart of the proposed method

Technology Selection Process

In order to decide on which technology to be used for the tracking system, initially a feasibility study was run and then the AHP method was used. As the alternatives for the tracking system, RFID and Barcode were considered among all the current Auto-ID systems.

Economic Analysis

Net present value (NPV) and internal rate of return (IRR) methods were used to economically analyze RFID and barcode systems. The following components were considered in the financial analysis section of the feasibility analysis of the RFID system: Hardware (Label, Reader, Antenna and Depreciation), Software, Service (System integration, training, maintenance and support) and the cost of carton boxes. The components of the similar analysis for the barcode system are as follows: Hardware (Barcode label printer, barcode reader, LED, Lens protector, unique license calibration card and depreciation), Software, Service (System integration, training, maintenance and support), the cost of misreading and the cost of carton boxes.

The net present value (NPV) of the investment is calculated by subtracting the present value of the expenditures from the present value of the incomes as follows:

$$NPV = -I_0 + \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} \tag{1}$$

where I_0 is the initial investment (period 0), T is the number of periods, C_t is the cash flow in period t (t=1,…,T) and r is the annual interest rate.

The internal rate of return (IRR) for the investment is calculated as follows:

$$0 = -I_0 + \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} \tag{2}$$

Considering the cash flows of RFID and Barcode systems and assuming an annual interest rate of 18 % and a project duration of 7 years, NPV and IRR values for both alternatives were calculated as shown in Table 1. Both systems have IRR values greater than 18 %. When the incremental analysis method for RFID-Barcode were used, the IRR value was calculated as 35 %. RFID was evaluated as more economical after applying both methods.

Table 1. Results of economic analysis for RFID and Barcode

Method	RFID	BARCODE
NPV (€)	478,567.27	429,345.27
IRR (%)	90	141

Analytical Hierarchy Process (AHP)

AHP is an intuitive method formed to analyze the alternatives of a decision problem and determine the alternative providing the best performance under a number of given criteria. In an AHP model, the concrete and abstract criteria that affect the decision making are digitalized, compared and their relative preferences are obtained and finally put in an order of importance [15]. However, only the monetary factors of the alternatives are considered in the economic analysis. Therefore, AHP method was used to extend the analysis to include all criteria when evaluating technology alternatives.

The following ten criteria are considered when evaluating the system:

1. Cost (C_1)
2. Durability (C_2)
3. Precision/capacity (C_3)
4. Lifetime (C_4)
5. Applicability (C_5)
6. Efficiency (C_6)
7. Project time requirement (C_7)
8. System reliability and performance (C_8)
9. Ability to integrate to the current system (C_9)
10. Compatibility to data filtering (C_{10})

The company representatives were interviewed to identify their relative preferences for pairs of criteria. Then, the performance of each alternative with respect to a given criterion was determined. After the standard procedure was applied, it was observed that the alternative of RFID outperformed the alternative of Barcode as shown in Table 2.

Table 2. Results obtained for criteria preferences and the best alternative

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	**Grade**
RFID	0.13	0.89	0.89	0.88	0.50	0.89	0.17	0.88	0.14	0.50	0.643
BARCODE	0.88	0.11	0.11	0.13	0.50	0.11	0.83	0.13	0.86	0.50	0.357

Supplier Selection Process

In the second stage of the decision making process, the supplier from which the technology products to be purchased was determined. At first, both systems were evaluated by using TOPSIS and PROMETHEE methods. Additionally, in this work an integrated method is suggested in which TOPSIS and PROMETHEE results are further evaluated. We compare the results of both integrated methods.

TOPSIS

The TOPSIS method is based on the concept that the selected alternative should have the shortest distance from the positive-ideal solution and the longest distance from the negative-ideal solution [16, 17].

The following criteria have been identified along with the opinions of the company representatives:

1. Quality and Safety: Reading the labels with almost zero-error. It is very important for the company that the readers can sense the labels from very different angles. It is required that the RFID labels that will be attached to the existing containers be durable against changing weather conditions and impacts and also securely hold the information about the products in the containers (A_1).
2. Warranty Assurance: The warranty time assured by the supplier for its products (A_2).
3. After-Sale Service, Software and Technical Support: Providing the necessary technical support during and after the project, periodical maintenance and software support in the company or by a service partner (A_3).
4. Flexibility: The property of the label being able to be read by different readers and when the production plan is changed the tracking can be done by changing the labels on the containers (A_4).
5. Experience of the company: The references of the supplier (experience of working with big well-known companies) and an experience of a similar project is important for the company (A_5).
6. Applicability: Required time to implement the stages of the technology (preparation stage, testing stage and operation stage) (A_6).

After some initial interviews with supplier alternatives, the company representatives filled out a questionnaire to obtain pairwise comparisons for the final group of suppliers $S1$, $S2$ and $S3$ with respect to the above criteria. The decision matrix were formed and grades in the matrix were normalized. After the distances of each alternative to the positive and negative ideal solutions were obtained, these are used to calculate the relative distance to the ideal solution (C_i^*).

Table 3. Relative Distance to Ideal Solution

Suppliers	C_i^*	%
S1	0.739	0.43
S2	1.000	0.57
S3	0.000	0.00

As seen in Table 3, the suitability sequence of the alternatives is $S2 \succ S1 \succ S3$.

TOPSIS and 0-1 Goal Programming Model

The goal programming approach used to solve multi-objective problems try to minimize the deviations from the target values to be achieved. In this work, the sequence obtained by TOPSIS method considering the qualitative criteria was used as a special constraint in the 0-1 GP model along with other goals that the company desires to achieve when selecting the best supplier. The notations for the 0-1 GP model used for this purpose are as follows:

Indices:

i index of goal (i = 1 ,…, I)

j index of supplier (j = 1 ,…, M)

Parameters:

P_i coefficient of the goal i

a_{ij} coefficient indicating technology achievement of supplier j on goal i

b_i target value of goal i

Decision Variables:

$$X_j = \begin{cases} 1 & \text{if supplier } j \text{ is selected} \\ 0 & \text{otherwise} \end{cases}$$

d_i^+, d_i^- variables indicating positive and negative deviations from goal i

The parameters used in the model are given in Table 4 (total cost is assumed as €600,000). The model based on this information is as seen in the following formulation GP1:

GP1:

$$Min\ Z = P_1\,(d_1^+) + P_2(d_2^+) + P_3(d_3^+) + P_3(d_3^-) \tag{3}$$

Subject to

$$516000X_1 + 800000X_2 + 320713X_3 + d_1^- - d_1^+ = 600000 \tag{4}$$

$$0.012X_1 + 0.001\,X_2 + 0.03\ X_3 + d_2^- - d_2^+ = 0.013 \tag{5}$$

$$0.43X_1 + 0.57X_2 + d_3^- - d_3^+ = 1 \tag{6}$$

$$X_1 + X_2 + X_3 = 1 \tag{7}$$

$$d_i^+, d_i^- \geq 0 \tag{8}$$

$$X_j \in \{0,1\} \tag{9}$$

The objective function which is expressed by Eq. (3) minimizes the total weighted deviations from the goals. Eq. (4) expresses the budget goal, Eq. (5) indicates the error-rate goal, Eq. (6) shows the TOPSIS priority goal and Eq. (7) makes sure that only one supplier is selected. Finally, Eqs. (8) and (9) indicates that the decision variables corresponding to deviations should be nonnegative and the decision variables corresponding to selection of suppliers should be either 0 or 1, respectively.

The developed model was solved by using the Gurobi 6.0.0 solver in the MPL 4.2 mathematical modeling environment. The solution shows that selecting the supplier $S1$ provides the highest benefit.

Table 4. Parameter Values

Constraints	**Suppliers**			**Goal Value**
	***S*1**	***S*2**	***S*3**	
Total Cost (€)	516,000	800,000	320,713	600,000
Error Rate	0.012	0.001	0.03	0.013
TOPSIS Priority Value	0.43	0.57	0	1

PROMETHEE I and II

The PROMETHEE methods are a class of outranking methods for a finite set of alternative actions to be ranked and selected among criteria, which are often conflicting [14]. In this study, the criteria considered in the TOPSIS method were also used in the PROMETHEE methods. The common preference functions were formed for pairs of alternatives according to the basic preference functions developed by Brans and Vincke [18]. Later, positive and negative dominance results were obtained by using the preference indices for each pair of alternatives. PROMETHEE I was used to obtain the partial priorities and PROMETHEE II was used for complete priorities. The complete sequence of priorities was obtained by evaluating all alternative on the same basis considering their complete priority values (Table 5).

Table 5. PROMETHEE I partial and PROMETHEE II complete priority values

	Suppliers		
Method	***S*1**	***S*2**	***S*3**
PROMETHEE I	0.329	0.630	0
	0.149	0	0.810
PROMETHEE II	0.180	0.630	-0.810

The results obtained by PROMETHEE I and PROMETHEE II show that the priority sequence of suppliers is $S2 \succ S1 \succ S3$.

PROMETHEE II and 0-1 Goal Programming Model

In order to introduce the results of PROMETHEE II in the context of 0-1 Goal Programming, Eq. (6) of GP1 is replaced by the following Eq. (10) to express the PROMETHEE II priority goal and all remaining constraints of GP1 are used to form a new formulation GP2:

$$0.180X_1 + 0.630X_2 - 0.810X_3 + d_3^- - d_3^+ = 1 \tag{10}$$

When the model was solved considering the total cost and error rates in Table 4 and PROMETHEE II priority results, the supplier $S1$ was obtained as the best solution. As seen in the previous sections, the same best solution was obtained as the supplier $S1$ when TOPSIS and PROMETHEE II results were introduced as priority constraints in the 0-1 GP model individually. All results are summarized in Table 6.

Considering the offer made by the selected supplier, total cost of the project is €503,957.5 while net present value is €15,018.05. The pay-back period of the period is 4 years and its internal rate of return is 19 %.

Table 6. Comparison of the Results Provided by Suggested Methods

TOPSIS	PROMETHEE I & II	TOPSIS + 0-1 GP	PROMETHEE II + 0-1 GP
$S2 \succ S1 \succ S3$	$S2 \succ S1 \succ S3$	$S1$	$S1$

CONCLUSION

Radio Frequency Identification (RFID) is being increasingly used to track products and materials by utilizing the radio waves. In this work, a technology investment for an RFID system that will provide the container flow information between a major automotive company and its suppliers has been evaluated. The utilization of this system will provide the tracking of the containers, inform the company about the damaged containers in case and prevent the inventory level of the material from dropping below the critical level. Even though the project has several benefits, it is necessary to properly evaluate the economical factors since the project has a high initial cost. For this reason, the technology investment of the company for the RFID system was taken into an economic analysis. In order to provide a comparison between alternative investments, the analytical hierarchy process was applied. As a result, the suggested solution has provided a guidance for the decision makers to consider the critical factors in the RFID investment and collaboratively found the best system to be implemented.

This work has considered the problem of feasibility evaluation for the technology infrastructure to be purchased by a major automotive company to track its material containers and selection of the supplier that gives an offer which is both competent and economical. Therefore, technology investment alternatives were economically analyzed. Moreover, the analytical hierarchy process was used to extend the analysis to include other non-monetary critical factors as well when comparing alternatives. As a result, the suggested method showed the decision makers that the RFID option is the most suitable alternative for this specific purpose.

Tracking of the material containers by the RFID system will provide the company with the information on the damaged containers and prevent the stock-outs of the critical components from occurring. In spite of these potentials, this RFID investment with a high initial cost can provide the expected benefits only if it is properly tailored to the requirements of the company. There are many criteria that affect this kind of investment decisions. Therefore, TOPSIS and PROMETHEE methods, which are viable methods of multi-criteria decision making, were used to consider all related criteria in the process of selecting the best RFID supplier. Moreover, the alternatives which have been weighted by the results of both methods were individually evaluated in a 0-1 GP model. All results obtained by different methods were compared to check the consistency. As a result, the best supplier was selected by considering all critical factors that affect the investment decision.

This work may also be helpful to others dealing with facility location, purchasing and marketing problems which require the consideration of multiple objectives and/or criteria. When the problems have a natural structure with tangible and intangible costs and allow a solution process to be applied in stages, the suggested method in this work may be of help. The multi-criteria decision making methods used in this work can be easily replaced by some equivalents as requested by the concentrated problem.

Some future work may include an integration of the fuzzy logic approach and/or stochastic linear programming to classical methods of multiple criteria decision making in order to better represent and resolve the uncertainties in the supply chains.

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GEOGRAPHICAL INFORMATION SYSTEM BASED OPTIMIZATION OF INVOICE CLERK ROUTE FOR ACCRUING

Nevra AKBİLEK

Abstract- Electricity and water distribution companies have a large number of subscribers and make a deal with reader companies for billing timely of the subscribers. In this article the Travelling Salesman Problem defines as invoice clerk that is referred to as reader task for accruing. All distances of the TSP problem were obtained from geographic information systems. Genetic algorithm method is used optimization of invoice clerk route. The routes of all streets in the county assigned to the reader are optimized in this study. In conclusion, time savings achieved and the required number of workers has been reduced.

Keywords: optimization; genetic algorithm; travelling salesman problem; geographical information system

1. INTRODUCTION

Traveling Salesman Problem (GSP) is firstly defined mathematically by Karl Menger at the begining of 1930 (Menger, 1932). It is one of the combinatorial optimization problems that many researchers and academics are working on. Although easy identification of this problem, its solution is very difficult. This problem is among NP-hard problems in the literature (nphard) (Garey and Johnson, 1979). Traveling salesman problem has wide application especially in distribution, planning, logistics areas. Today, businesses are forced to use scientific methods rather than being based on experience by emerging technologies and globalization. Businesses provide cost savings and competitive advantage with scientific approaches. Genetic algorithm is one of the meta-heuristic methods commonly used in the solution of combinatorial optimization problem. Genetic algorithm (that is)a search and optimization method works similar to the evolutionary processes in biological systems has been proposed by Holland in 1975. Rapid and satisfactory results are obtained by genetic algorithms have been used in the solution of many optimization problem. A solution was sought to the traveling salesman problem by genetic algorithm method in this study. The developed method is encoded with java programming language. Data of readers (that are) assigned to locations for billing of the subscribers of a water distribution company in Turkey, has been used. The results obtained showed (that) the more efficient route and cost savings can be achieved by the use of this method

2. TSP Problem

3. Distance calculation by geographical information system data

The following equation is used to calculate the Spherical internalangle. This equation is called as Harvesine equation. The Harvesine equation shown below is used to calculate the Spherical internalangle.

A sample calculation :

3. The Proposed genetic algorithm

4. Computational Results

4.1 Data Gathering

The distribution company with the aim of providing services to subscribers has 4.5million subscribers. Having a greater number of subscribers is a factor that makes it difficult to provide timely customer service. The tender agreements are made with reader companies in order to eliminate this difficulty. These reader companies are listed in table 1.

Reader company code
2
9
102
112
113
124

Table 1. Reader companies

Subscribers are distributed to reader companies. So, companies have undertaken to billing the county groups. the county groups has undertaken for billing . At the end of this distribution the companies has undertaken county groups for billing.

Reader codes	**COMPANY CODE**
GPK124018	124
KKK124015	124
KKS124004	124
KKO124037	124
KKO124038	124
KCO124005	***124***
…….	……….

Table2. The reader company 124

While subscriber is assigning to the selected reader , a transaction number is generated for each assignment. A transaction number comprises daily reading data about the subscribers.

Transaction number	**Transaction type**
555000586	23
560001055	15
565003435	15
1510378520	***64***
555000590	15
587002007	61

Table 3. Transaction numbers

The data required from the main table to be used is shown in the following table 5.

Used data	**Data type**	**Explanation**
Transaction sequence number	NUMBER(7)	Sequence of record is hold
District/county name	VARCHAR2(20)	County where location is billed
District name	VARCHAR2(300)	District where location is billed
Street name	VARCHAR2(300)	Street where location is billed
Building number	VARCHAR2(4)	Building where location is billed
Transaction number	NUMBER(10)	Company name makes billing and billing dates
Reader code	VARCHAR2(11)	Job definition of invoice clerk

Table 5. Required data

Query applied to obtain the data required on the Oracle Database:

SELECT TRANSACTION_SEQUENCE_NUMBER, COUNTY_NAME, DISTRICT_NAME, STREET_NAME, BUILDING_NUMBER

FROM ELBMT016

WHERETRANSACTION_NUMBER=1510378520

ANDREADER_CODE='KCO124005 ORDERBY TRANSACTION_SEQUENCE_NUMBER;

1262 data was obtained by simplification of 27165 data.

4.2. Grouping:

1262 data contain only one county and one district.This is Kücükçekmece county and Sultan murat Street. Representative data is consist of 9 streets and 1262 invoiced subscribers. Therefore the reader(Invoice clerk) should read 1262 subscribers and stop 9 streets in daily business working hours.

The values of locations that must undergo reader shown in Table 5.

Street	latitude	longitude
MANSUROĞLU St.	40°59′55″	28°47′21″
Özden St.	41°0′7″	28°47′22″
Köprü St.	41°0′3″	28°47′22″
Aytürk Street	41°0′3″	28°47′21″
İpek Street	41°0′2″	28°47′10″
Emsal Street	40°59′57″	28°47′11″
Çizmeci Street	41°0′3″	28°47′20″

Güray Street	41°0′3″	28°47′18″
Özdemir Street	41°0′1″	28°47′25″
İpek Street Number:33	40° 59' 57"	28° 47' 8.361"
Menekşe Street Number:35	40° 59' 57"	28° 47' 11.52"

Table 5. Location values

4.3. Location recording

Latitude and longitude of the current location information is recorded and kept in Lokasyon.class . Necessary data for transaction is called from this location class.

$$(location(0), location(1), location(2) \ldots location(27))$$

4.4. Population formation

After the chromosomes that include the locations recorded are saved, it is necessary to create and initial population for next generations. Initial population size is 50 and every initial solution consists of 27 locations. Different values are tested to determine thepopulation size. In order to determine the more appropriate population size Goldberg method suggested in 1985 is used. Goldberg method depends only on the length of chromosome. Thus, if the chromosome length is n, population size must be selected between[n, 2n]. According to this method for n = 27 ,the width of the population have been selected among [27, 54] .

4.5. Fitness Value

The first step after the creation of ageneration is to calculate the fitness value of each member in the population. Thehigherfitnessvalue of a solutionthat is more chances for survival and proliferation. The higher fitnessvalue of a solution is, the more chances for survival and proliferation, and thus the representation rate of it in the next generation is going to be so high.

4.6. Objective Function:

$$\text{F}\,\boldsymbol{min} = \boldsymbol{distance} * (\boldsymbol{transaction\ speed} + \boldsymbol{walking\ speed}) \qquad \textbf{\textit{(1)}}$$

$$\boldsymbol{Fitness\_value} = {}^{\mathbf{1}}/_{\boldsymbol{distance}}$$

The total distance of the tour is determined by get distance function for fitnessvalue.

Distance calculation

The distance of members in a population is calculated by Havers fornula using the latitude and longitude information.Mathematically, this can be expressed as;

$$\Delta\widehat{\sigma} = 2\arcsin\left(\sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + \cos\phi_s\cos\phi_f\sin^2\left(\frac{\Delta\lambda}{2}\right)}\right).$$

4.7. Reproduce by Tournament method

Reproduction is a process in which the series are copied according to their fitness value.
In this study all reproduction methods are tested and tournament method is selected because of the better results/ turning out well in routing problems. The series is randomly selected from the generation and so, the individuals will be joined in the tournament. A tournament size of 5 is used also each individual participates in the tournament twice. Therefore, the best individual will succeed in both tournaments, and so, the selection process is completed .mutation rate = 0.010;
elitism = true

4.8. Elitist Strategy

Eliteststrategy of using the best individual fitnessvalue, is replaced by the worst individual, and thus ensuring the formation of a new society, a better individual.

4.9. Partially Mapped Crossover

Crossoveroperators can be divided into three main typesaccordingtothearity of theoperator (ComputationalIntelligence). These classes are sexual, multi-recombination. In this study sexual operator where two parents are used to produce one offspring by Partially Mapped Crossover(PMX) is applied. PMX is widely used in traveling salesman and vehicle routing problem. Because in this problems genes formed string need not be repeated in the same string and PMX method prevents this repetition.

Mutation Opertor

Crossover process, explores the potential of existing genes. If a satisfactory solution is not reached it does not contain any encrypted information that is needed to solve the population problem. Therefore the need for an operator capable of producing new individuals from existing gene pool. Mutations perform this task and so, genetic diversity is increased.

Mutation is applied at a certain probability to each gene of the individuals, to produce the mutated individual. Mutation probability, also referred to as the mutation rate. In this study the values between[0, 0.003] are tried as mutation rate and compared the differences. When mutation is executed, two genes selected randomly are swapped according to the probability.

5. The Results

Five sets of computational experiments are conducted and best result is choosed. According to it, population size of 60, the number of iterations 100, mutation rate is 0,010, and also elitism is used; starting from 2.633204878 km, the optimal distance is provided as 0.922201511 km.

Analysing the effect of GA parameters (population size, crossover rate and mutation rate) on the solution quality

Table 6. Analysing the effect of GA parameters (population size, crossover rate and mutation rate) on the solution quality

Population size	**Iteration number**	**Crossover rate**	**Mutation rate**	**Elitism**	**Initial Solution value**	**Objective function value**
60	100	0,9	0,01	true	2.633204878	0.922201511
40	100	0,9	0,01	true	3.127703241	0.965081232
40	100	0,9	0,001	true	2.778965567	1.499933052
60	100	0,9	0,001	true	2.965063646	1.293920309
35	100	0,9	0,01	false	3.133374831	1.399618448
GA parameters						

Our aim is spent shortest time in the area where the reader is assigned to billing. The minimal cost is result of shortest time and so, the reduction in cost as follows;

- Working hours : 8 hours/day
- Idle time : 2 hours/ day
- Salary of the reader : 1.300 tl/month
- Number of subscribers : 1262
- The number of districts where billing is done : 1
- The number of neighborhoods where billing is done : 1
- The number of streets where billing is done : 9

- Average walking speed. : 5 KM/hour
- Average transaction speed : 12 second/subscriber
- Total reader number : 534

Firstly, we find total time spent of the a reader

1. Total time spent = [distance traveled(km)/average walking speed(km/sa)] + [transaction_time * the number of subscriber]
2. The daily earnings are calculated from the salary of the reader

A reader's daily earnings = 1.300tl / month ÷ 20 days / month ÷ 8 h / day = 65 TRY / dayl cost

Total cost : **total_time(hour) *reader_cost(tl/hour)**

The results:

Total time of initial solution = [2.6332048782421555 km ÷ 5km/hour] + [1292 * (12/(60*60)hour] = 0,528 + 4,306 = 4 , 83 hour

Total cost of initial solution = 4 , 83 hour * [1.300 tl/month ÷ 20 day/month ÷ 8 hour/day]

= 4,83 hour * 8,125 tl/ hour

= 39,243 tl

Total time of final solution = [0.9222015110332569km ÷ 5km/hour] + [1292 * (12/(60*60)hour] = 0,184 + 4,306 = 4 , 49 hour

Total cost of final solution = 4 , 49 hour * [1.300 tl/month ÷ 20 day/month ÷ 8 hour/day]

= 4,49 hour * 8,125 tl/ hour

= 36,481 tl

The results are obtained by GA -TSP	Initial solution	Final solution
Total time(hour)	4 , 83 hour	4 , 49 hour
Cost (tl)	39,243 tl	36,481
Profit (initial cost – final cost) = 39,243 tl - 36,481 = 2,762 tl / day		

Table 7. The comparison of initial solution and final solution

The cost reduction obtained is about 2,762 per day for a worker.

For a worker ; monthly 2,762*20 =55,24 tl

Annual, 55,24 *12 = 662,88 tl cost reduction.

If you consider all the readers

534* 662,88 = 353,98 tl cost reduction.

A NEW MIXED-INTEGER PROGRAMMING MODEL FOR STRATEGIC AND TACTICAL FLEET PLANNING PROBLEMS IN INTERMODAL TRANSPORTATION NETWORKS WITH A REAL LIFE APPLICATION

Adil Baykasoğlu[166], Kemal Subulan[167], Nurhan Dudaklı[168], A. Serdar Taşan[169],
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Abstract − Recently, fleet planning in intermodal transportation has become an important issue for global logistics industry. In fact, fleet sizing and composition have to be addressed in an integrated way with mode selection, load planning, vehicle allocation and empty vehicle repositioning problems. For this reason, fleet planning problems are much more complex in intermodal transportation systems than unimodal road freight transportation. In this study, a mixed-integer programming model is developed to solve strategic and tactical fleet planning problems. The proposed model minimizes total transportation cost consisting of marine, rail and road freight transport costs for both export and import transportation operations. Finally, the proposed model is tested on a fleet planning problem of a large-sized logistics company and solved by LINGO 15.0 optimization software. The obtained results show that the proposed model is able to provide meaningful contributions in generating effective and efficient fleet plans in intermodal transportation networks.

Keywords − Empty vehicle repositioning, Fleet Planning, Intermodal transportation, Mixed-integer linear Programming

INTRODUCTION

Nowadays, there has been a growing attention to fleet planning problems in intermodal logistics networks by global logistics sector. In addition optimization of fleet sizing and composition has become a seriously studied research area in the recent literature. Although there are numerous studies on the logistics network design, hub location, transportation planning and vehicle routing problems; there is still a lack of studies in literature on fleet planning problems in intermodal transportation systems. In fact, most of the existing studies approached to these problems for logistics companies that provide only unimodal road freight transportation. Moreover, many papers in this field presented theoretical solution methodologies for hypothetical case studies instead of real applications. However, fleet planning problems in intermodal transportation will arise as a new research area because of the increasing interests to intermodal transportation by the logistics companies all over the world. In other words, strategic fleet planning decisions contain fleet sizing and composition, design of intermodal transportation networks, hub location problems whereas tactical level decisions involve load planning, vehicle allocation/reallocation, empty vehicle repositioning issues etc. Actually, fleet sizing and composition have to be addressed in an integrated way with mode selection, load planning, vehicle allocation and empty vehicle repositioning problems. For this reason, fleet planning problems are much more complex in intermodal transportation systems than unimodal road freight transportation. A brief summary of the articles handling fleet sizing and composition, empty vehicle repositioning is given as follows: The concept of fleet size optimization

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was first introduced by Kirby [1]. It was aimed to determine the appropriate fleet sizes of owned and hired wagons which minimize total expected cost in a small railway system. Wyatt [2] extended that approach by incorporating fixed and variable costs of per unit capacity for company-owned barges into the total transportation cost function. A linear programming model was proposed by Gould [3] to determine optimal fleet size and composition of an industrial firm in order to satisfy the seasonal variations in customers' demands. Piecewise linear approximations for costs were also included into that model using separable programming. A dynamic programming formulation was developed by Mole [4] to extend previous fleet sizing models in order to take into account the time dependency of optimal fleet size. A mixed-integer linear programming model was developed by Etezadi and Beasley [5] for a vehicle fleet composition problem. Determination of optimal fleet composition for a central depot which serves several customers was intended. A comprehensive literature review on empty vehicle redistribution in freight transportation was presented by [6]. The need for empty vehicle flows arises because of unbalanced loaded movements and these empty vehicle inventories should be balanced throughout the entire transportation network. This study revealed that there is a significant impact of an effective empty vehicle management on both operational and economic performance of the logistics companies. An approximate solution methodology was proposed by [7] for the integrated fleet sizing and empty vehicle redistribution by making use of a multi-location inventory model and Markovian decision theory. A two-stage stochastic programming model was developed by [8] for fleet sizing problem by incorporating the uncertainty related to future demands and vehicle productivity. An integer programming model was proposed by [9] to determine the minimum fleet size at a container terminal with lifting vehicles and capacitated buffer areas. A mathematical programming model was developed by [10] for determining the fleet size, allocating the rail-cars to several locations and redistributing of empty rail-cars. A mixed-integer programming model was proposed by [11] for the tactical transportation planning problem of an intermodal logistics network by incorporating production planning issues. Meisel et al. [12] extended the model of [11] by adding multiple types of commodity, production setups, master production scheduling in plants, inventory management and multiple time periods. A mixed-integer programming model was presented by Cheon et al. [13] for a railcar fleet sizing problem in chemical industry by emphasizing on the optimal fleet procurement plan. Redmer et al. [14] formulated two distinct mathematical models for the fleet composition problem of a medium-size fuel distribution network where the fuels are transferred from a central depot to the several gas stations. Linear and non-linear programs were developed by [15] in order to specify proper fleet size and investigate the effects of performing additional tractor repositioning moves on fleet size reductions in a less-than-truckload company. A novel modular heuristic algorithm depending on sequential paradigm was presented by [16] to solve fleet sizing problems for multi-depot and periodic vehicle routing problems.

According to the current literature, most of the existing studies mainly depend on the single mode freight transportation and handled the load planning, fleet sizing and composition, vehicle allocation/reallocation and empty vehicle repositioning problems in a separated manner. Based on these motivations, this paper presents a new mixed-integer linear programming (MILP) model for a multimodal fleet planning problem which combines load planning, fleet sizing and composition of multiple resources and finally empty truck/trailer repositioning issues. Apart from the existing literature, the import and export transport operations are considered simultaneously in the load planning component of the proposed model. In addition to the truck fleet size, the size of trailer fleet is also optimized. The transit times, period length or duration and truck/trailer availabilities are taken into account while determining the fleet sizes. The repositioning decisions on both empty trucks and trailers are made by considering the periodic truck/trailer inventories on the intermodal logistics network. To the best of our knowledge, a similar fleet planning problem which is studied through this paper is not encountered in the current literature.

The rest of the paper is organized as follows: fleet planning problem with its mathematical formulation is described in Section 2. In section 3, the proposed model is applied to a real-life case study of a logistics company operating in Turkey. The computational results are also presented in the same section. Finally, conclusions and future works are given in Section 4.

A NEW MILP MODEL PROPOSAL FOR FLEET PLANNING PROBLEM

In this study, a new multi-mode and multi-period fleet planning model with multiple resources is developed. In the intermodal logistics network, both import and export transportation operations are performed simultaneously. In the modelling phase, the load planning model is first proposed afterwards extended by incorporating the truck/trailer fleet sizing, loaded and empty truck/trailer movements. The examined fleet planning problem is portrayed as in Figure 1.

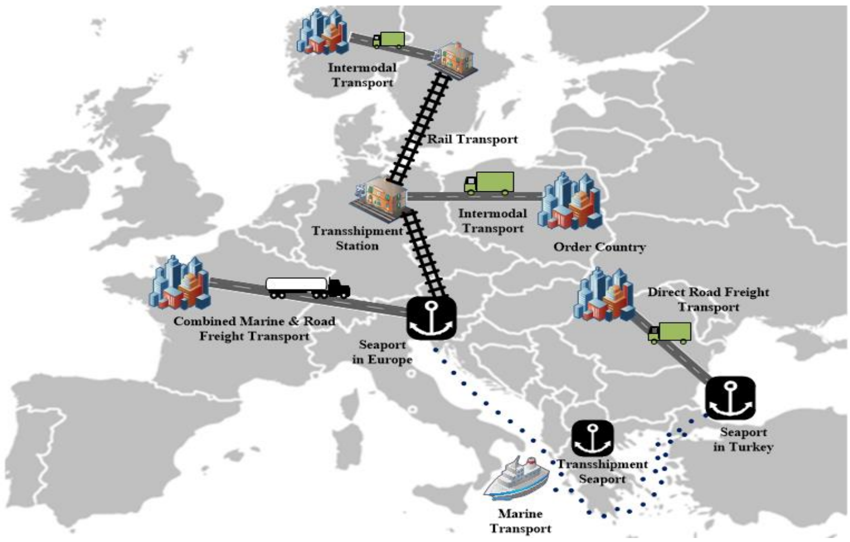

Figure 1. Schematic Depiction of the Fleet Planning Problem in Intermodal Transportation Network

The load planning model is developed based on the following assumptions: (i) The domestic distribution services in Turkey are not included within the proposed model, (ii) The shipments can be loaded/unloaded at transshipment seaports by only company owned Ro-Ro vessels, (iii) There is no capacity limitation on the transportation units (TUs) shipped by other logistics service providers' Ro-Ro vessels, (iv) In contrast to block trains, there is no limitation on the quantity of TUs transferred by the public trains. Since the big size and complex structure of the proposed model, it is partly presented in this section. The summary of the network notation with model parameters and decision variables are given in Tables 1 and 2.

Table 1. **Some Important Notations Used in Model Development**

i	seaports for export/import transports in Turkey, $i \in I$
j	seaports for export/import transports in Europe, $j \in J$
k	railway terminals for export/import transports in Europe, $k \in K$
l	order country in Europe (aggregated customers) for import/export transportation operations, $l \in L$
t	monthly time period, $t \in T$
$(i,j) \in L_{ij}$	set of seaports where transports can be performed by only other logistics service providers
$(i,j) \in B_{ij}$	seaports where both company owned & other logistics service providers' Ro-Ro vessels can operate
$j \in T_j$	set of transshipment seaports where shipments can be loaded/unloaded during transport service
$j \in \gamma_j$	the main destination/origin marine port which also incorporates the transshipment marine ports
$j \in D_j$	set of marine ports where directly connected with a railway terminal
$(j,k) \in C_{jk}$	set of rail lines where transports can be performed by only the fixed schedule block trains
$k \in D_k$	set of railway terminals where directly connected with a marine port
$k \in T_k$	set of transshipment railway terminals which have connections with other railway terminals

The goal of the model (1) is to minimize total cost of the overall intermodal transportation system composed of marine transport costs, rail transport costs and road freight transport costs. The road freight transportation cost is divided into three categories, i.e., costs for loaded trucks, empty trucks and trucks with empty trailers.

$$
\begin{aligned}
Min\ \ Z = & \sum_{(i,j)\notin L_{ij}} \sum_{l\in L} \sum_{t\in T} (R_{ijt}^{imp} + R_{jit}^{exp}).Co_{ij}^{imp/exp} + \sum_{(i,j)\notin C_{ij}} \sum_{t\in T} (P_{ijt}^{imp} + P_{jit}^{exp}).Cp_{ij}^{imp/exp} + \sum_{(j,k)\notin L_{jk}} \sum_{t\in T} (S_{jkt}^{imp} + S_{kjt}^{exp}).Cb_{jk}^{imp/exp} \\
& \sum_{(j,k)\notin C_{jk}} \sum_{t\in T} (P_{jkt}^{imp} + P_{kjt}^{exp}).Cp_{jk}^{imp/exp} + \sum_{j\neq j'} \sum_{t\in T} VR_{jj't}^{rep}.d_{jj'}.Cr^{V} + \sum_{k\in D_k} \sum_{l\in L} \sum_{t\in T} (V_{klt}^{imp} + V_{lkt}^{exp}).d_{kl}.Cr + \sum_{i\neq i'} \sum_{t\in T} VR_{ii't}^{rep}.d_{ii'}.Cr^{V} + \\
& \sum_{s\in T_k} \sum_{k\in G_k} \sum_{t\in T} (P_{skt}^{imp} + P_{kst}^{exp}).Cp_{sk}^{imp/exp} + \sum_{i\in I} \sum_{l\in L} \sum_{t\in T} (SP_{ilt}^{imp} + SP_{lit}^{exp}).SPc_{ilt}^{imp/exp} + \sum_{k\neq k'} \sum_{t\in T} VR_{kk't}^{rep}.d_{kk'}.Cr^{V} + \\
& \sum_{j\in J} \sum_{l\in L} \sum_{t\in T} (V_{jlt}^{imp} + V_{ljt}^{exp}).d_{jl}.Cr + \sum_{j\in J} \sum_{k\in J} \sum_{t\in T} (VR_{kjt}^{rep} + VR_{jkt}^{rep}).d_{kj}.Cr^{V} + \sum_{l\neq l'} \sum_{t\in T} TR_{ll't}^{rep}.d_{ll'}.Cr^{VT} + \sum_{l\neq l'} \sum_{t\in T} VR_{ll't}^{rep}.d_{ll'}.Cr^{V} + \\
& \sum_{i\in I} \sum_{l\in L} \sum_{t\in T} (V_{ilt}^{imp} + V_{lit}^{exp}).d_{il}.Cr + \sum_{j\in J} \sum_{l\in L} \sum_{t\in T} (VR_{jlt}^{rep} + VR_{ljt}^{rep}).d_{lj}.Cr^{V} + \sum_{k\in D_k} \sum_{l\in L} \sum_{t\in T} (VR_{klt}^{rep} + VR_{lkt}^{rep}).d_{kl}.Cr^{V} + \\
& \sum_{j\in J} \sum_{l\in L} \sum_{t\in T} (V_{jlt}^{rep} + V_{ljt}^{rep}).d_{lj}.Cr^{V} + \sum_{k\in D_k} \sum_{l\in L} \sum_{t\in T} (V_{klt}^{rep} + V_{lkt}^{rep}).d_{kl}.Cr^{V} + \sum_{i\neq i'} \sum_{t\in T} TR_{ii't}^{rep}.d_{ii'}.Cr^{VT} \qquad (1)
\end{aligned}
$$

Table 2. Some of the Model Parameters and Decision Variables

Model Parameters

Co_{ij}^{imp} marine transport cost of import operation per TU by the company owned Ro/Ro on link $(i,j) \notin L_{ij}$

Cb_{jk}^{imp} rail transport cost of import operation per block train chartered on link $(j,k) \notin L_{jk}$

Cr road freight transport cost in both import and export directions per TU of per km

Cr^{V} repositioning cost for empty trucks per km

d_{jl} road travel distance along link $(j,l) \in J \cup L$

De_{lit}^{exp} export transport demand of order country l to marine port in Turkey i in time period t

Cap_{ij}^{imp} load capacity of a company owned Ro/Ro on marine link $(i,j) \notin L_{ij}$

Cap_{jk}^{exp} load capacity of a block train on rail link $(j,k) \in C_{jk} \backslash \{T_k\}$

N_{ijt}^{imp} maximum number of cruises for import operations on link $(i,j) \notin L_{ij}$ in time period t

UB_{kj}^{exp} maximum number of block train services for export operations on link $(k,j) \notin L_{kj}$ in each time period

T_{kj} the rail transit time between the stations *k* and *j* in Europe

φ_{lt} the working days in order country *l* at a time period *t*

α the percent of time that a truck is available

Γ the duration in hours of time period t

Decision Variables

X_{ilt}^{imp} import quantity of TUs shipped by only road freight transportation on link $(i,l) \in I \cup L$ in period t

SP_{lit}^{exp} the export quantity of TUs shipped from order country *l* to marine port *i* by outsourcing option

S_{jkt}^{imp} number of import train services by block trains on rail link $(j,k) \notin L_{jk}$ in period t

S_{ijt}^{imp} number of import cruises by the company owned Ro/Ro on link $(i,j) \notin L_{ij}$ in period t

Z_{lkjit}^{exp} export TUs shipped from order country l to seaport i via the railway terminal k and seaport *j* in period t

V_{jlt}^{imp} total number of loaded truck positions from seaport *j* to order country *l* in period *t*

VS_{lkt}^{exp} the required truck size from order country *l* to rail terminal *k* in period *t*

TS_{lit}^{exp} the required trailer size from order country *l* to seaport *i* in Turkey in period *t*

VLE_{lt} total number of European plated truck inventory in order country *l* at the end of period *t*

TI_{it} total number of trailer inventory in seaport *i* in Turkey at the end of period *t*

V_{ljt}^{rep} total number of empty truck internal repositions from order country *l* to seaport *j* in period *t*

$TTR_{l'lt}^{rep}$	total number of Turkish plated external truck repositions among the order countries l and l' in period t
$TR_{ii't}^{rep}$	total number of trailer repositions among the seaports in Turkey i and i' in period t

The considerable part of the load planning component of the proposed model can be summarized by the following Equations (2) to (17):

$$X_{ilt}^{imp} + \sum_{j \in J} Y_{ijlt}^{imp} + \sum_{j \in D_j} \sum_{k \in D_k} Z_{ijklt}^{imp} + SP_{ilt}^{imp} \geq De_{ilt}^{imp} \qquad \forall i \in I, \forall l \in L, \forall t \in T \qquad (2)$$

$$\sum_{l \in L} Y_{ljit}^{exp} \leq \sum_{l \in L} N_{j^*it}^{exp}.Cap_{ji}^{exp} \qquad \forall (i,j) \in C_{ij} \wedge \{j \in T_j \vee j \notin D_j\},\ j^* \in \gamma_j, \forall t \in T \qquad (3)$$

$$\sum_{l \in L} Y_{ijlt}^{imp} = R_{ijt}^{imp} \qquad \{\forall (i,j) \in C_{ij}, j \in T_j\} \wedge \{\forall (i,j) \in C_{ij}, j \notin D_j\}, \forall t \in T \qquad (4)$$

$$\sum_{l \in L} Y_{ljit}^{exp} + \sum_{k \in D_k} \sum_{l \in l} Z_{lkjit}^{exp} \leq N_{jit}^{exp}.Cap_{ji}^{exp} - \sum_{l \in L} Y_{lj'it}^{exp} \qquad \forall (j,i) \in B_{ji}, j \in D_j, j' \in T_j, \forall t \in T \qquad (5)$$

$$\sum_{l \in L} Y_{ljit}^{exp} + \sum_{k \in D_k} \sum_{l \in l} Z_{lkjit}^{exp} = R_{jit}^{exp} \qquad \forall (j,i) \in B_{ji}, j \in D_j, \forall t \in T \qquad (6)$$

$$\sum_{l \in L} Y_{ijlt}^{imp} + \sum_{k \in D_k} \sum_{l \in L} Z_{ijklt}^{imp} \leq P_{ijt}^{imp} \qquad \forall (i,j) \notin C_{ij}, j \in D_j, \forall t \in T \qquad (7)$$

$$\sum_{l \in L} Y_{ljit}^{exp} \leq P_{jit}^{exp} \qquad \forall (j,i) \in L_{ji}, j \notin D_j \forall t \in T \qquad (8)$$

$$R_{ijt}^{imp} / Cap_{ij}^{imp} = S_{ijt}^{imp} \qquad \forall (i,j) \notin L_{ij}, \forall t \in T \qquad (9)$$

$$U_{jit}^{exp} = R_{jit}^{exp} / \left(N_{jit}^{exp}.Cap_{ji}^{exp}\right) \qquad \forall (j,i) \notin L_{ji}, \forall t \in T \qquad (10)$$

$$\sum_{i \in I} \sum_{l \in L} Z_{ijklt}^{imp} \leq S_{jkt}^{imp}.Cap_{jk}^{imp} \qquad (j,k) \in C_{jk} \backslash \{T_k\}, \forall \in T \qquad (11)$$

$$\sum_{i \in I} \sum_{l \in L} Z_{lkjit}^{exp} \leq P_{kjt}^{exp} \qquad (k,j) \in L_{kj} \backslash \{T_k\}, \forall t \in T \qquad (12)$$

$$\sum_{i \in I} \sum_{l \in L} Z_{ijklt}^{imp} \leq S_{jkt}^{imp}.Cap_{jk}^{imp} + P_{jkt}^{imp} \qquad (j,k) \in B_{kj} \backslash \{T_k\}, \forall t \in T \qquad (13)$$

$$\sum_{i \in I} \sum_{l \in L} Z_{lkjit}^{exp} + \sum_{i \in I} \sum_{l \in L} \sum_{k \in G_k} Z_{lkjit}^{exp} \leq S_{kjt}^{exp}.Cap_{kj}^{exp} \qquad \forall j \in D_j, \forall k \in T_k \cap (k,j) \in C_{kj}, \forall t \in T \qquad (14)$$

$$\sum_{i \in I} \sum_{j \in D_j} \sum_{l \in L} Z_{ijklt}^{imp} \leq P_{skt}^{imp} \qquad \forall s \in T_k, \forall k \in G_k \cap (s,k) \in L_{sk}, \forall t \in T \qquad (15)$$

$$LB_{kjt}^{exp} \leq S_{kjt}^{exp} \leq UB_{kjt}^{exp} \qquad \forall (k,j) \notin L_{kj}, \forall t \in T \qquad (16)$$

$$\left|S_{jkt}^{imp} - S_{kjt}^{exp}\right| \leq 1 \qquad \forall (j,k) \notin L_{jk}, \forall t \in T \qquad (17)$$

Constraint (2) maintains the import demand satisfaction of each order country in each month. The constraint (3) represents the capacity restrictions on export TUs that can be shipped by only company owned Ro-Ro vessels. By the constraint set (4), one can calculate the TUs transferred by only the company owned Ro-Ro vessels from/to the seaports which have no railway connection. Apart from the constraints (3) and (4), origin or destination seaports may be connected with a railway terminal as given by constraints (5)-(7). Additionally, the marine links may also incorporate at least one transshipment seaport where additional TUs can be loaded/ unloaded by only the company owned Ro-Ro vessels (5). The TUs delivered by the company owned Ro-Ro vessels from/to the marine ports which have a railway connection can be computed based on the constraint (6). The shipments in marine transportation which can be performed by only the other logistics service providers can be computed by constraints (7) and (8). The number of cruises that have to be carried out by the company owned Ro-Ro vessels on each marine link can be calculated by the constraint (9). The capacity utilization rate of these Ro-Ro vessels can be calculated by means of the constraint (10). Constraint (11) represents the capacity limitations on TUs that can be shipped by only the block trains. The export TUs that can only be transferred by public trains can be calculated by constraint (12). The capacity constraint is formulated as in (13) for the railway terminals where export TUs can be performed by both block trains and public trains. The constraint (14) is also capacity restrictions for the transshipment railway terminals. Some of the TUs which arrive at this terminal can be distributed to surrounding order countries via road freight transportation. The remaining TUs can be transferred to the other order countries by chartering extra public trains (15). Constraint (16) presents the monthly lower/upper bounds on export TUs shipped by the block trains. Based on scheduling limitations, the difference between number of import and export block train services on each rail link may be at most one at each month (17). This is also valid for the annual basis.

It is supposed that outsourcing option is just available for the transportation operations from Turkey to Europe. It is not possible to outsource any truck or trailer for the transportation operations within Europe.

The constraints related to strategic fleet sizing component of the proposed model considering multiple resources, i.e., trucks and trailers can be partially given by the following Equations (18) to (30):

$$X_{ilt}^{imp} = V_{ilt}^{imp} \qquad \forall i \in I, \forall l \in L, \forall t \in T \qquad (18)$$

$$\sum_{i \in I} \sum_{j \in J} Z_{ijklt}^{imp} = V_{klt}^{imp} \qquad \forall k \in K, \forall l \in L, \forall t \in T \qquad (19)$$

$$\sum_{i \in I} Y_{ljit}^{exp} = V_{ljt}^{exp} \qquad \forall j \in J, \forall l \in L, \forall t \in T \qquad (20)$$

$$V_{klt}^{imp}.T_{kl} + V_{lkt}^{exp}.T_{lk} + \left|V_{klt}^{imp}.T_{kl} - V_{lkt}^{exp}.T_{lk}\right| \le \left(VS_{klt}^{imp} + VS_{lkt}^{exp}\right).\varphi_{klt}.\Gamma.\alpha \qquad \forall k \in K, \forall l \in L, \forall t \in T \qquad (21)$$

$$VS_{ilt}^{imp} + VS_{lit}^{exp} = VEP_{ilt}^{imp} + VEP_{lit}^{exp} + VTP_{ilt}^{imp} + VTP_{lit}^{exp} \qquad \forall i \in I, \forall l \in L, \forall t \in T \qquad (22)$$

$$VS_{jlt}^{imp} \le V_{jlt}^{imp} \qquad \forall j \in J, \forall l \in L, \forall t \in T \qquad (23)$$

$$\begin{aligned} & X_{ilt}^{imp}.T_{il} + \sum_{j \in J} Y_{ijlt}^{imp}.\left(TM_{ij} + T_{jl}\right) + \sum_{j \in J} \sum_{k \in K} Z_{ijklt}^{imp}.\left(TM_{ij} + TT_{jk} + T_{kl}\right) + X_{lit}^{exp}.T_{li} + \sum_{j \in J} Y_{ljit}^{exp}.\left(T_{lj} + TM_{ji}\right) + \\ & \sum_{j \in J} \sum_{k \in K} Z_{lkjit}^{exp}.\left(T_{lk} + TT_{kj} + TM_{ji}\right) + \Bigg| X_{ilt}^{imp}.T_{il} + \sum_{j \in J} Y_{ijlt}^{imp}.\left(TM_{ij} + T_{jl}\right) + \sum_{j \in J} \sum_{k \in K} Z_{ijklt}^{imp}.\left(TM_{ij} + TT_{jk} + T_{kl}\right) - \\ & X_{lit}^{exp}.T_{li} - \sum_{j \in J} Y_{ljit}^{exp}.\left(T_{lj} + TM_{ji}\right) - \sum_{j \in J} \sum_{k \in K} Z_{lkjit}^{exp}.\left(T_{lk} + TT_{kj} + TM_{ji}\right)\Bigg| \le \left(TS_{ilt}^{imp} + TS_{lit}^{exp}\right)\varphi_{ilt}.\Gamma.\beta \qquad \forall i \in I, \forall l \in L, \forall t \in T \qquad (24) \end{aligned}$$

$$TS_{lit}^{exp} \le X_{lit}^{exp} + \sum_{j \in J} Y_{ljit}^{exp} + \sum_{j \in J} \sum_{k \in K} Z_{lkjit}^{exp} \qquad \forall i \in I, \forall l \in L, \forall t \in T \qquad (25)$$

$$\begin{aligned} VLE_{lt} = {} & VLE_{lt-1} + \sum_{j \in J} VS_{jlt}^{imp} - \sum_{j \in J} VS_{ljt}^{exp} + \sum_{k \in K} VS_{klt}^{imp} - \sum_{k \in K} VS_{lkt}^{exp} - \sum_{j \in J} VR_{ljt}^{rep} + \sum_{j \in J} VR_{jlt}^{rep} - \sum_{k \in K} VR_{lkt}^{rep} + \\ & \sum_{k \in K} VR_{klt}^{rep} + \sum_{l' \ne l} VR_{l'lt}^{rep} + \sum_{l' \ne l} TR_{l'lt}^{rep} - \sum_{l' \ne l} VR_{ll't}^{rep} - \sum_{l' \ne l} TR_{ll't}^{rep} + \sum_{i \in I} VEP_{ilt}^{imp} - \sum_{i \in I} VEP_{lit}^{exp} \qquad \forall l \in L, \forall t \in T \qquad (26) \end{aligned}$$

$$VLT_{lt} = VLT_{lt-1} + \sum_{i \in I} VTP_{ilt}^{imp} - \sum_{i \in I} VTP_{lit}^{exp} + \sum_{l' \ne l} TTR_{l'lt}^{rep} - \sum_{l' \ne l} TTR_{ll't}^{rep} \qquad \forall l \in L, \forall t \in T \qquad (27)$$

$$TI_{it} = TI_{it-1} + \sum_{l \in L} TS_{lit}^{exp} - \sum_{l \in L} TS_{ilt}^{imp} + \sum_{i' \ne i} TR_{i'it}^{rep} - \sum_{i' \ne i} TR_{ii't}^{rep} \qquad \forall i \in I, \forall t \in T \qquad (28)$$

$$VJ_{jt-1} \ge \sum_{l \in L} VS_{jlt}^{imp} + \sum_{j' \ne j} VR_{jj't}^{rep} + \sum_{k \in K} VR_{jkt}^{rep} + \sum_{l \in L} VR_{jlt}^{rep} \qquad \forall j \in J, \forall t \in T \qquad (29)$$

$$TI_{it-1} \ge \sum_{l \in L} TS_{ilt}^{imp} + \sum_{i' \ne i} TR_{ii't}^{rep} \qquad \forall i \in I, \forall t \in T \qquad (30)$$

The constraints (18)-(20) provide the connections between load plans and loaded truck movements. The number of loaded truck positions between different locations (seaports in Turkey – order countries, railway terminals in Europe – order countries etc.) can be computed by these constraints. By the loaded truck positions and transit times, one can calculate the minimum number of truck sizes between the seaports and order countries by constraint (21). Moreover, the number of working days in the order countries, truck availability and the duration of the period are considered. According to constraint (22), both of the European and Turkish plated trucks can operate between the seaports in Turkey and order countries. The constraint (23) ensures that the number of trucks assigned to any route on road transport network should be less and equal to the number of loaded truck positions on the same route. The trailer fleet size on the overall intermodal logistics network can be computed by constraint (24). The constraint (25) makes sure that the number of export trailers assigned to any route cannot excess the number of loaded trailer positions on the same route. The constraints (26)-(27) present the periodic European and Turkish plated truck inventories at order countries. These constraints are also available for seaports and railway terminals. The constraint (28) is trailer inventory constraint at the seaports in Turkey. Constraint (29) guaranteed that sufficient number of trucks is available at the end of a time period so as to use them either loaded or empty truck movements from any seaport in the subsequent time period. This constraint should also be extended for loaded and empty trailer movements as formulated in (30) Thus, there will be a sufficient number of trailers in the seaports in Turkey at the beginning of the next time period. The structures of load planning and fleet sizing problems are summarized by the following Figure 2.

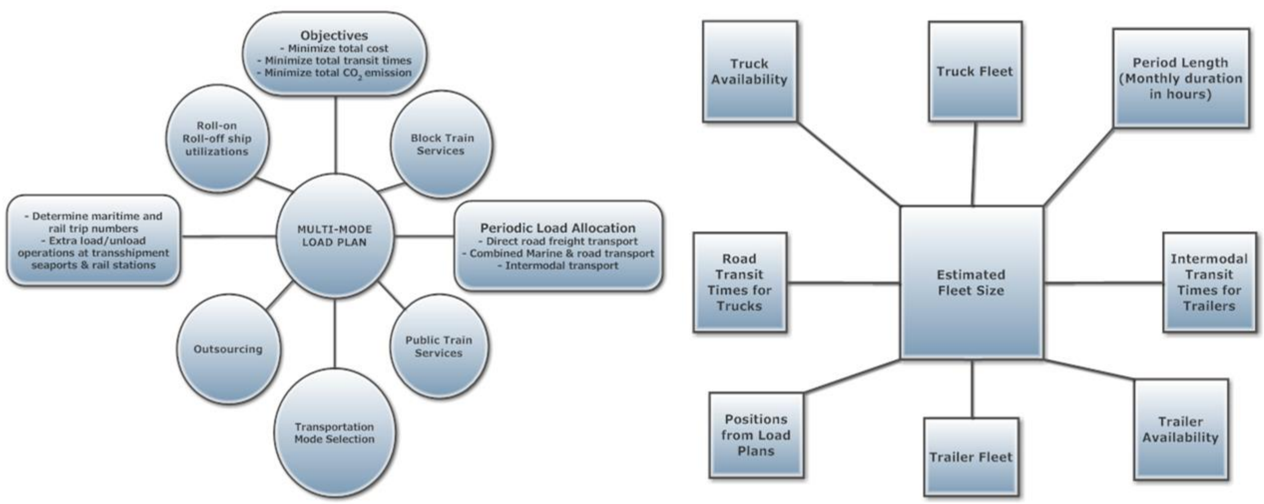

Figure 2. Structures of the Load Planning and Fleet Sizing Problems in Intermodal Transportation

In order to reflect empty truck/trailer repositioning into the proposed model, the following assumptions are made: (i) In Turkey, both of the empty trucks and trailers can be repositioned between the seaports, (ii) The empty trucks can be repositioned between the seaports, railway terminals and order countries in Europe without any trailer, (iii) The empty trucks with European plates cannot be repositioned in Turkey. But Turkish plated trucks can be repositioned with their own trailers in Europe, (iv) Trucks with empty trailers can be repositioned between only the different order countries. The constraints related to tactical empty truck/trailer repositioning component of the proposed model can be summarized by Equations (31) to (41):

$$V_{jlt}^{imp} - V_{ljt}^{exp} - VJ_{jt-1} \leq V_{ljt}^{rep} \qquad \forall j \in J, \forall l \in L, \forall t \in T \qquad (31)$$

$$V_{ilt}^{imp} - V_{lit}^{exp} \leq VIE_{it-1} + VIT_{it-1} \qquad \forall i \in I, \forall l \in L, \forall t \in T \qquad (32)$$

$$V_{klt}^{rep} \leq VS_{klt}^{imp} \qquad \forall k \in K, \forall l \in L, \forall t \in T \qquad (33)$$

$$X_{ilt}^{imp} + \sum_{j\in J} Y_{ijlt}^{imp} + \sum_{j\in J}\sum_{k\in K} Z_{ijklt}^{imp} - X_{lit}^{exp} - \sum_{j\in J} Y_{ljit}^{exp} - \sum_{j\in J}\sum_{k\in K} Z_{lkjit}^{exp} \le TI_{it-1} \qquad \forall i \in I, \forall l \in L, \forall t \in T \qquad (34)$$

$$\sum_{k'\neq k} VR_{k'kt}^{rep} + \sum_{j\in J} VR_{jkt}^{rep} + \sum_{l\in L} VR_{lkt}^{rep} \ge \sum_{l\in L} VS_{klt}^{imp} - VK_{kt-1} \qquad \forall k \in K, \forall t \in T \qquad (35)$$

$$\sum_{l'\neq l} TTR_{l'lt}^{rep} \ge \sum_{i\in I} VTP_{lit}^{exp} - VLT_{lt-1} \qquad \forall l \in L, \forall t \in T \qquad (36)$$

$$\sum_{l'\neq l} TR_{l'lt}^{rep} + \sum_{l'\neq l} TTR_{l'lt}^{rep} \ge \sum_{i\in I} TS_{lit}^{exp} - TL_{lt-1} \qquad \forall l \in L, \forall t \in T \qquad (37)$$

$$\sum_{j'\neq j} VR_{j'jt}^{rep} + \sum_{k\in K} VR_{kjt}^{rep} + \sum_{l\in L} VR_{ljt}^{rep} \le \sum_{l\in L} VS_{jlt}^{imp} \qquad \forall j \in J, \forall t \in T \qquad (38)$$

$$\sum_{j\in J} VR_{jlt}^{rep} + \sum_{k\in K} VR_{klt}^{rep} + \sum_{l'\neq l} VR_{l'lt}^{rep} + \sum_{l'\neq l} TR_{l'lt}^{rep} \le \sum_{j\in J} VS_{ljt}^{exp} + \sum_{k\in K} VS_{lkt}^{exp} + \sum_{i\in I} VEP_{lit}^{exp} \qquad \forall l \in L, \forall t \in T \qquad (39)$$

$$\sum_{i'\neq i} VR_{i'it}^{rep} + \sum_{i'\neq i} TR_{i'it}^{rep} \le \sum_{l\in L} VTP_{ilt}^{imp} \qquad \forall i \in I, \forall t \in T \qquad (40)$$

$$\sum_{l'\neq l} TR_{l'lt}^{rep} + \sum_{l'\neq l} TTR_{l'lt}^{rep} \le \sum_{i\in I} TS_{lit}^{exp} \qquad \forall l \in L, \forall t \in T \qquad (41)$$

$$0 \le U_{ijt}^{imp} \le 1 \text{ and } 0 \le U_{jit}^{exp} \le 1$$

$$X_{ilt}^{imp}, Y_{ljit}^{exp}, Z_{ijklt}^{imp}, SP_{ilt}^{imp}, P_{jit}^{exp}, S_{jkt}^{imp}, P_{kst}^{exp}, V_{jlt}^{imp}, V_{lkt}^{exp}, V_{ilt}^{imp}, VS_{jlt}^{imp}, VS_{lkt}^{exp}, TS_{ilt}^{imp}, VEP_{lit}^{exp}, VTP_{ilt}^{imp} \ge 0 \quad are \quad integer \qquad (42)$$

The repositioning concept for empty trucks can be divided into two categories namely internal and external. The constraints (31)-(32) are related to the internal repositioning. These repositions are resulted from the difference between the import and export loaded truck positions within the same time period. The constraint (31) presents the internal empty truck repositioning between seaports and order countries. According to constraint (32), it is not possible to reposition any empty truck between seaports in Turkey and order countries. Constraint set (33) ensures that amounts of internal empty truck repositions on any given route (railway terminals – order countries) cannot exceed the truck fleet size assigned to this route. The empty trailers with their trucks cannot be repositioned between the seaports in Turkey and order countries as in constraint (34).The constraints (35)-(36) are related to external empty truck repositioning. The external repositions are resulted from the different loaded truck positions of a given route in successive time periods. The difference between the loaded truck positions of a node and the truck inventory of this node at the beginning of a time period can be satisfied by the external repositioning. Similarly, the constraint (37) is related to the external empty trailer repositioning. The empty trailers can be repositioned with either European plated or Turkish plated trucks among the order countries in Europe. Constraints (38)-(40) maintain that the amounts of the external empty truck repositions on any given route cannot exceed the truck fleet size assigned to this route in each time period. Similarly, constraint (41) ensures that external trailer repositions among the order countries cannot exceed the trailer fleet size assigned to the routes. The constraint (42) preserves the non-negativity of the decision variables and maintains that some of these variables must take integer values.

A REAL LIFE APPLICATION IN A LARGE-SIZED LOGISTICS COMPANY

In order to illustrate usefulness, validity, and practicality of the proposed MILP model, a real-life application is presented in a large-sized logistics company in Turkey. According some criteria such as transit time, tonnage limitations and product characteristics etc., the company provides various transportation services including road freight transport, combined marine & road transport and intermodal transport. In road freight transport, the loads are transferred from seaports in Turkey to consolidation centers of the company via highways and then delivered again from these centers to final destinations. The combined marine & road transport serves as an alternative for particularly high tonnage products since the tonnage limitations imposed in European highways. Firstly, the products are transported from the seaports in Turkey to the port of Trieste and then delivered to the relevant destinations via highways. Finally, intermodal transport is composed of three distinct transportation modes, i.e., maritime, railway, and road transportation. The configuration of the real-life intermodal logistics network where the company operates is shown in Figure 3.

Figure 3. Intermodal Logistics Network Configuration of the Real Life Application

In the case study, the intermodal logistics network is composed of 4 seaports in Europe with a single transshipment seaport, 3 origin seaports in Turkey, 3 railway terminals of block trains with a single transshipment railway terminal and finally 3 railway terminals for the public train services. There are also 49 order countries in Europe which correspond to aggregated customers with their import/export transportation demands. The planning horizon is set to one year composed of 12 months. The details of the marine and railway logistics network structures in intermodal transportation can be given by the following Tables 3 and 4.

Table 3. Marine Logistics Network Structure

From/To	Istanbul			Izmir			Mersin			T_j	D_j	γ_j
	L_{ij}	C_{ij}	B_{ij}	L_{ij}	C_{ij}	B_{ij}	L_{ij}	C_{ij}	B_{ij}			
Trieste			⊗	⊗			⊗				⊗	⊗
Lavrion		⊗								⊗		
Sete					⊗							
Toulon	⊗											

Table 4. Railway Line Structure

From/To	Trieste			T_k	D_k	G_k
	L_{kj}	C_{kj}	B_{kj}			
Ostrava		⊗			⊗	
Munich	⊗				⊗	
Ludwigshafen		⊗			⊗	
Cologne		⊗		⊗	⊗	
Malmö	⊗					⊗
Gothenburg	⊗					⊗

The following data is gained from intermodal freight transportation department of the company: 3 round trips per week take place between Istanbul origin seaport – Trieste seaport and a single round trip between Izmir – Sete seaports. Each trip's duration is 60 hours and trips are realized with modern company owned Ro-Ro vessels which have a capacity of 249 mega-trailers or 45ft container. The transportation capacity of a block train is defined as 32 TUs per train service and maximum 8 train services can be performed on each rail link in a month. The ranges of some other parameters used in the case study are given in Table 5. Running the model with these data through a mixed integer programming solver of LINGO 15.0 on a PC with an Intel Core i7 2.4 GHz CPU yields a feasible solution with the objective function value of €138288799 under a 24-hour time limit. The usage rates of different transportation modes and outsourcing (in total number of TUs) can be seen as in Figure 4 for both import and export operations. The import/export load quantities in marine transport by the company owned Ro/Ro vessels and the required number of block train services are presented in Table 6. Finally, the variability of truck and trailer fleet sizes in different months is given by Figure 5a. The total number of internal/external repositions can also be seen in Figure 5b. The company experts evaluated the provided results and enounced that effective and efficient fleet plans can be obtained by making use of the proposed MILP model.

Table 5. Data Intervals Used in the Case Study

Parameters	Range of values
Monthly import load demands of the order countries (TU/Month)	0 - 370
Marine transport cost by the company owned Ro/Ro vessels (€/TU)	500 - 1475
Transportation capacity of the company owned Ro/Ro vessels (TU)	165 - 240
Marine transport cost by the other logistics service providers (€/TU)	647.73 – 918.3
The rail cost of per block train service (€/Train service)	20121 - 23328
Rail transport cost by the public trains (€/TU)	685
Road freight transport cost for loaded movements per kilometer (€ TU/km)	1.20
Road freight transport cost for empty movements per kilometer (€ TU/km)	1.0
Maximum cruise numbers by the company owned Ro/Ro vessels per month	4 - 14
Maximum train services by the block trains per month	12 - 41
The road distance between rail stations and order countries (km)	50 - 3015
The road transit time between rail stations and order countries (hr)	2.5 – 150.8
The rail transit time between seaports and rail stations in Europe (hr)	20 - 24
The marine transit time between seaports in Turkey and Europe (hr)	17 - 96

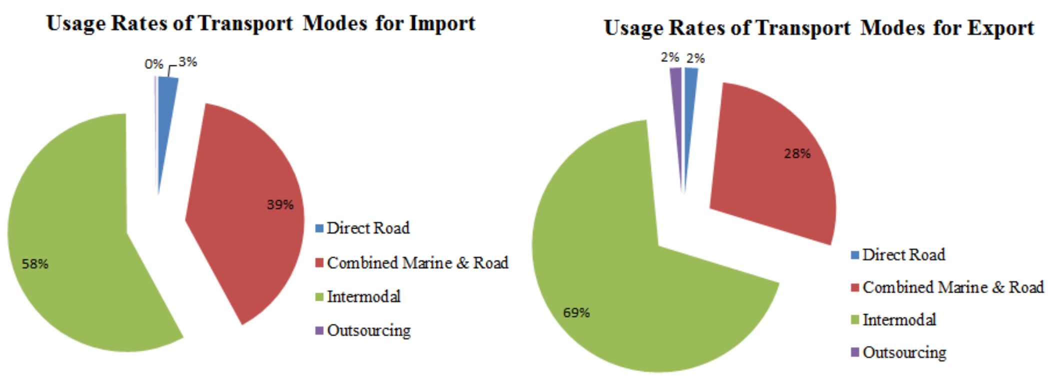

Figure 4. Load Planning Results: Usage Rates of Different Transportation Modes

Table 6. The Planning Results Related to Marine and Rail Transportation

Monthly Block Train Services (Import/Export)												
Trie/Ostra	7/7	6/6	7/8	7/7	7/7	8/9	8/9	4/3	8/7	8/8	9/8	7/6
Trie/Ludw	26/27	24/24	26/26	26/26	27/26	25/26	26/27	26/25	26/26	27/27	25/24	27/26
Trie/Col	27/28	30/30	35/34	33/33	34/33	33/34	29/30	24/23	37/36	29/29	36/35	29/30
Monthly TUs Shipped by Company Owned Ro-Ro Vessels (Import/Export)												
Ist/Lav	35/13	36/12	38/13	37/13	35/14	38/13	36/14	36/12	36/13	47/13	40/13	34/11
Ist/Trie	2193/2254	2261/2114	2499/2366	2418/2341	2485/2291	2339/2442	2448/2418	2101/1796	2712/2505	2205/2100	2513/2244	2238/2148
Izmir/Sete	48/67	62/78	68/94	62/95	80/111	77/86	85/109	79/98	89/97	63/68	65/89	49/79

It should be emphasized that intermodal transportation is the most appropriate way of international freight transportation in terms of economic and environmental issues.The solution report is also given in Table 7.

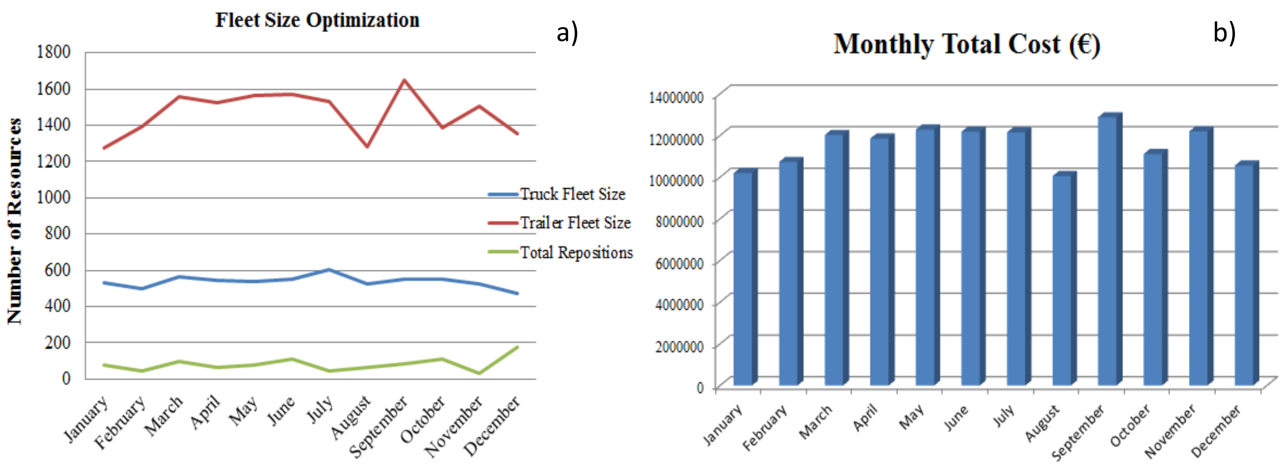

Figure 5. a) Fleet Sizing and Empty Vehicle Repositioning Results, b) Variability of Monthly Cost Value

Table 7. Summary of the Optimization Results

Total cost objective	€138288799	Model class	MILP
Costs of marine transport	€55720100	Total number of variables	191300
Costs of rail transport	€35567960	Number of integer variables	73152
Costs of road transport	€45474500	Total number of constraints	97457
Costs of outsourcing	€1424500	Running time limit	24-hours
Repositioning costs	€101730	Optimality gap	0.0014

CONCLUDING REMARKS

In this study, a novel MILP model is developed to solve a multi-mode, multi-period fleet planning problem considering load planning, fleet sizing and empty vehicle repositioning issues. The proposed model aims at minimizing the overall total costs throughout the intermodal logistics network which consist of marine, rail and road freight transportation costs. In order to show the validity and practicality of the proposed model, a real-life application is presented in large-sized logistics company in Turkey. The computational results have shown that effective and efficient load plans, truck/trailer fleet sizes and empty vehicle repositions can be generated by making use of the proposed model. It is also revealed that logistics companies can provide sustainable competitive advantage by improving their fleet planning mechanisms which may contribute to the high level of customer satisfaction in addition to the possible cost reductions. In the future, the proposed model may be extended by incorporating the fleet replacement, expansion and reduction decisions. Additionally, development of a fuzzy-stochastic MILP model which is able to handle the uncertainty on transport demands, transit times and cost parameters may also be scheduled as a future work.

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IMPACTS OF 3D PRINTING ON SUPPLY CHAIN MANAGEMENT

Cihan Çetinkaya[172], Eren Özceylan[173]

Abstract − *3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. It can "print" in plastic, metal, nylon, and over a hundred other materials. It can be used for manufacturing prototypes, end user products, quasi-legal guns, aircraft engine parts and even human organs using a person's own cells. This application can lead to innovative solutions in traditional supply chain management which contains very complicated and -hard to manage- chains. With 3D printing, a design file can transform directly to a product, skipping many traditional manufacturing steps. Therefore the production may take place anywhere in the world where the printers are available. Thus this new application will affect all logistics and supply chain activities. In this paper, definition, advantages and disadvantages of 3D printing are explained, sectors which apply 3D printing technology are given, and finally impacts of 3D printing on supply chain management are discussed.*

Keywords − *3D printing, additive manufacturing, innovative solutions, supply chain management.*

WHAT IS 3D PRINTING?

3D Printing or "additive manufacturing" is a process of making three dimensional solid objects from a digital file. McKinsey Global Institute named 3D printing as one of the twelve disruptive technologies that will transform life, business and the global economy by 2025 [1]. With 3D printing, an idea can go directly from a design file to a product, skipping many traditional manufacturing steps. 3D Laser Scanning is used in additive manufacturing and it is a way to capture a physical object's exact size and shape into the computer world as a digital 3-dimensional representation. The creation of a 3D printed object is achieved using additive processes. In an additive process, an object is created by laying down successive layers of material until the entire object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object [2].

The earliest 3D printing technologies first became visible in the late 1980's, at that time they were called Rapid Prototyping technologies. This is because the processes were originally conceived as a fast and more cost-effective method for creating prototypes for product development within industry. Wohlers Associates has been tracking the 3D printing industry since the 1980s, and according to Wohlers Report 2014, the worldwide 3D printing industry is expected to grow from $3.07 billion in revenue in 2013 to $12.8 billion by 2018, and exceed $21 billion in worldwide revenue by 2020 [2].

ADVANTAGES AND DISADVANTAGES OF 3D PRINTING

In spite of the huge hype surrounding 3D printing and how it's on its way to revolutionize the way we manufacture products, it has its own share of disadvantages. With the advantages of 3D printing, mankind may be entering a new post-industrial manufacturing age where products are significantly cheaper and built quicker than ever before, however the disadvantages of 3D printing needs to be known to be better understood and mitigated against.

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Advantages of 3D Printing

Manufacturing Options: 3D printing provides a wide variety of manufactured products, including customizable products and even an individual's personal designs.

Less Waste: Manufacturing plastic and metal objects in particular is generally a wasteful process with a lot of surplus materials and chunky parts. Creating a similar object with the use of additive manufacturing not only utilizes less energy, but also minimizes waste. Sometimes, the finished product of 3D printing can be up to 60 percent lighter than the machined part but still sturdy.

Reduced Costs: Even though the initial setup costs are higher, 3D printing has become cheaper than cheap labor in third world countries. Additionally, the costs of 3D printing are still decreasing, with the potential of 3D printers in homes in the near future.

Quick Production: The speed of 3D printing is quicker as compared to the traditional method. With industrial 3D printing technologies being able to create an object in a few hours, the traditional manufacturing methods, taking up to two or more days (from prototype to finish product), are gradually becoming obsolete.

Quick availability of organs: The long and often traumatic wait for an organ donor could come to an end with advances in bio printing or manufacture of 3D printed organs. Research is on to create bio printers that can create living organs along with the structural lattice for the organ using the patient's own cells and tissues.

Rapid production of prototypes: 3D printing enables quick production of prototypes or small-scale versions of the real object. This helps researchers and engineers plan the actual object and catch any design flaws that may affect quality and functionality [3].

Warehousing: With 3D printing, only products that are sold need to be manufactured, thus warehousing of excess inventory is significantly less needed.

More Jobs: More engineers are needed to design and build 3D printers, and more technicians are needed to maintain, use, and fix 3D printers too. Additionally, with the lower cost of manufacturing, more designers and artists would be able deliver their products to the market. Even more domestic jobs for shipping these products should be created too.

Disadvantages of 3D Printing

Fewer Manufacturing Jobs: As with all new technologies, manufacturing jobs will decrease. This disadvantage can and will have a large impact to the economies of third world countries, especially China, that depend on a large number of low skill jobs.

Limited Materials: Currently, 3D printers only manufacture products out of plastic, resin, certain metals, and ceramics. 3D printing of products in mixed materials and technology, such as circuit boards, are still under development.

Intellectual property issues: The ease with which replicas can be created using 3D technology raises issues over intellectual property rights. The availability of blueprints online free of cost may change with for-profit organizations wanting to generate profits from this new technology.

Loss of Control on Dangerous Items: 3D printers can create dangerous items, such as guns and knives, with very little or no oversight.

More Useless Stuff: One of the dangers of 3D printers is that they will be used to create more useless stuff that is bad for the environment and wallets. Fortunately, there are new methods of automatically recycling objects made by 3D printers that hold promise of better recycling in the future.

Size: Currently, 3D printers are limited with the size of the products that they can create. Ultimately, large items, such as houses and building, could be created using 3D printers [4].

Limited Strength: Due to the layered additive process, products have limited strength, restrained resistance to heat and moisture, and compromised color stability [5].

Possibility of 3D printed drugs: Assembling chemical compounds on a molecular level using a 3D printer is possible. A researcher at the University of Glasgow created a prototype of a "Chemputer" that makes drugs and medicine. Of course, this is a very long way off, but it stands to enable DIY chemists to create anything from cocaine to ricin [6].

Unhealthy air emissions: 3D printers may pose a health risk when used in the home, according to researchers at the Illinois Institute of Technology. The emissions from desktop 3D printers are similar to burning a cigarette or cooking on a gas or electric stove. The 2013 study was the first to measure these airborne particle emissions from desktop 3D printers. These particles can settle in the lungs or the bloodstream and pose health risk, especially for those with asthma [7].

CURRENT MARKET OF 3D PRINTING

Figure 1 shows the market share (%) of sectors which uses 3D printing technology. According to Figure 1, consumer products/electronics (21.8%), motor vehicles (18.6%) and medical/dental (16.4%) take the biggest pie.

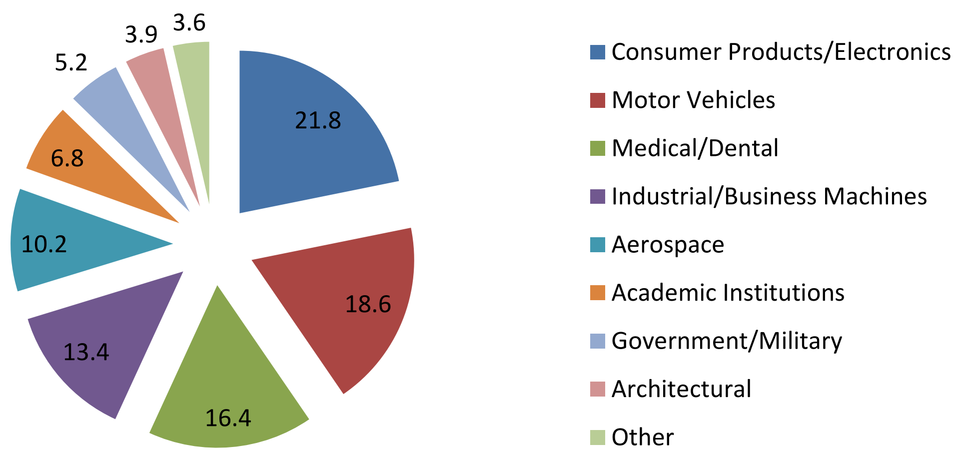

Figure 1. Market share of sectors using 3D printing [8]

Most popular sectors which use 3D printing technology are given below:

Consumer products/electronics: 3D printing is mostly used in the consumer products/electronics sector and it has been for the last eight years. There is a large variety of products within the consumer markets, including toys and fashion (Figure 2).

Figure 2. 3D printed shoes and game controller [9]

Automotive industry: The automotive industry sees many applications of 3D printing technology (Figure 3). Within this sector, 3D printing is mainly used for prototyping by design engineers, but in the near future customized devices are expected. At the same time, custom parts can be produced in order to serve customers in the car tuning and luxury car segments.

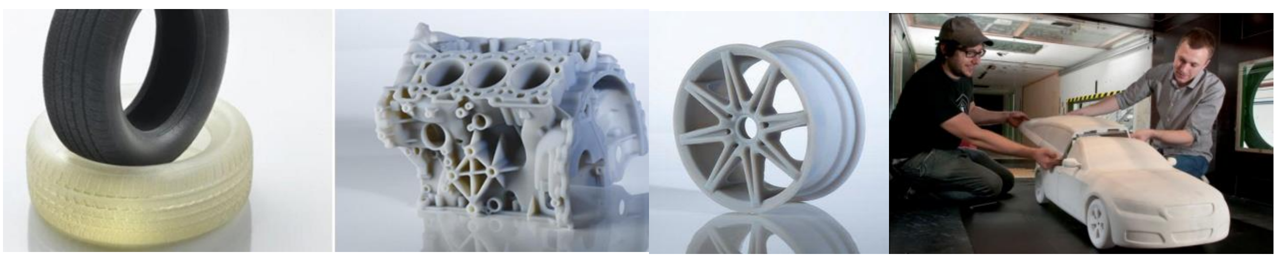

Figure 3. 3D printed tires, rim and an automobile prototype [10]

Medical and dental: One of the innovative products that 3D printing may provide is the manufacturing of customizable human body parts or organs (Figure 4). The medical and dental sectors have been the third largest sector for over the past twelve years 3D printing techniques have been applied within the medical and dental arena for the creation of assistive, surgical and prosthetic devices, surgical implants, and scaffolds for tissue engineering. More than half of the hearing aids and orthotics are already produced using 3D printing. Very recently, a Dutch patient received a completely new skull, printed using 3D printing technology, at the University Medical Center Utrecht.

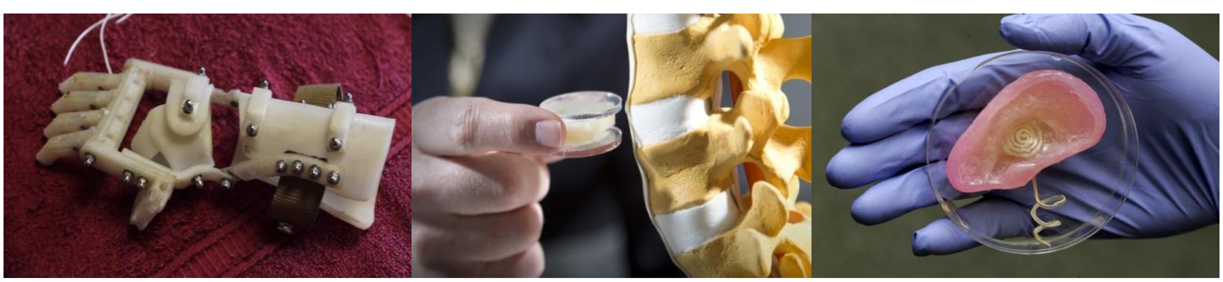

Figure 4. 3D printed organs [11]

Industrial/business machines and aerospace: Industrial/business machines and aerospace sector makes up the fourth and fifth largest sectors using 3D printing technology. Especially the aerospace market is quite varied in the use of 3D printing, with many examples of niche components being made and supplied using various forms of 3D printing. Here, 3D printing reduces the Buy-to-Fly ratio due to the possibility of substituting multiple heavy parts by a single lightweight 3D printed component (Figure 5), its high material use efficiency, and ability to process aerospace grade titanium and nickel alloys [5].

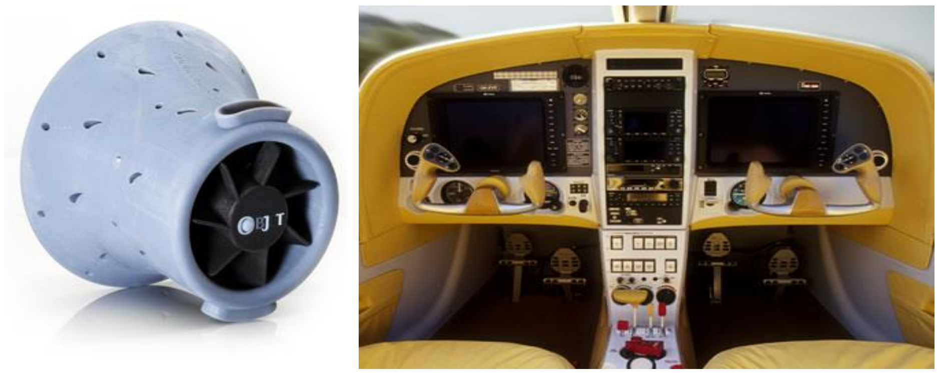

Figure 5. 3D printed plane console and aerospace parts [12]

Firearms: When customized equipment is vital and deadlines are non-negotiable, 3D printing gives government, military and defense manufacturers the freedom to design a single end-use part, quickly create low-volume tooling, or build complex, precise prototypes (Figure 6). An US-based group Defense Distributed succeeded in designing the first working blueprint to produce a plastic gun with a 3D printer in May 2013. But the questions were raised regarding the effectiveness on gun control. So although the armies will be more solid with this disruptive technology, there will be some issues to discuss.

Figure 6. 3D printed firearms and bullets [13]

A technology research company called as Gartner conducted a worldwide survey to determine how organizations are using or planning to use 3D printing technologies [14]. Survey participants were 330 individuals employed by organizations with at least 100 employees that are using or planning to use 3D printing. Prototyping (24.5%), product development (16.1%) and innovation (11.1%) are the three most common reasons companies are pursuing 3D printing (Figure 7). Of those surveyed, 37 percent had just one 3D printer within their organizations, with 18 percent owning 10 or more. The average number of printers per organization was 5.4.

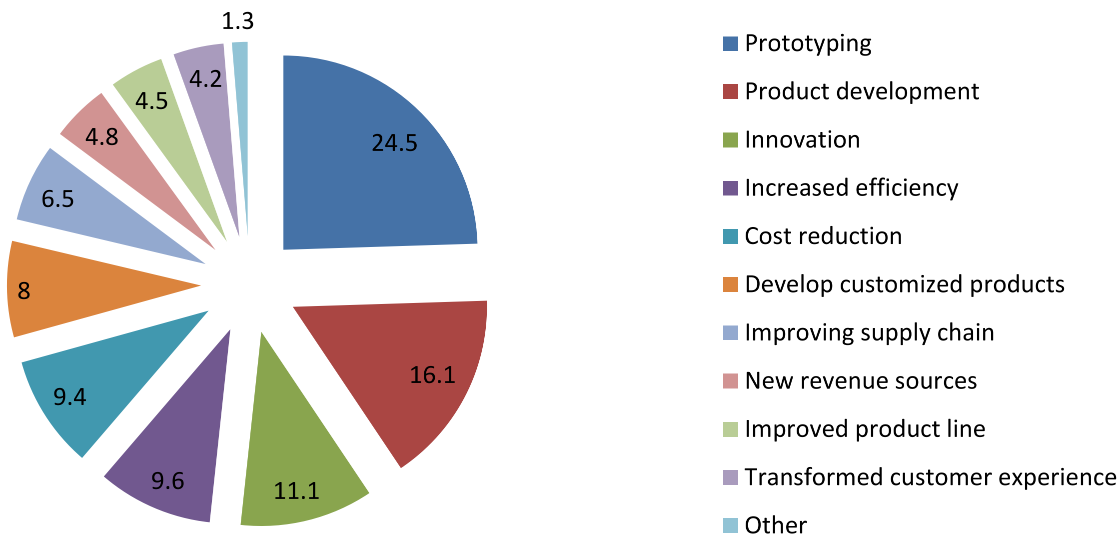

Figure 7. Reasons for pursuing 3D printing [14]

IMPACT OF 3D PRINTING ON SUPPLY CHAIN MANAGEMENT

A 3D printing revolution might be a huge opportunity for the supply chain management area. With 3D printing, an idea can go directly from a design file to a product, skipping many traditional manufacturing and transportation steps. It must be acknowledged that 3D printing technology is suitable for light or small goods for today, however, it should not be forgotten that future of 3D printing technology is very promising. Main impacts of 3D printing on supply chain management are given below [5]:

From mass production to mass customization: In traditional supply chains, mass production is the main goal to produce large quantities of products with very low per unit costs. However, changing the customers' demand and competition in the market enforces the companies to apply mass customization. In that case, traditional supply chains are insufficient. In contrast, 3D printing is very well suited for mass customization. It enables firms to economically build custom products in small batches as there is no need for the crafting of tools and molds and machine setup and change-overs are virtually non-existent.

Low manufacturing waste: In traditional supply chains, material waste is typically high due to milled, scrapped and sanded away products/materials. Although remanufacturing technologies are applied to minimize the waste caused by manufacturing, it also consumes additional processing times to make used material ready. In 3D printing or additive manufacturing, manufactures products by adding material layer upon layer. In that case, no waste is provided because only the material that is needed for the end product is added.

Environmental advantage: Amongst the proclaimed benefits of 3D printing is that it may help to preserve natural resources and reduce CO_2 emissions. For example, manufacturers are using 3D print technology in the aerospace industry to build aircraft with parts that are lighter than conventionally manufactured parts. This reduces weight and fuel consumption and leads to lower CO_2 emissions. 3D printing also enables more local production, which may minimize the need for shipping goods around the globe, thereby further reducing CO_2 emissions and fuel consumption. The US Department of Energy recently estimated that 3D printing has the potential to reduce energy costs by 50% and cut material costs by 90%. Another figure shows that a 100 kg save in aerospace can save $2.5 million of fuel.

Less complexity and supply risk: In traditional manufacturing, a final product can consists of hundreds of components. To find suppliers for each component and to transport necessary components from suppliers is a very difficult job that can increase the supply risk. On the contrary, a product can be made out of a single raw material or a combination of multiple raw materials, eliminating the need for sourcing different components in 3D printing. 3D printing uses raw materials as input materials such as nylons, plastic, metal, clay and silicone which can be find anywhere. Also, the raw materials can be sourced in bulk, decreasing the transportation costs. Figure 8 shows the reduced product complexity of a 3D printed air duct used in aircrafts. Originally, the air duct consisted of 16 parts assembled together, but using additive manufacturing the product can be engineered and manufactured in one part.

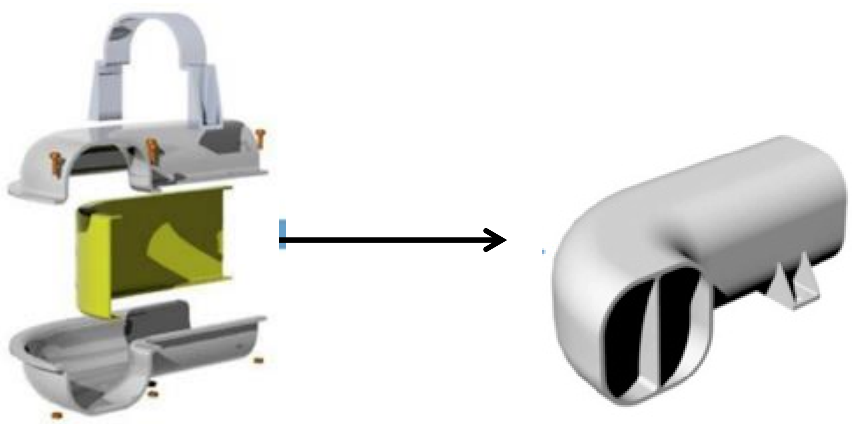

Figure 8. Reduced product complexity through 3D printing for aircraft air duct [5]

Decrease the complexity of existing supply chain networks: Traditionally, raw materials or components are supplied from suppliers, assembled in manufacturers and shipped to customers through retailers or distribution centers. On the contrary, 3D printing enables anyone with a digital design to bypass the traditional supply chain and manufacture a product themselves (Figure 9).

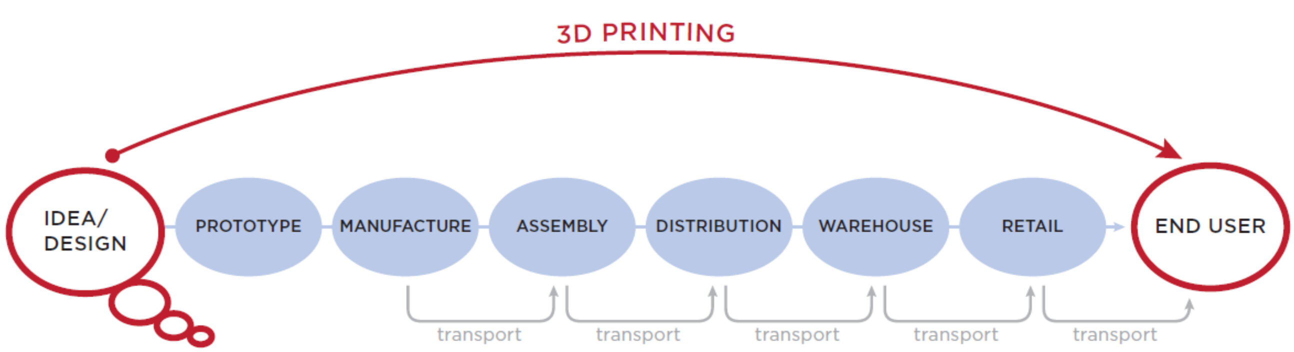

Figure 9. Traditional supply chain versus 3D printing supply chain [15]

Decrease product returns: Product returns are common due to defective manufacturing, misusing, or other customer failures in traditional supply chain networks. As the products can be fully specified and tailor-made in

3D printing, this will reduce the number of returns as consumers can be expected to be more satisfied with the product specifications and quality.

EXAMPLES OF 3D PRINTING TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

Orthopedic insoles production in SOLS Company: SOLS Company is producing and selling orthopedic insoles to customers in two different ways. While first one is traditionally, second one is using 3D printing technology (Figure 10). Traditionally, purchase of an orthopedic insole requires frequent contact between the client and an orthopedist, and resultantly the insole manufacturer. The orthopedist takes a foam print from the clients. Then he sends the scan to the insole manufacturer. The insole manufacturer fabricates the sole using CNC manufacturing technology. After the sole is finished, it is send to the orthopedist that will perform the final fitting with the customer. If the customers are not satisfied with the product adjustments to the insole are usually needed. The insole is send back to orthopedist to optimize the fitting, and the customer has to visit the orthopedist every time for fitting. The total process easily takes up four to six weeks and costs of the final product are around €200 [5]. However, by using 3D printing technology this production and distribution process is stepped up and simplified. The orthopedist can also take a direct 3D scan from the client's foot, digitally add the required adjustments and send the digital model to the 3D printing manufacturer. The manufacturer produces the insole straight from the design. This time around, there's less room for human induced error. In future, a client can make the 3D scan herself, using an app, using a process called photogrammetry. The insole is printed at a 3D printing supplier of company and directly shipped off to the client for approximately $100 [14].

Figure 10. Foam scanning in traditional way and 3D printed insoles in modern way [5]

Trucks with 3D Printers from Amazon: Amazon has a plan to 3D print straight from its delivery trucks. To do so, Amazon filed several patents for a system of printing 3D products on-demand from inside a delivery truck. Amazon reported that time delays between receiving an order and shipping the item to the customer may reduce customer satisfaction and affect revenues generated. With the system, Amazon could guarantee to have a product without having to even stock the inventory for especially toys and small equipment. By utilizing mobile manufacturing apparatuses Amazon would be able to send an STL file to a mobile unit that's closest to a customer, providing it with instructions to print out an item which was ordered. When the item has been completed, it could then be within miles of the customer who ordered it and quickly delivered or picked up. The mobile hubs such as trucks, according to the patent filing, would include a means to both additively and subtractively manufacture an item. This could include a number of different 3D printing technologies as well as CNC machining tools, which would ultimately reduce Amazon's reliance on warehouse space as well as the robots and employees needed to sort through these stored items [16].

CONCLUSION

As part of supply chain management, firms have to make decisions on how and where to manufacture products, which channels to use to distribute a product, where to source raw materials and/or components, and whether to do the physical distribution themselves or outsource to a service provider [5]. As 3D printers become faster, easier to use, handle multiple materials, and print active components or systems, firms have to plan for the widespread adoption of 3D printing. As mentioned in the paper, up to now, 3D printing has been used in from the automotive to the electronics and toy industries. According to technology forecasters, 3D printers will increasingly produce critical parts and finished products and food, jewelry and military industries will be also disrupted in future. Finally, firms have to take advantages of 3D printing technology to (i) reduce supply chain network and product complexity; (ii) improve order fulfillment; (iv) bring back sourcing/manufacturing operations to the market and (v) manufacture product according to customer's specifications.

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A MULTI-OBJECTIVE OPTIMIZATION MODEL FOR REVERSE SUPPLY CHAIN NETWORK DESIGN

Seval Ene[174], Nursel Öztürk[175]

Abstract − *Reverse supply chain concerns reverse flow of used products or materials. Product returns, environmental regulations and customer awareness obligate companies to incorporate reverse supply chain issues to their businesses. In reverse supply chain, network design provides efficient management of reverse flows. The scope of this paper is to focus on network design problem for reverse flow of end-of-life products. A multi-objective optimization model is developed for designing and planning reverse supply chain network. In the proposed multi-objective model, maximization of total profit of the reverse supply chain network and minimization of the environmental impact objectives are considered. Illustrative examples are performed to assess the performance and to show the applicability of the proposed model. The results showed that the proposed model provides effective solutions for reverse supply chain network design problems and it can be applied as an efficient tool for strategic planning of product returns.*

Keywords −*Multi-objective optimization, network design, product returns, reverse supply chain*

INTRODUCTION

Supply chain management can be defined as the discipline that optimizes the delivery of goods, services and information from suppliers to customer [1]. Recent attention in supply chain management tends to extend traditional forward supply chain to involve product returns, environmental issues and social responsibilities. Reverse supply chain management is described as the efficient and effective management of a series of activities required to retrieve a product from customer and recover value or dispose of it [2]. Although there are some similarities between traditional supply chain and reverse supply chain, numerous differences between them create new research areas in supply chain management. For instance, collection of returns requires an extensive network in reverse supply chain. Product complexity and qualities are other complicating factors [3].

Network design plays an important role in overall environmental and economic performance of a supply chain. Additionally, product returns' management and reverse supply chain network design has an increased importance because of substantial impacts of end-of-life products on the environment [4]. Network design is the problem of determining number and location of facilities, specifying transportation channels between these facilities and setting quantity of items to transport in these channels [5].

The scope of this paper is to design a reverse supply chain network for end-of-life products. A multi-objective optimization model is developed for addressing the studied problem; multi-product, multi-period, multi-stage reverse supply chain network design problem. In multi-objective frame of the model, environmental aspects (e.g. CO_2 emissions caused from transportation, environmental impact caused from opening new centers,

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environmental impact of recovery/remanufacturing or disposal processes based on used clean technology, recyclable materials, renewable energy etc.) are considered as well as economic aspects.

LITERATURE REVIEW

There are several studies in literature that considers reverse supply chain or logistics network design problem. Some of these studies are summarized as follows. Pochampally and Gupta [6] proposed a three-phase fuzzy logic approach to design a reverse supply chain network. Their solution approach aimed to choose most economical product and minimize overall cost of the network. Lee and Dong [7] developed a deterministic programming model and a heuristic approach to obtain the logistics network design for end-of-life computers recovery with minimum cost. Tuzkaya et al. [8] developed a multi-objective model and a two stage methodology for reverse logistics network design problem. The model considers cost minimization and weighted product volume maximization objectives. The reverse logistics network design model is solved via genetic algorithms. Assavapokee and Wongthatsanekorn [9] developed a mixed integer linear programming model for designing the infrastructure of a reverse production system to support product recovery activities. Ene and Öztürk [10] presented a mixed integer linear programming model that maximizes total profit of the network model for product recovery operations. Kannan et al. [11] proposed a mixed integer linear programming model for the design of a reverse logistics network based on the carbon footprint. The objective of the model was to minimize both the total cost involved in the reverse logistics network and the emissions produced in processing and shipping. Ramezani et al. [5] developed a stochastic multi-objective model for forward/reverse logistics network design problem. They considered profit maximization, customer service level maximization and minimization of total number of defects in raw materials as objective functions.

Although there are several studies about reverse supply chain network design problem in literature, multi-objective network models that consider environmental issues studied rarely in reverse supply chain network design research area. Some studies considered environmental aspects in addition to economic aspects in green or sustainable supply chain network design problem concept (e.g. Wang et al. [12], Jamshidi et al. [13], Comas Marti et al. [14], Tognetti et al. [15] etc.). Some authors studied environmental issues in closed-loop supply chain network design problem concept (Pishvaee and Razmi [4], Amin and Zhang [16], Garg et al. [17] etc.). In this paper, differently from previous studies reverse supply chain network design problem is dealt with economic and environmental issues that includes CO_2 emissions caused from transportation, environmental impact caused from opening new centers, environmental impact of recovery/remanufacturing or disposal processes based on used clean technology, recyclable materials, renewable energy etc.

PROBLEM DESCRIPTION AND MODEL FORMULATION

In this paper, a general reverse supply chain network that considers five network stages is studied. As presented in Figure 1, structure of the reverse supply chain network consists of customers, collection centers, inspection/disassembly centers, recovery/ remanufacturing centers and disposal centers.

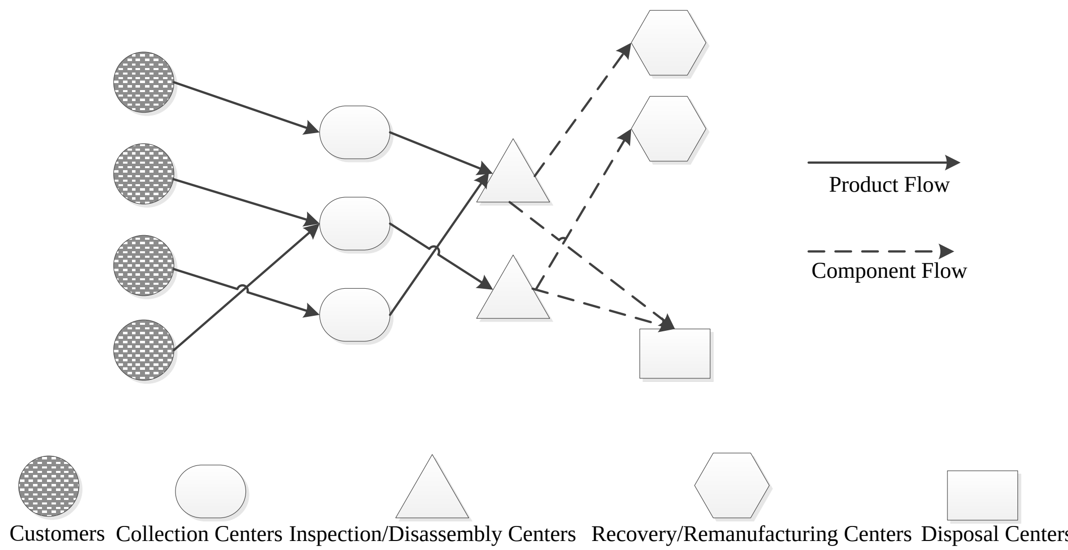

Figure 1. Network Structure of the Reverse Supply Chain

In the considered network, end-of-life or used products are initially collected from customers. All customer demands must be satisfied. Collected end-of-life or used products are then transported to inspection/disassembly centers. Responsibilities of inspection/disassembly centers are disassembling returned products into components level and identifying condition of disassembled components by inspection. Disassembled components which are good quality or recoverable are transported to recovery/ remanufacturing centers. Disassembled components which are unrecoverable are transported to disposal centers for disposing. At recovery/ remanufacturing center, the purpose of the process on the components is to bring the same conditions as the new ones.

It is assumed that, all customer locations, recovery/remanufacturing centers and disposal centers, potential locations of collection and inspection/disassembly centers are known. All centers have capacity restrictions. Demands of customers for end-of life or used products' collection are uncertain and they are defined by scenarios. Network model for described problem is designed as a multi-objective frame. Total profit maximization and environmental impact minimization objectives are considered. Environmental impact minimization includes CO_2 emissions minimization caused from transportation, environmental impact minimization caused from opening new centers to potential locations and environmental impact minimization caused by recovery/remanufacturing or disposal processes. The criteria for recovery/remanufacturing or disposal centers' environmental impact are using clean technology, recyclable materials, renewable energy etc.

Considered reverse supply chain network can be formulated as a multi-objective optimization model. Sets, decision variables and parameters used in the model are defined as follows:

Sets:

I	set customers, $\forall i \in I$
J	set of collection centers, $\forall j \in J$
K	set of inspection/disassembly centers, $\forall k \in K$
L	set of recovery/remanufacturing centers, $\forall l \in L$
M	set of disposal centers, $\forall m \in M$

T set of periods, $\forall t \in T$

P set of products, $\forall p \in P$

Q set of product components $\forall q \in Q$

Q_p set of components of product p $\forall p \in P$ $Q_p \subset Q$

S set of scenarios, $\forall s \in S$

Decision Variables:

$$a_j = \begin{cases} 1 & \text{if a collection center opens at location } j \\ 0 & \text{otherwise} \end{cases}$$

$$b_k = \begin{cases} 1 & \text{if an inspection/disassembly center opens at location } k \\ 0 & \text{otherwise} \end{cases}$$

x_{pijts} number of products *p* transported from customer *i* to collection center *j* in period *t* for scenario *s*

y_{pjkts} number of products *p* transported from collection center *j* to inspection/disassembly center *k* in period *t* for scenario *s*

z_{qklts} number of product components *q* transported from inspection/disassembly center *k* to recovery/remanufacturing center *l* in period *t* for scenario *s*

w_{qkmts} number of product components *q* transported from inspection/disassembly center *k* to disposal center *m* in period *t* for scenario *s*

Parameters:

c_j fixed cost of opening collection center *j*

c_k fixed cost of opening inspection/disassembly center *k*

cap_j capacity of collection center *j*

cap_k capacity of inspection/disassembly center *k*

cap_l capacity of recovery/remanufacturing center *l*

cap_m capacity of disposal center *m*

ct_{ij} distance between customer *i* and collection center *j*

ct_{jk} distance between collection center *j* and inspection/disassembly center *k*

ct_{kl} distance between inspection/disassembly center *k* and recovery/remanufacturing center *l*

ct_{km} distance between inspection/disassembly center *k* and disposal center *m*

uc_p	unit transportation cost for products
uc_q	unit transportation cost for components
cd	unit disposal cost
oc_j	unit operating cost for collection center *j*
oc_k	unit operating cost at inspection/disassembly center *k*
oc_l	unit operating cost at recovery/remanufacturing center *l*
r_q	unit revenue from recovered component *q*
e_{pits}	number of products *p* returned from customer *i* in period *t* for scenario *s*
n_{qp}	number of components *q* in product *p*
fr_q	recovery ratio for component *q*
fd_q	disposal ratio for component *q*
ps_s	probability of occurrence of scenario *s*
α	emission factor for transportation per unit of weight of products or components and per unit of distance between network stages
ω_p	weight of product *p*
ω_q	weight of component *q*
β_j	environmental impact level for collection center *j*
β_k	environmental impact level for inspection/disassembly center *k*
δ_l	environmental impact level for recovery/remanufacturing center *l*
δ_m	environmental impact level for disposal center *m*

Objective functions:

$$\begin{aligned}\max z_1 = &\sum_{q\in Q}\sum_{k\in K}\sum_{l\in L}\sum_{t\in T}\sum_{s\in S} ps_s z_{qklts} r_q - \sum_{j\in J} a_j c_j - \sum_{k\in K} b_k c_k - \sum_{p\in P}\sum_{i\in I}\sum_{j\in J}\sum_{t\in T}\sum_{s\in S} ps_s x_{pijts} oc_j \\ &- \sum_{p\in P}\sum_{j\in J}\sum_{k\in K}\sum_{t\in T}\sum_{s\in S} ps_s y_{pjkts} oc_k - \sum_{q\in Q}\sum_{k\in K}\sum_{l\in L}\sum_{t\in T}\sum_{s\in S} ps_s z_{qklts} oc_l - \sum_{q\in Q}\sum_{k\in K}\sum_{m\in M}\sum_{t\in T}\sum_{s\in S} ps_s w_{qkmts} cd \\ &- \sum_{p\in P}\sum_{i\in I}\sum_{j\in J}\sum_{t\in T}\sum_{s\in S} ps_s x_{pijts} ct_{ij} uc_p - \sum_{p\in P}\sum_{j\in J}\sum_{k\in K}\sum_{t\in T}\sum_{s\in S} ps_s y_{pjkts} ct_{jk} uc_p \\ &- \sum_{q\in Q}\sum_{k\in K}\sum_{l\in L}\sum_{t\in T}\sum_{s\in S} ps_s z_{qklts} ct_{kl} uc_q - \sum_{q\in Q}\sum_{k\in K}\sum_{m\in M}\sum_{t\in T}\sum_{s\in S} ps_s w_{qkmts} ct_{km} uc_q \end{aligned} \tag{1}$$

$$\min z_2 = \sum_{p\in P}\sum_{i\in I}\sum_{j\in J}\sum_{t\in T}\sum_{s\in S} ps_s x_{pijts}\omega_p \alpha ct_{ij} + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K}\sum_{t\in T}\sum_{s\in S} ps_s y_{pjkts}\omega_p \alpha ct_{jk} + \sum_{q\in Q}\sum_{k\in K}\sum_{l\in L}\sum_{t\in T}\sum_{s\in S} ps_s z_{qklts}\omega_q \alpha ct_{kl} + \sum_{q\in Q}\sum_{k\in K}\sum_{m\in M}\sum_{t\in T}\sum_{s\in S} ps_s w_{qkmts}\omega_q \alpha ct_{km} \quad (2)$$

$$\min z_3 = \sum_{j\in J} a_j \beta_j + \sum_{k\in K} b_k \beta_k + \sum_{q\in Q}\sum_{k\in K}\sum_{l\in L}\sum_{t\in T}\sum_{s\in S} ps_s z_{qklts}\delta_l + \sum_{q\in Q}\sum_{k\in K}\sum_{m\in M}\sum_{t\in T}\sum_{s\in S} ps_s w_{qkmts}\delta_m \quad (3)$$

Constraints:

$$\sum_{j\in J} x_{pijts} = e_{pits} \qquad p\in P, i\in I, t\in T, s\in S \quad (4)$$

$$\sum_{p\in P}\sum_{i\in I} x_{pijts} \le cap_j a_j \qquad j\in J, t\in T, s\in S \quad (5)$$

$$\sum_{p\in P}\sum_{j\in J} y_{pjkts} \le cap_k b_k \qquad k\in K, t\in T, s\in S \quad (6)$$

$$\sum_{q\in Q}\sum_{k\in K} z_{qklts} \le cap_l \qquad l\in L, t\in T, s\in S \quad (7)$$

$$\sum_{q\in Q}\sum_{k\in K} w_{qkmts} \le cap_m \qquad m\in M, t\in T, s\in S \quad (8)$$

$$\sum_{i\in I} x_{pijts} = \sum_{k\in K} y_{pjkts} \qquad p\in P, j\in J, t\in T, s\in S \quad (9)$$

$$\sum_{j\in J} y_{pjkts}\ fr_q\ n_{qp} = \sum_{l\in L} z_{qklts} \qquad p\in P, q\in Q_p, k\in K, t\in T, s\in S \quad (10)$$

$$\sum_{j\in J} y_{pjkts}\ fd_q\ n_{qp} = \sum_{m\in M} w_{qkmts} \qquad p\in P, q\in Q_p, k\in K, t\in T, s\in S \quad (11)$$

$$x_{pijts}, y_{pjkts}, z_{qklts}, w_{qkmts} \ge 0 \qquad p\in P, q\in Q_p, i\in I, j\in J, k\in K, l\in L, m\in M, t\in T, s\in S \quad (12)$$

$$a_j, b_k \in \{0,1\} \qquad j\in J, k\in K \quad (13)$$

Objective function (1) maximizes total profit of the network. Objective function (2) minimizes environmental impact caused from transportations between the stages of the network depending on distance and weights of products or components. Objective function (3) minimizes environmental impact arised by opening a new center and environmental impact resulted from processes of recovery/remanufacturing or disposal centers. Constraint (4) ensures that all returned end-of-life or used product demands of customers must be satisfied in each period for each scenario and product type. Constraint (5) specifies that in each period total end-of-life or used products transported to opened collection centers can not exceed the capacity of the center for each scenario. Constraint (6) states that total end-of-life or used products transported to opened inspection/disassembly center in each period can not exceed the capacity of the facility for each scenario. Constraint (7) specifies that total components transported to selected recovery/ remanufacturing center in each period can not exceed the capacity of the center for each scenario. Constraint (8) states that total components transported to disposal center in each period can not exceed the capacity of the center for each scenario. Constraint (9) specifies flow balance between collection and inspection/disassembly centers. Constraints (10) and (11) ensures disassembled components' rates transported to recovery/remanufacturing and disposal centers respectively for each period, scenario, product and component type. Constraint (12) states that decision variables $x_{pijts}, y_{pjkts}, z_{qklts}, w_{qkmts}$ must be greater than 0. Constraint (13) specifies that decision variables a_j, b_k must be 1 or 0.

MULTI-OBJECTIVE METHODOLOGY

Weighted sums method is the most popular approach in order to solve multi-objective problems. In weighted sums method, objective functions are combined by assigning appropriate weights ($\psi_1, \psi_2, ...$) and the problem is transformed to a single-objective optimization problem. It is noticeable that all weights are greater than zero and summation of weights equals to one [16]. The studied problem is transformed to the form written in Equation (14):

$$\begin{aligned} &min\ z = -\psi_1 z_1 + \psi_2 z_2 + \psi_3 z_3 \\ &s.t. \\ &Equations\ (4-13) \\ &\sum_{i=1}^{3} \psi_i = 1 \\ &\psi_i > 0 \qquad i = 1,2,3 \end{aligned} \tag{14}$$

Setting up an appropriate weight for objective functions depends on the scaling of each objective function. Different objective functions may take different orders of magnitude. When weighting that kind of objective functions, normalization can be applied by scaling them appropriately in order to make them same order of magnitude [18].

ILLUSTRATIVE EXAMPLE

The multi-objective optimization model presented in this paper is coded in MPL (Mathematical Programming Language) and solved with GUROBI solver. To show the performance and applicability of the model an illustrative example is designed. The example consists of ten customer locations, six alternative collection center locations, four alternative inspection/disassembly center locations, five alternative recovery/remanufacturing centers and four disposal centers. Three product types and 12 component types (four component types for each product type) are considered in the example over three planning periods. In every product type, number of components for each type of component is equal to one. It is assumed that, through the components of each product only three of them can be recovered or remanufactured. Remaining parameter values used in the example are presented in Table 1. Environmental impact levels of collection, inspection/disassembly, recovery/remanufacturing and disposal centers are determined by experts and decision makers. Scenarios described for overcoming uncertainty in number of returned products are designed as worst, expected and best cases. Emission factor for transportation per unit of weight of products or components and per unit of distance between network stages is obtained from Aksoy et al. [19].

Table 1. Parameter Values

Parameter	Value	Parameter	Value
c_j	UNIF (10000, 15000)	ps_s	(0.15, 0.50, 0.35)
c_k	UNIF (15000, 20000)	uc_p	6
cap_j	UNIF (500, 1000)	uc_q	2.5
cap_k	UNIF (3000, 5000)	cd	100
cap_l and cap_m	UNIF (5000, 7000)	oc_j, oc_k and oc_l	40
ct_{ij}, ct_{jk}, ct_{kl} and ct_{km}	UNIF (50, 100)	α	0.427
r_q	UNIF (400, 800)	β_j	(0.1, 0.5, 0.8, 0.2, 0.3, 0.7)
e_{pits}	UNIF (50, 80) UNIF (80, 125) UNIF(125, 160)	β_k δ_l	(0.7, 0.2, 0.9, 0.4) (0.3, 0.8, 0.1, 0.9, 0.2)
ω_p	0.1	δ_m	(0.5, 0.1, 0.9, 0.2)
ω_q	0.02		

To solve the multi-objective model, various numerical experiments were performed. First of all, payoff table of the objective functions were calculated as can be seen in Table 2. The payoff table can be obtained by optimizing each objective function independently from the others. For instance, in the first row of Table 2, by maximizing z_1, optimum value for z_1 and values of z_2 and z_3 associated with solution of z_1 are acquired. It can be clearly seen from Table 2 that z_1 and z_3 are contradictory. Besides, z_1 and z_2 have about a similar trend.

Table 2. Payoff Table of Objective Functions

Objective of the model	Value of z_1	Value of z_2	Value of z_3
Max z_1	2471492.95	66420.52	14316.54
Min z_2	2465628.33	66420.52	16460.52
Min z_3	-90736.68	82148.81	5061.63

In order to obtain Pareto optimal solutions of the model, weighted sums method is applied. Different experiments are performed by assigning different weights to the objective functions and the values of objective functions are obtained. Some of the efficient solutions obtained from weighted sums method can be seen in Table 3.

As summarized in Table 3, obtained results show that, different combinations in weights of objective functions result varied values for each objective function. For instance, while high objective function weight for z_1 raises profit described in z_1, it causes increased adverse environmental impacts described in z_3. On the other hand, high objective function weight for z_1 likewise minimizes z_2 as CO_2 emissions caused from transportations are proportional to the distance and weights of products or components. Similarly, high weights for z_2 minimize CO_2 emissions caused from transportations and increase profit of the network depending on weight of the z_3. However, high objective function weight for z_3 shows opposite effects on z_1 and z_2. It causes decrease in profit and increase in CO_2 emissions produced from transportation. From overall results, we can say that balanced weights in objective functions may cause satisfactory values for each objective function. Or, one can select appropriate weights according to the given importance to each objective function in order to obtain preferred results.

Table 3. Efficient Solutions for the Example

Number of Experiment	ψ_1	ψ_2	ψ_3	Value of z_1	Value of z_2	Value of z_3
1	0.8	0.1	0.1	2445585.24	66421.78	7872.89
2	0.5	0.3	0.2	2292458.53	67122.39	7061.62
3	0.3	0.6	0.1	2318128.37	66994.35	7167.21
4	0.1	0.8	0.1	2445585.24	66421.78	7872.89
5	0.3	0.4	0.3	1474541.11	69779.61	5403.07
6	0.4	0.1	0.5	1382863.83	71560.92	5063.63
7	0.1	0.1	0.8	1379733.03	71672.16	5062.83
8	0.1	0.5	0.4	1354607.29	70132.18	5244.91
9	0.5	0.2	0.3	1793771.13	69286.25	5790.88
10	0.1	0.7	0.2	1836613.21	68485.64	5972.06

Effects of different weights on the network decisions are presented in Table 4 by experiment number.

Table 4. Network Decisions for the Example

Number of Experiment	Opened Collection Centers	Opened Inspection/Disassembly Centers	Selected Recovery/Remanufacturing Centers	Selected Disposal Centers
1	1,2,5,6	1,4	1,3,5	4
2	1,2,5,6	1,2,4	1,3,5	2,4
3	1,2,5,6	1,2,4	1,3,5	2,4
4	1,2,5,6	1,4	1,3,5	4
5	1,2,3,5,6	1,2,3,4	1,3,5	2,4
6	1,2,3,4,5	1,2	1,3,5	2
7	1,2,4,5	1,2	1,3,5	2
8	1,2,5,6	1,2,3,4	1,3,5	2,4
9	1,2,5,6	1,2,4	1,3,5	2,4
10	1,2,5,6	1,2,3,4	1,3,5	2,4

It can be seen from the results that, weight values for objective functions do not affect recovery/remanufacturing centers' selection decisions. However, collection centers', inspection/disassembly centers' and disposal centers' opening or selection decisions are affected by weight values of objective functions significantly. In case of high objective function weight for z_3, decisions about the collection, inspection/disassembly and disposal centers tend to open or select centers which have less environmental impacts. For instance, in experiment 7, collection centers, inspection/disassembly centers and disposal centers with less environmental impact are opened and selected for operating. On the other hand, in case of high objective function weights for z_1 and z_2, decisions about the collection, inspection/disassembly and disposal centers are taken in the manner of increasing economic benefits and minimizing distance (in order to minimize CO_2 emissions produced from transportation), respectively.

For illustration, network structure obtained by experiment 9 is presented in Figure 2. The figure shows obtained network structure for product type 1 and first planning period by scenarios as stating product and component flow.

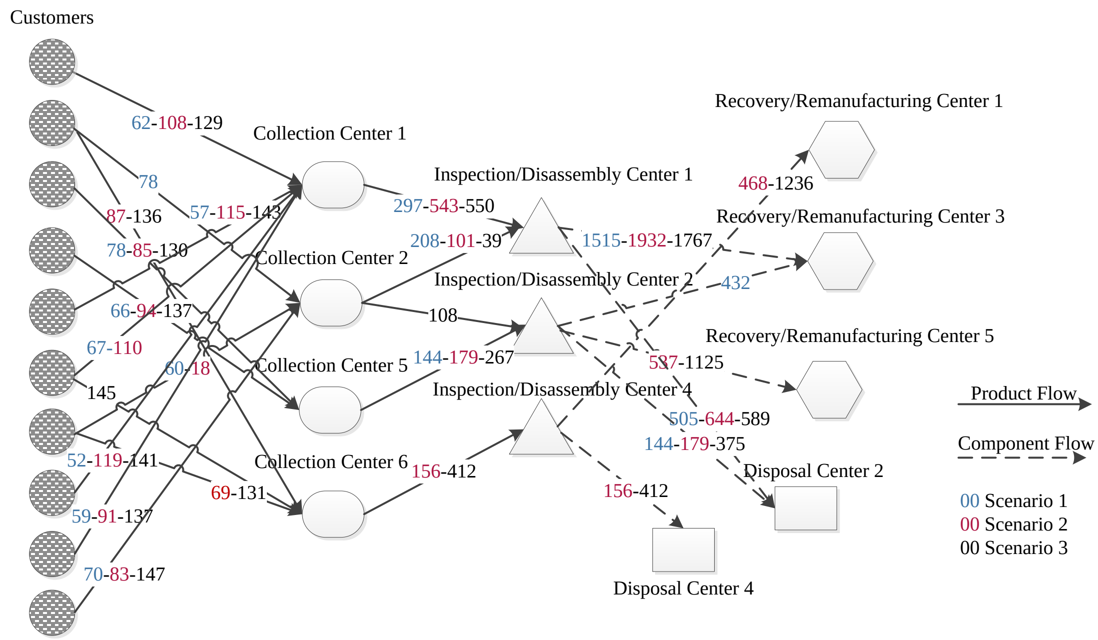

Figure 2. Network Structure Obtained by Experiment 9 for Product Type 1

CONCLUSIONS

Network design has a significant importance in supply chain performance combined with an objective compatible with performance goals of the chain. In this paper, a multi-objective optimization model for designing reverse supply chain network that considers economic issues as well as environmental issues is presented. Economic issues are composed of total profit maximization and environmental issues are composed of CO_2 emissions minimization caused from transportation, environmental impact minimization caused from opening new centers to potential locations and environmental impact minimization caused by recovery/ remanufacturing or disposal processes. To solve the proposed model and obtain Pareto optimal solutions, weighted sums method is employed. Obtained results showed that the model produces effective and efficient solutions for conflicting objectives of economic and environmental issues. Although the model has been illustrated for a small network example, it is capable of designing larger networks. The proposed model can be used as a strategic tool for multi objective decisions in reverse supply chain problems.

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DISCRETE PARTICLE SWARM OPTIMIZATION ALGORITHM FOR TRUCK DOOR ASSIGNMENT PROBLEM IN CROSSDOCKS

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Abstract – Cross-docking is a relatively new logistics strategy in order to minimize total transportation costs in supply chain. This strategy can be described as the process of moving products from suppliers to customers through cross-docking centers without storing them for a long time in these centers, which almost eliminates the storage costs and speeds up the product flow in network. This paper considers the truck door assignment problem of the cross-docking centers with product allocations. The aim of the study is to find best assignment plan for the incoming and outgoing trucks in order to minimize total transportation distance of the products in cross-docking centers. The problem is formulated as a mixed integer mathematical model which identifies the truck door assignment and product allocation decisions in crossdocks. Moreover, this paper presents a discrete particle swarm optimization algorithm in order to solve large scale problems. Proposed algorithm is tested on different sized randomly generated instances. Numerical results show that the proposed algorithm exhibits effective performance in short computational times.

Keywords – Cross-docking, truck door assignment, mathematical model, particle swarm optimization

INTRODUCTION

The efficiency of transportation is one of the most important factors for supply chain management. For this reason, many companies develop various strategies to boost customer satisfaction and bring down the total costs. Cross-docking which almost eliminates the storage costs and speeds up the product flows is one of these strategies. It can be described as the process of moving products from suppliers to customers through cross-docking centers without storing products for a long time in these centers. At each center, incoming trucks loaded from different suppliers arrives to incoming doors and unloaded to incoming area quickly. These products are sorted and consolidated according to their destinations and then reloaded to outgoing trucks for distribution. This strategy provides different advantages compared with traditional distribution centers: the consolidation of shipments, a shorter delivery lead time, the reduction of costs, improved customer service, fewer overstocks, etc. [1]. As a result of these advantages, cross-docking has become an interesting logistics strategy that can give companies important competitive benefits.

Until now, lots of studies considering cross-docking have been studied in the literature and they categorized in many ways. Belle et al. [1] presented a comprehensive literature review about cross-docking and classified them based on the problem type: location of cross-docks, cross-docking layout design, cross-docking networks, vehicle routing, dock door assignment, truck scheduling, storage and other issues. Some of these problems are more concerned about long term decisions (strategic or tactical), while others deal with short-term decisions (operational).

In this study, truck door assignment problem of cross-docking center (TDAPCD) is considered with product allocation plans. The aim is to find optimum assignments for trucks to inbound and outbound dock doors that minimize the handling costs. A detailed review on the truck-door assignment problem is provided by Shuib and Fatthi [2]. An early work related to truck-door assignment is studied by Tsui and Chang [3], who propose a bilinear program for assigning the origins and destinations to dock doors rather than to trucks. Subsequently, a

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branch-and-bound algorithm was proposed by Tsui and Chang [4] for the same problem. Cohen and Keren [5] also expanded the same problem by allowing freight splitting for capacitated trailers and proposed a heuristic algorithm to solve the problem. Another assignment problem is considered by Oh et al. [6], who addresses the real-life problem of mail distribution centers. Bozer and Carlo [7] studied static and dynamic truck-door assignments, in which the outbound doors are fixed over the planning horizon with a static door assignment while both the inbound and outbound door assignments are specified every day with a dynamic door assignment. The problem is considered a quadratic assignment problem with rectilinear distances and is formulated with mixed integer programming. Likewise, the static assignment problem is taken into account by Yu et al. [8], and two heuristic methods are developed to solve the problem, which are a local search and a genetic algorithm that both heuristics provide about approximately 20% reduction in travel times compared with the current system. Miao et al. [9] considered the truck-door assignment problem with an operational time constraint in crossdocks where the number of trucks exceeds the number of doors available. Luo and Noble [10] presented a mathematical model for truck-door assignment problem with staging operations and cargo scheduling. Since the run time of the exact solver increases significantly as the problem size increases, the authors proposed a genetic algorithm which obtains effective solutions in practical times for large size problems include more than 50 dock doors. Konur and Golias [11] discussed the truck-scheduling problem of cross-docking at inbound doors in the case of unknown truck arrival times in which the scheduling strategy is subject to variations in costs of serving the trucks. The problem is formulated as a bi-objective, bi-level optimization problem and is solved using a genetic algorithm. The proposed algorithm is compared to the first-come-first-served strategy.

As mentioned above, there are numerous works on truck door assignment problems in the literature. Distinctly from the existing studies, this paper considers the TDAPCD with product allocation plans with two dimensional placement constraints. The problem is formulated as a mixed integer mathematical model and a discrete particle swarm optimization (DPSO) algorithm is proposed as a solution method. The rest of the paper consists of the following parts: problem definition and mathematical model, proposed DPSO algorithm, computational results and finally conclusion.

PROBLEM DEFINITION AND MODEL FORMULATION

The TDAPCD can be described as finding the best assignment plan of the incoming and outgoing trucks to dock doors. In this study, the truck door assignment problem is considered for I incoming trucks, O outgoing trucks and D dock doors in cross-docking center. The products picked up from suppliers are unloaded from incoming trucks at dock doors and located at consolidation areas in cross-docking center. Subsequently, products are loaded into the outgoing trucks for distribution operations according to their destinations. The objective is to find best truck door assignment and product allocation plan that minimizes the total traveling distance of the products in cross-docking center. The TDAPCD is taken into account with the following assumptions:

- There are at least as much dock doors as trucks, so each truck can be assigned to a door.
- Each dock door can be used by any incoming or outgoing truck.
- Products unloaded from incoming trucks must be located at any consolidation area.
- Products cannot stacked on each other in consolidation areas.
- The consolidation areas are identified with two dimensional physical limits.
- Products are identified as rectangular shapes and located in the consolidation areas according to the two dimensional boundary limits.
- Material flow in cross-docking center is formed in two stages: First, products unloaded from incoming trucks are transported to consolidation areas and temporarily stored. Then, products are carried to outgoing trucks.
- Movements of the products in cross-docking center are described as rectilinear distance.

The concept of the described problem is depicted in Figure (1), which illustrates an example for three incoming and two outgoing trucks at cross-docking center. According to the assumptions described above, the mixed integer mathematical model of the problem is formulated as follows:

Parameters and Notations

I : Number of incoming trucks

O : Number of outgoing trucks

D : Number of doors

P : Number of products transported from suppliers to customers

A : Number of consolidation area in cross-docking center

W : Width of the consolidation areas

L : Length of the consolidation areas

dem_p : Incoming truck label of product p; $p = 1, \dots, P$

dem'_p : Outgoing truck label of product p; $p = 1, \dots, P$

w_p : Width of the product p; $p = 1, \dots, P$

l_p : Length of the product p; $p = 1, \dots, P$

DRX_d : Central x coordinate of door d; $d = 1, \dots, D$

DRY_d : Central y coordinate of door d; $d = 1, \dots, D$

AX_a : Lowest x coordinate of consolidation area a; $a = 1, \dots, A$

AY_a : Lowest y coordinate of consolidation area a; $a = 1, \dots, A$

M : Big number

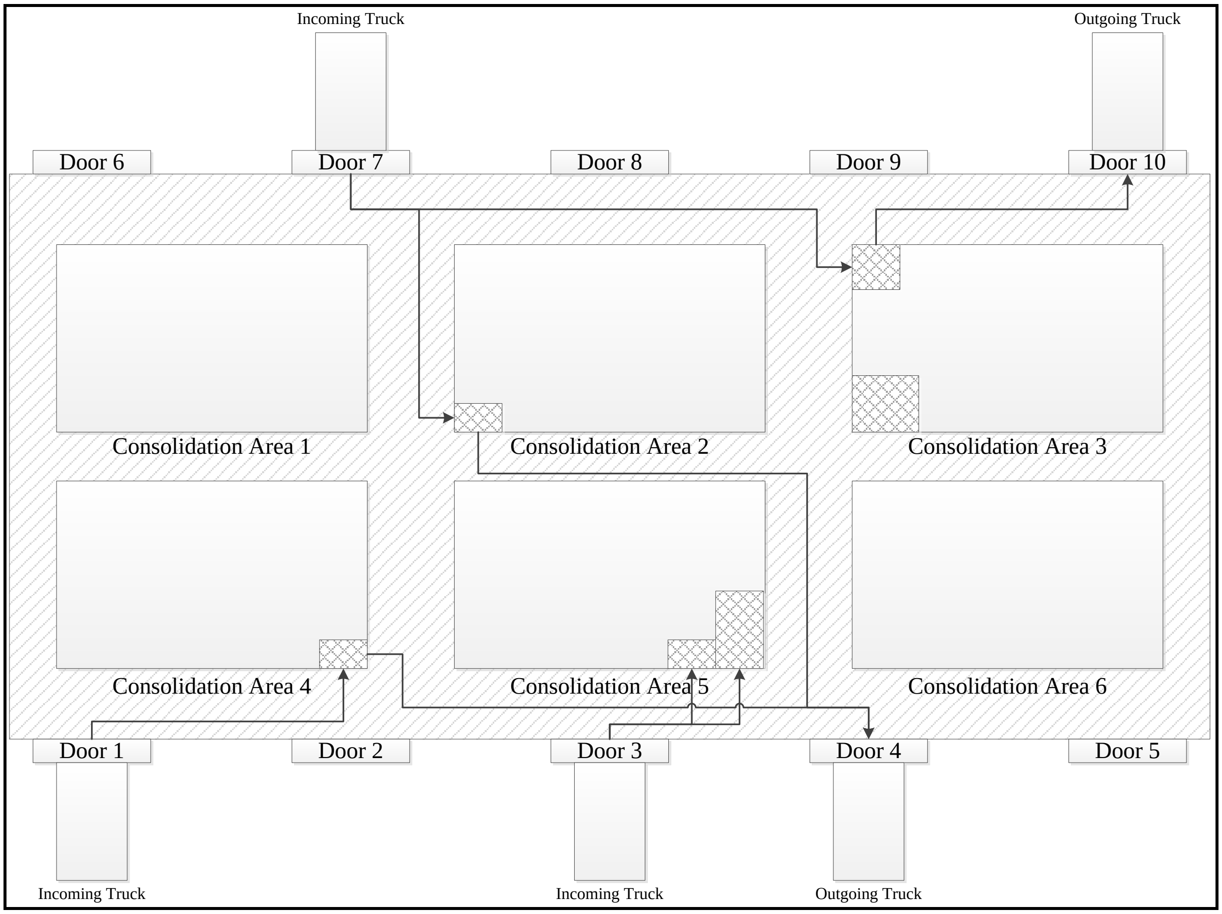

Figure 1. An Illustrative Example of Described Problem

Decision Variables

z_{id} : is a binary variable and equal to 1 if incoming truck i is assigned to door d and 0 otherwise; $i = 1, \dots, I; d = 1, \dots, D$

z'_{od} : is a binary variable and equal to 1 if outgoing truck o is assigned to door d and 0 otherwise; $o = 1, \dots, O; d = 1, \dots, D$

s_{pa} : is a binary variable and equal to 1 if product p is assigned to consolidation area a in cross-docking center and 0 otherwise; $p = 1, \dots, P; a = 1, \dots, A$

x_p : is a nonnegative variable and specify the x coordinate of the product p in a consolidation area; $p = 1, \dots, P$

y_p : is a nonnegative variable and specify the y coordinate of the product p in a consolidation area; $p = 1, \dots, P$

h_p : is a nonnegative variable and specify the horizontal movement of product p from incoming truck to a located position in consolidation area; $p = 1, \dots, P$

v_p : is a nonnegative variable and specify the vertical movement of product p from incoming truck to a located position in consolidation area; $p = 1, \dots, P$

h'_p : is a nonnegative variable and specify the horizontal movement of product p from a located position in consolidation area to outgoing truck ; $p = 1, \dots, P$

v'_p : is a nonnegative variable and specify the vertical movement of product p from a located position in consolidation area to outgoing truck ; $p = 1, \dots, P$

$\alpha_{pr}, \beta_{pr}, \gamma_{pr}, \delta_{pr}$: are binary variables equal to 1 if product p is on the left, right, bottom and top side of product r in the same consolidation area, respectively, and 0 otherwise; $p, r = 1, \dots, P$

Using the notations, parameters and decision variables mentioned above, the truck door assignment problem of cross-docking center is formulated as follows.

$$Min \sum_{p=1}^{P} \left(h_p + v_p + h'_p + v'_p \right) \tag{1}$$

Subject to:

$$\sum_{d=1}^{D} z_{id} = 1 \qquad i = 1, \dots, I \tag{2}$$

$$\sum_{d=1}^{D} z'_{od} = 1 \qquad o = 1, \dots, O \tag{3}$$

$$\sum_{i=1}^{I} z_{id} + \sum_{o=1}^{O} z'_{od} \le 1 \qquad d = 1, \dots, D \tag{4}$$

$$\sum_{a=1}^{A} s_{pa} = 1 \qquad p = 1, \dots, P \tag{5}$$

$$x_p + w_p \le x_r + M\left(1 - \alpha_{pr}\right) \qquad p, r = 1, \dots, P; \qquad p < r \tag{6}$$

$$x_r + w_r \le x_p + M\left(1 - \beta_{pr}\right) \qquad p, r = 1, \dots, P; \qquad p < r \tag{7}$$

$$y_p + l_p \le y_r + M\left(1 - \gamma_{pr}\right) \qquad p, r = 1, \dots, P; \qquad p < r \tag{8}$$

$$y_r + l_r \le y_p + M\left(1 - \delta_{pr}\right) \qquad p, r = 1, \dots, P; \qquad p < r \tag{9}$$

$$\alpha_{pr} + \beta_{pr} + \gamma_{pr} + \delta_{pr} \ge s_{pa} + s_{ra} - 1 \qquad p, r = 1, \dots, P; \qquad p < r; \qquad a = 1, \dots, A \tag{10}$$

$$x_p + w_p \le W \qquad p = 1, \dots, P \tag{11}$$

$$y_p + l_p \le L \qquad p = 1, \dots, P \tag{12}$$

$$h_p \geq \sum_{a=1}^{A} AX_a s_{pa} + x_p - \sum_{d=1}^{D} DRX_d z_{dem_p d} \qquad p = 1, \dots, P \tag{13}$$

$$h_p \geq \sum_{d=1}^{D} DRX_d z_{dem_p d} - \sum_{a=1}^{A} AX_a s_{pa} - x_p \qquad p = 1, \dots, P \tag{14}$$

$$v_p \geq \sum_{a=1}^{A} AY_a s_{pa} + y_p - \sum_{d=1}^{D} DRY_d z_{dem_p d} \qquad p = 1, \dots, P \tag{15}$$

$$v_p \geq \sum_{d=1}^{D} DRY_d z_{dem_p d} - \sum_{a=1}^{A} AY_a s_{pa} - y_p \qquad p = 1, \dots, P \tag{16}$$

$$h'_p \geq \sum_{a=1}^{A} AX_a s_{pa} + x_p - \sum_{d=1}^{D} DRX_d z'_{dem'_p d} \qquad p = 1, \dots, P \tag{17}$$

$$h'_p \geq \sum_{d=1}^{D} DRX_d z'_{dem'_p d} - \sum_{a=1}^{A} AX_a s_{pa} - x_p \qquad p = 1, \dots, P \tag{18}$$

$$v'_p \geq \sum_{a=1}^{A} AY_a s_{pa} + y_p - \sum_{d=1}^{D} DRY_d z'_{dem'_p d} \qquad p = 1, \dots, P \tag{19}$$

$$v'_p \geq \sum_{d=1}^{D} DRY_d z'_{dem'_p d} - \sum_{a=1}^{A} AY_a s_{pa} - y_p \qquad p = 1, \dots, P \tag{20}$$

The objective function (1) seeks to minimize total travelling distance of the products in cross-docking center. Constraints (2) and (3) assign each incoming and outgoing truck to a door, respectively. Constraint (4) ensures that maximum one vehicle can be assigned to a door. Constraint (5) assigns each product to a consolidation area in cross-docking center. Constraints (6)-(12) provide a feasible allocation plan for the products in consolidation areas. Constraints (6)-(10) ensure that products do not overlap each other if a pair of products is assigned to same consolidation area. Constraints (11) and (12) avoid the overflow of the products with respect to borders of the consolidation area. Constraints (13)-(20) determine the horizontal and vertical movement of each products from incoming truck to outgoing truck. Constraints (13) and (14) determine the horizontal movement of each product from incoming truck to its located position in consolidation area. In the same way, constraints (15) and (16) determine the vertical movement of each product from incoming truck to its located position in consolidation area. Similarly, constraints (17) - (20) determine the horizontal and vertical movements of each product from its located position in consolidation area to its destination outgoing truck.

PROPOSED PARTICLE SWARM OPTIMIZATION ALGORITHM

Particle swarm optimization (PSO) is a population based stochastic searching algorithm, which was proposed by Eberhart and Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling [12]-[13]. PSO searches the solutions with a group of individuals called as “particle”. Each particle has a position and a velocity vector, where the position vector simulates the candidate solution to the optimized problem and the velocity vector denotes the position changing tendency. Although, classical PSO was originally developed to solve continuous optimization problems, in recent years several researchers have developed new variants of the PSO to solve combinatorial problems [14]. In this study, discrete variant of the PSO proposed by Goldbarg et al. [15] is taken into account and built up to solve TDAPCD.

In DPSO the population consist of NP particles and each particle (φ_n) represented with permutation based integer array which is illustrated in Figure (2). The solution array includes two parts, where the first part identifies the truck priorities and the second part identifies the door priorities. The truck door assignment procedure is executed by using these priority lists. After the truck door assignment procedure, the positions of the products in consolidation areas are determined by using bottom left algorithm proposed by Chazelle [16]. The bottom left algorithm first order the products by non-increasing area and then packs the products one by one according to the given order, where each product is placed at the bottom left feasible point of the current layout. Each product unloaded from an incoming truck is assigned to first available consolidation area that has the minimum travelling distance with the destination door of the product.

Truck Priority										Door Priority									
5	2	10	7	1	3	8	4	6	9	3	7	6	5	9	10	2	1	8	4

Figure 2. Representation of the Particles

For the initialization, the positions of the particles are generated randomly. At each generation, the new positions of the particles are formed by using the three main parameters: inertia parameter ω and the learning factors c_1 and c_2 where $\omega + c_1 + c_2 = 1$. The new position of φ_n is generated by following its own way with the probability of ω, by going towards its best position (p_best_n) with the probability of c_1 and by going towards the global best position of the particles (g_best) with the probability of $(1 - \omega - c_1)$ [15]. For this procedure, the ordered crossover operator is used. The new position of particle φ_n is determined by crossing over the current particle with any randomly selected particle or p_best_n or g_best. The pseudo code of the proposed DPSO is shown in Figure (3).

Define the parameter values: NP, G_{max}, ω, c_1, c_2
Generate the initial population φ_n for $n = 1, \dots, NP$
Specify the p_best_n for $n = 1, \dots, NP$ and g_best
For $g = 1$ **to** G_{max}
    For $n = 1$ **to** NP
        Generate a random number $random[0,1]$
        If $random \leq \omega$ **Then**
            Compute the new position of the φ_n by using a randomly selected particle
        Else If $random > \omega$ and $random \leq \omega + c_1$ **Then**
            Compute the new position of the φ_n by using p_best_n
        Else
            Compute the new position of the φ_n by using g_best
        End If
    Next
    Update the p_best_n for $n = 1, \dots, NP$ and g_best
    $\omega = \omega \times 0.95$; $c_1 = c_1 \times 1.01$; $c_2 = 1 - \omega - c_1$
Next

Figure 3. The Pseudo Code of the Proposed DPSO

COMPUTATIONAL RESULTS

In order to test the performance of the proposed DPSO, we generated our own problem set with different sizes, which are identified with three parameters: the number of incoming trucks, the number of outgoing trucks and the number of products picked up from suppliers. Table (1) presents the details of the generated problems and their solutions obtained by Gurobi 6.0.4 with one hour time limitation. Solution of each problem is identified with mixed integer programming (MIP) best bound value, objective function value and optimality gap value in the table.

Table1. Problems Descriptions and Gurobi Solutions

	Number of Trucks			Gurobi Solution		
Problem No	**Incoming**	**Outgoing**	**Number of Products**	**MIP Best Bound**	**Objective Value**	**%Optimality Gap**
1	5	2	59	1854	2412	23.1
2	5	3	73	1765	3382	47.8
3	6	3	58	1470	2644	44.4
4	6	4	52	1469	2442	39.9
5	7	3	49	1743	2216	21.3
6	7	3	85	2138	4446	51.9
7	8	4	31	1132	1530	26.0
8	8	5	70	2199	4542	51.6
9	9	6	64	2217	4416	49.8
10	9	7	59	2284	4272	46.5
11	10	8	73	2990	5668	47.2
12	10	10	69	3029	5292	42.8
13	11	7	60	2347	4166	43.7
14	12	6	62	2461	4252	42.1
15	13	7	64	2690	4750	43.4
Average	8.4	5.2	61.9	2119.2	3762.0	41.4

$\%Optimality\ Gap = ((Objective\ Value - MIP\ Best\ Bound)/Objective\ Value) \times 100\%$

The proposed DPSO algorithm is developed in the Visual Basic programming language and experiments are carried out on 2.20-GHz Intel Core i7 processor with 8-Gb memory. The performance of the DPSO is exposed by comparing the results with Gurobi solutions. Moreover, DPSO is compared with the classical PSO proposed by Eberhart and Kennedy in 1995, which is operated with continuous variables. For each problem, algorithms are executed 10 times with the following parameter values: $NP = 20$, $\omega = 0.90$, $c_1 = c_2 = 0.05$, $G_{max} = 1000$. In addition to the primary stopping criteria G_{max}, each run is terminated if the algorithm does not provide a new best solution during the 100 iterations. Table (2) shows the results of the computational studies carried out with PSO and DPSO where the algorithms are compared via the best and average solutions. On the basis of best results, DPSO obtains better solution than the best integer value of the Gurobi for 14 problems and provides 4.92% average saving on objective value, while PSO finds 11 better solutions and provides 2.97% average saving. According to the average solutions obtained by the algorithms, DPSO provides 2.35% average savings according to the Gurobi solutions, while this value is less than 0.50% for PSO. On the other hand, when the computational times are compered, DPSO reaches the solution in shorter times with respect to the PSO. Consequently, it can be expressed that the proposed DPSO provides effective solution in a short computational times compared with the Gurobi solutions. Moreover, DPSO outperforms the PSO and obtains better results for most of the problems.

CONSLUSION

In this paper, the truck door assignment problem in cross-docking center is considered to minimize total travelling distance of the products. As distinct from the existing studies on truck door assignment problem, TDAPCD considers the assignment decision with product allocation plans in cross-docking consolidation areas, which provides a realistic operational plan to operators for material flows. The problem as formulated as a mixed integer mathematical model and a DPSO is proposed as a solution approach due to the complexity of the problem. The proposed algorithm is tested on several randomly generated problems and compared with the PSO. The results show that proposed DPSO obtains better results than the best integer solution of the Gurobi in short processing times and outperforms the PSO with respect to the both of the objective value and CPU times.

Table 2. Results of the PSO and DPSO

Problem	PSO						DPSO					
	Best Solution			Average Solution			Best Solution			Average Solution		
No	Distance	$\%Gap$	CPU Time(s)	Distance	$\%Gap$	CPU Time(s)	Distance	$\%Gap$	CPU Time(s)	Distance	$\%Gap$	CPU Time(s)
1	2368	1.82	20.76	2437.2	-1.04	21.51	2372	1.66	7.49	2426.0	-0.58	8.48
2	3206	5.20	81.45	3265.8	3.44	82.86	3218	4.85	20.16	3286.2	2.83	18.72
3	2596	1.82	36.71	2673.0	-1.10	38.66	2596	1.82	6.67	2684.0	-1.51	9.46
4	2572	-5.32	40.67	2725.0	-11.59	38.09	2434	0.33	12.04	2614.8	-7.08	8.62
5	2308	-4.15	30.52	2384.4	-7.60	30.96	2218	-0.09	15.25	2248.6	-1.47	11.92
6	4008	9.85	160.41	4183.0	5.92	142.01	4006	9.90	21.82	4092.8	7.94	27.78
7	1644	-7.45	5.04	1677.8	-9.66	5.89	1528	0.13	3.24	1578.0	-3.14	2.89
8	4106	9.60	130.61	4206.2	7.39	122.43	4086	10.04	18.71	4178.2	8.01	21.05
9	4208	4.71	76.26	4289.0	2.88	71.15	4176	5.43	18.96	4238.2	4.03	15.90
10	3882	9.13	56.22	4008.6	6.17	55.25	3842	10.07	11.85	3934.6	7.90	12.07
11	5268	7.06	79.70	5379.4	5.09	82.95	5230	7.73	18.24	5378.8	5.10	18.54
12	5052	4.54	67.70	5119.6	3.26	63.50	4962	6.24	14.64	5119.6	3.26	15.03
13	4024	3.41	52.58	4062.2	2.49	51.40	3838	7.87	12.42	3961.0	4.92	11.61
14	4284	-0.75	64.52	4356.4	-2.46	63.88	4216	0.85	11.08	4274.8	-0.54	14.00
15	4510	5.05	73.47	4566.2	3.87	72.53	4420	6.95	13.73	4485.4	5.57	13.81
Average	3602.4	2.97	65.11	3688.9	0.47	62.87	3542.8	4.92	13.75	3633.4	2.35	13.99

$\%Gap = ((Gurobi\ Solution - Heuristic\ Solution)/Gurobi\ Solution) \times 100\%$

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IMPLICATIONS OF AN INSTITUTIONAL-BASED-VIEW ON THE SUSTAINABILITY OF THE REVERSE LOGISTICS NETWORK

Ceyda Aktan[178]

Abstract - Recently, the growing importance to preserve the environment along with company reputations, protection of consumer rights and other legal requirements has led the companies to take on different measures such as trying to utilize the reverse logistics networks. Although these networks have been around for many years, the term 'Reverse Logistics' has only started being used in recent years. Through reverse logistics, most companies now enjoy more cost savings as well as a greater customer satisfaction. But, there is also an increasing pressure for supply chain sustainability which also affects the reverse logistics networks. However, institutional environment in emerging markets give rise to challenges that inhibit the implementation of these sustainable reverse logistics networks. Through an analysis of research from 2005 to 2015, this study aims to emphasize on the importance of sustainability on these reverse logistics networks in business focusing on the institutional environment for business strategy development.

Keywords –Business Strategy, Institutional-based-view, Reverse Logistics, Supply Chain Management, Sustainability

INTRODUCTION

World is constantly undergoing a change which causes the industry and the economy to change with it. Developments which took place in the last century, such as the free trade agreements, the Internet etc. has sped up the way goods, people and information interchange within the world. However, research shows that due to these fast developments the environment has been put under a great deal of pressure and that it needs external support for recovery [1].The current issue of sustainability was born together with this concern [2]. Governments throughout the world started passing laws for a sustainable development, businesses and enterprises placed sustainability on top of their priority list of concerns and at an individual level, people started to place more emphasis on the topic. Reverse logistics started to gain popularity [3].

Reverse logistics networks, although being around since the American Civil War, has only just gained attention in recent years, together with the growing environmental concerns [4]-[5]. They are particularly important for maintaining the business' reputation, image, customer service and for keeping up with the legal requirements of the business world [6]-[7]. But these networks need also be sustainable in order to survive in the current conditions of the business environment. Without a sustainable approach, the company may survive in the short run, however, in the long run they may struggle [8].

Businesses need to develop strategies in order to ensure the sustinability of these reverse logistics networks [9]. There are different approaches for strategy formation. Strategies can be formed by looking at the company's internal environment, capabilities and resources, which is referred to as the resource based view of the business [10]. The business can also focus on the industry conditions it competes in. Looking at the external environment is said to be the industry based view of the business [11]. According to the work of Peng et al. (2008), these two views form the two legs of the strategy tripod and the third leg of the tripod is completed with an institutional based view [12]. It is the institutional view that makes the business strategy complete. Without understanding the institutional environment the bussiness is within, it will be hard to form a successful, complete and correct strategy.

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Institutional factors, if placed importance, can be used as a competitive advantage for the business because through institutions businesses can gain social legitimacy and obtain economic benefits [13]. However, the lack of emphasis on them creates a barrier for businesses and becomes a challenge [14]. The creation and implementation of such sustainable networks can be severely inhibited. Therefore, with this study it is aimed to explain the importance of sustainability on these reverse logistics networks in business focusing on the institutional environment for business strategy development.

METHODOLOGY

To be able to show the connection between the three elements: reverse logistics, sustainability and the institutional based view, and to be able to find support for the connection, previous research needed to be analyzed. Therefore, first of all, to narrow the results into a workable number of articles, in this study, only the top logistics journals were selected. These journals were identified as: The International Journal of Logistics Management, Journal of Business Logistics, Journal of Operations Management, International Journal of Physical Distribution and Logistics Management, Journal of Supply Chain Management, Transportation Research Part E, The Journal of Production Economics, and The International Journal of Logistics Research and Applications [15].

After identifying the appropriate journals, a content analysis methodology was used to review the literature. Using this method helps researchers in identifying and sorting the literature under various categories [16]. The reason for using such an analysis for this study was to put forward the number of articles published in the last 10 years on the topics of reverse logistics, sustainability and the institutional based view, and to see which areas they coincided. What else that was important was to analyze the journals to see whether such a study was conducted previously and what sort of results they came up with.

During the literature search from the identified journals, there were few delimitations of the search for narrowing the results;

- In the literature review only the last 10 years were taken into account as these topics are still relatively new topics. Research shows that the issue of sustainability and the supply chain management started showing in jounals from the year 1990 onwards and the inclusion of the institutional view after the 2000s. Therefore, a more current body of literature needed to be looked into in order for the three elements to be found together.
- The issue of sustainability come up in different contexts however only ones where terms “sustainability”, “sustaining” and “sustainable” used in headings or keywords were taken into account.
- Articles with terms “institution(s)” and “institutional” in the heading or the keywords section were taken into account.

Secondly, search engines were used to search databases such as Google Scholar, EmeraldInsight and ScienceDirect to add to the article pool. During the search “reverse logistics”, “sustainability”, “institution based view, “institutional perspective” and “supply chain” keywords were used to further narrow the results. This step was taken in order to identify the articles written within these topics which were not among the ones identified previously.

The study then continued with a percentage summary of the findings from the analysis and short descriptions of each of the researched elements: reverse logistics, sustainability and the institutional based view. How these elements link together and how future research can shape the area will be discussed at the end.

RESULTS

From the 8 journals identified, altogether 5,812 articles were looked at for the terms “sustainability”, “reverse logistics”, “ institutional based view” and related keywords. Only 91 (1.57%) of them were found to include “reverse logistics” in their heading or keywords, 170 (2.92%) to include “sustainability”, “sustainable” and "sustaining", and 34 (0.58%) articles to include the terms "institutional", "institutions". All three terms did not appear together in any article and only 7 included reverse logistics and sustainability, 1 included reverse logistics and institutional view and 4 included sustainability and institutional view.

Second part of the research, searching using databases, also supported the journal analysis by showing that there are no articles showing the impact of sustainability on the reverse logistics networks from an institutional based view.

Reverse Logistics As An Emerging Area Of Importance

In the recent years businesses started realizing that remanufacturing, recycling and refurbishing was not as economic as it was believed to be [17] and that reverse logistics could also generate negative cash flows [7]. Although remanufacturing can save costs up to 60% when compared to manufacturing a new product [18], businesses needed to find the balance between the economics and the environmental issues of processes. This has led these businesses to structure efficient reverse logistics systems [19]. Costs relating to the reverse logistics network is on average said to be around 3-4 % of the total logistics costs that belong to a company [20].

Reverse logistics, although gaining attention within the last 2 decades, is a concept known for a very long time [14]. What is reverse logistics? Together with the use of reverse logistics, the definition itself also evolved with time. One of the earliest definitions was made in 1981 by Lambert and Stock which refers to reverse logistics as "going the wrong way" [21]. The term "reverse logistics" was first used then. Earlier definitions focused on the movement of goods and materials from consumers to the producers, however, in time, the definitions evolved into incorporating planning and control factors together with goals and processes [22]. One of the commonly used definitions of reverse logistics was given by the Council of Logistics Management. According to the Council, reverse logistics is defined as; *" The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value of proper disposal"* [21].

Reverse logistics network can be seen in many different industries: such as manufacturing, wholesales, and retailing [21]. Some examples of the worldwide known companies that use reverse logistics include Kodak, IBM, and Xerox [23].

Dowlatshahi (2000), in his research, has identified 5 strategic factors in the reverse logistics network. Focusing on these strategic factors can make the network more effective and efficient [18]. These strategic factors are: strategic costs, overall quality, customer service, environmental and legislative concerns. Looking at strategic costs, they only include the life cycle costs and the performance costs. Reduction of such costs can be achieved though using resources which are at hand effectively together with utilizing current methods and technologies. The quality of the products produced should always be the same, consistent, as below average quality when compared with the rest of the produced products can damage company reputation and hence, lower customer satisfaction. When businesses have already spent a high price building their own reputations, they would not want to reduce the value created by having their products end up in waste baskets or flea markets [21]. The third strategic factor, customer service is increasing in importance through time [24]. Reverse logistics networks should follow the rule of right place, right time, right price and right quantity in order to maintain the standards of their customer sevice [18].

It is expressed, however, that only focusing on the service side is not enough for the customers, as they are now demanding that businesses should also make sure that products they are producting do not have harmful impact on the environment. Through these environmental concerns reverse logistics can result in reducing costs as well as improving the environment at the same time. Cost savings which come about through the use of the reverse logictics networks are more lasting and effective when compared to traditional cost saving methods such as cutting back on employee salaries, using materials which are below the usual standards or closing down branches [18].

Besides the environmental concerns, another strategic factor that makes the reverse logistics so important is the legislative concerns the business faces [20]. It is also said that the force of the environmental concerns are partly due to the existing or possible future legislations which the governments place. Businesses use the reverse logistic networks in order to comply with these legislations [25].

All of these strategic factors needs to be dealt with before a business starts the operational side of the reverse logistic network, which consists of “collection, packaging, storage, sorting, transaction processing, delivery and integration” [26].Therefore, setting up a reverse logistics network is a strategic decision the business makes as it requires evaluating wide selection of criteria which involves strategic, operational, tangible and intangible elements [8].

Ensuring Sustainability: Why Is It Important?

In the previous part it was explained that reverse logistics became important due to topics such as costs, environmental concerns, legislations and issues relating to sustainability. However, these networks need also be sustainable for it to survive within this competitive environment [27]. Environmental management has a positive effect on the business competitiveness and its performance financially [28]. Therefore, it can be said that a link exists between environmental requirements leading to creation of reverse logistics networks which then needs to be sustainable in order for the business to gain competitive advantage and survive.

Sustainability is another term which is vague and hard to define and therefore can be seen having variety of definitions by different academics. These definitions have a range starting from a having a philosophical stance to being a term relating to business management with a multi dimensional stance. One of the most commonly used definitions was given by the Brundtland Report, sponsored by the World Commission on Environment. According to them, sustainability is defined as “ meeting the needs of the present generation without comprimising the ability of future generations to meet their own needs” [29]. Presley and Meade (2002), on the other hand sees sustainability as a response given to threats against the survival of humans and the planet [30].

Ahi and Searcy (2013) in their study express that as much as early sustainability studies focused more on the environmental issues, recent research on sustainability started focusing on a combination of economic, environmental and social components, which are also referred to as the “tripple bottom line” [31]. A move from a macro perspective to a more micro perspective [8]. Environmental component refers to managing natural resources whereas the social component focuses on the management of the social resources such as skills, abilities, institutions and values [32]. According to the tripple bottom line perspective, at the point where the social, environmental and the economic components coincide, businesses can gain long term benefits economically and increase their competitive advantages againt their competitors while protecting the environment and society [9, 28]. Carter and Rogers (2008) point out that risk management, transparency, strategy and culture also has an influence on sustainability and are given consideration in literature [33].

Businesses are now becoming aware that the decisions they make relating to the products and services they provide end up having an affect socially and on the environment [34]. Due to this, together with trying to achieve the fundamental reason for their existence such as high returns on investments, increased shareholder wealth and a longer business viability for their shareholders, businesses need to start incorporating stakeholder concerns, environmental pressures and the increasing social consciousness in their business strategies, which also includes strategies for their reverse logistics networks. As these are referred to as pressures and incentives categories in the work of Seuring and Müller (2008) [35].

There are factors that inhibit the sustainability of the supply chain management and these factors also need to be considered while making business strategy involving the reverse logistics networks. A sustainability oriented change in a business faces both internal and external barriers long the way. These barriers can relate to management attitudes, to the corporate culture, knowledge, or whether if the available technology is sufficient and if there are any current reguatory consraints [36]. Institutional environment of the business and the network it belongs in is found to have one of the biggest impact on their supply chains and hence the reverse logistics networks, which places institutions in the decision making process [37]. Therefore, to have an effective strategy for a sustainable reverse logistics network, the business must also consider the institutional point of view.

Creating A Business Strategy: The Strategy Tripod

For a business to survive in the competitive environment it belongs in, it needs to develop short term and long term strategies and align these strategies with the overall sustainability strategy [9]. This is one of the fundamental needs for business operations as with a correct strategy the business can first build, then maintain and in time continuously strenghten their identity within their environment and create a competitive advantage [38].

There are many ways a business can create this strategy and many factors to consider in the process. Resource based view and the industry based view of strategy building are couple of the most common approaches that is observed in research [12]. While the resource based view focuses on the internal strengths and weaknesses of the business, the industry view to the strategy focuses on the external environment where the threats and the opportunities are found [39]. Resource based view focuses on the company's internal resources and capabilities for building an effective strategy in order to achieve a superior performance. Factors such as value, rarity, imitability, core competence and organization is important for this view. Industry based view, on the other hand, focuses on the industry conditions for a successful strategy building [40]. Porters five forces (entry barriers, rivalry among firms, threat of substitutes, bargaining power of suppliers and the bargaining power of the buyers) need to be considered for this types of strategies [41].

However, according to Peng et al. (2008) both, the resource based and the institutional based view, neglects the concept of context found within the competitive environment [12]. Their research shows that there are formal and informal institutions which have an impact on the way businesses compete against their rivals. North (1990) refers to these institutions as the "rules of the game" [42]. Therefore, together with the resource based view and the industry based view, the institutional based view is referred to as the three legs of the strategy tripod. One cannot be seperated from the other for a sustainable competitive advantage [43].

From the conducted research, terms relating to institutions can be seen to be quite low but is observed to be increasing in importance over time with increasing number of articles published. A general definition of institutions can be that institutions are "regulative, normative, and cognitive structures and activities that provide stability and meaning to social behavior" [12]. Regulative structures mentioned covers the requirements of governments and other regulatory bodies. Normative structures on the other hand are the rules and regulations placed through values and norms established by the society [44]. Business will be expected run according to social obligations and expectations. The third type of structure, cognitive structures, are the previously established boundaries of the society which act as prefabricated actions [45]. Businesses are now believed to compete as part of the supply chain they belong in rather than as an individual. Therefore an integration becomes necessary for the business to fit its surroundings in the chain. Cognitive, regulatory and the normative elements of the institutions have an impact on this fit [46].

According to the institutional based view, institutions in society are divided to formal and informal institutions. The interaction of these institutions together with the businesses brings about outcomes which form the basis of the business strategy [47]. Formal institutions are the rules and regulations found whereas the informal institutions refer to norms and cultures [48]. Institutional environment may not be as distinct in developed economies as in emerging economies around the World because when the markets work poorly in developing economies, the the lack of formal institutions become clear and the effects of informal institutions will start to show [49]. It was observed that when there is lack in one type of institution then the other will take over to complete its absence [50]. One of the best examples for this situation is in China. Although the country lacks a preestablished formal system, it still is considered as one of the top countries for rapid economic growth. It is believed that the informal institutional structures called 'guanxi' play an important role for China's fast development [51]-[53].

While institutional environment can have great benefits on businesses, without a proper knowledge of the institutional environment the business is established in, it can also lead to some detrimental effects such as influencing the supply chain and hence the logistics networks through a change in the corporate culture [54].

Reverse Logistics, Sustainability And The Institutional-Based-View

From the research it was found that previously there were no study conducted involving the three variables: reverse logistics, sustainability and the institutional based view.

Carter and Ellram (1998) have expressed in their study that there are two major forces that drive the reverse logistics networks: the internal forces and the external forces [55]. Internal forces include the company factors whereas the external forces are the forces within the task environment the business is found within. Environmental factors are said to be the customers, supliers, competitors and the government. Both of these forces go hand in hand and they can either drive these networks or actually constrain them.

Another factor that was necessary for the reverse logistics networks' effectiveness and efficiency was for it to be sustainable. It was from the growing importance of sustainability that reverse logistics became popular in recent years, and it is its sustainability that will make these networks a competitive advantage for the business. Therefore, if the internal and the external environment is important for the reverse logistics networks then both these factors must also have impact on the sustainability of them. Businesses need to develop effective strategies incorporating these factors.

However, looking at the definition of institutions, "regulatory, normative and cognitive structures and activities…", it can be related to the internal and external factors as that these are the mechanisms that link the factors to each other and to the business. The formal and informal institutions give direction to the business. This way, it could clearly be seen that institutional environment has the power to control the forces within the business environment such as the government regulations, supplier attitudes and the corporate culture. Having stability within these forces can lead to long term success of the reverse logistics networks of the business and hence will also cause it to be sustainable. It can be deduced that incorporating the institutional environment into the business strategy will impact the sustainability of these reverse logistics networks.

CONCLUSION

Growing environmental concerns, regulatory pressures and social demands have recently started placing more importance on the issue of sustainability and hence on the way individual businesses operate. To compete with the changing conditions, businesses started implementing new strategies and developed new ways of doing business. This is where reverse logistics networks started gaining importance in the business environment. In order for these networks to operate successfully in the long term, they also need to be sustainable. This is the point where businesses need to implement a correct strategy for the sustainability of the reverse logistics networks.

A business can use few different ways to form this strategy. They can consider their capabilities and their resources to effectively use for strategy building, or they can analyse the industrial environment, their competitors, suppliers, cutomers. However, without taking "context" into consideration a complete strategy cannot be formed. Together with the resource based view and the industry based view, the institutional based view completes the three legs of the strategy tripod and is vital for businesses to consider when making their strategies.

In this study all of these three issues were briefly explained and the connection between them were put forward. From the literature study on the identified journals, it was seen that although being small, there were some articles relating to the issues individually or in pairs, but there were no study identified involving all three issues together.

Considering the importance and the link between reverse logistics, sustainability and the institutional based view, it can be identified as a major gap in the business field. Research should be conducted to fill this gap.

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GOOGLE GLASS-WEARABLE DEVICES AND WAREHOUSING SYSTEM

Songül Aksoy[179], Batuhan Kocaoğlu[180]

Abstract -By the development of the technology, the computing based companies have invented some devices which are really useful for all sectors. Google glass is a wearable device which is not commonly but recently used by some companies in the world. Most of the companies use pick by voice devices for warehousing equipments for along time. Now adapting to the new system may challange them or help them to improve the warehousing management. In this case, we will search for the company Ekol Logistics which is the biggest in intermodel and warehousing system in Turkey, whether he may adapt to his sytem to this google glass device or not.

1. RESEARCH METHODS

The researching methods contains a deep searching internet articles, related warehousing books,some conference articles which are published recenty regarding google glass and warehousing management, since the topic is new and also succesful in some practices and unsuccesful with some others. Also an experience in a company which is a 3PL in one of the five in Turkey, using his own warehousing software and not tend to adopt his system to out practises such as google glass. Visiting the most well organised warehouse among others in Turkey with his own technology and an appoinment with a project manager is also the other method we used for this article.

2. INTRODUCTION TO WEARABLE TECHNOLOY AND THE HISTORY

These can be determined that carried on the body which are based on elecktornics and computing system devices. Wearable technology must be really wearable not carriable. It must be under the control of the users with concious or unconcious, and must develop the users experience. (Kocaoğlu, Batuhan; Özel, Ayşe;, 2015)

2.1. THE HISTORY OF THE WEARBELE TECHNOLOGY

Wearable technology has been existing since 17. century. The Qing Dynasty has minimized the abacus and replaces it on a ring. This system is still being used by some merchandisers One of the wearable devices which was invented for the seeman was the stopwatch is still being used in 1762. In 1961, when the chance plays were really common and played in the parties, the gambling shoes were invented. Hamilton used iths LED technology in 1972 and invented digital watch. In 1987, the fisrts device which helps for heraing was invented. In 2000s first bluetooth headsets were invented. (Kocaoğlu, Batuhan; Özel, Ayşe;, 2015)

2.2.SOME SECTORS WHICH BE AFFECTED BY WEARABLE TECHNOLOGY

Already, companies are putting wearables to work in the work force and our data shows that people are remarkably unconcerned about the net impact wearable technology could have on their job security and atonomy. And in an era where workplace loyalities are fragile, wearable technology could actually inrease morale if it makes it easier for workers to produce more efficiency and provide better service, making them stronger employees overall. Likewise, use of wearable technology in employer-sponsored health and wellness program can lead to a healthier and thereby more productive workforce. Implementation of wearable tech could have clear

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implications for a companys bottom line, opening the door for enterprice to subsidize the use of wearable devices amongst both employees and consumers

There are many applications for wearbale tech in enterprice. The potantiel benefits of wearable devices are manifold. Among the workforce, devices can be used as training agent speeding up the onboarding process through realtime feedback. In retail, wearable devices can upend point of sale processes, improve consumer service, throughtout the store and speed up purchasing. In manufacturing, wearable tech can help expedite, production by creating handsfree guidance tools. In service ındustries, wearable devices can speed access to information in real time and enable seamless action. In medical centers, wearable devices can improve accuracy of informatio, streamline procedures and increase clinical trials. Ant through fitness devices and corresponding incentives, wearable technology can drive significant decreases in health care costs. In all of these cases, effecgtive implementation of wearable technology stands to benefit both the user and company driving adoption, increasing efficeincy and efficacy. (http://www.pwc.com/es_MX/mx/industrias/archivo/2014-11-pwc-the-wearable-future.pdf)

3. SMART CLOTHING DESIGN

Smart clothing aims to provide greater added value to its user than either traditional clothing or seperate electronic devices. In practice, this means that smart clothing system usage must offer more benefits than drawbacks to achieve user acceptance. Therefore, it is evident that the smart clothing design process is based on users and their needs. This is also a way of ensuring that the smart clothing prototypes are designed for real needs rather tahn invented ones. The overall design of wearable electronics systems utilizing a clothing platform or accessories is a demanding process since it requires multidiciplinary group work. In addtition to electronics and software engineers, representatives from human sciences, clothing and textile sciences, metarial science, and industrial design are needed to ensure funtional designs. (Hannikainen, 2006)

3.1 SMART CLOTHING DESIGN FLOW

A smart clothing design is presented in figure below, The starting point for the design is obviously the decision or assignment, appropriate team members can be assambled so that the necessary expertise is represented in the working group. The working group can then make the preliminery problem statement and the define the target user group for application, the user group must also be specified. This is necessary during the next phases, which focus in more detail on the funtionality and requrements of the system.

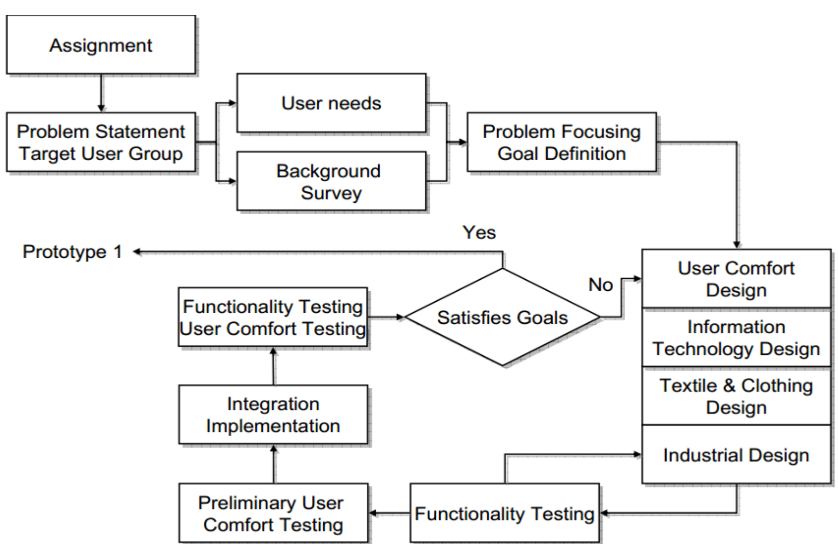
The team members can now start gathering data on user needs and performing a literature background survey, ıf necessary. These are two phases can be carried out, simultaniously along with the other information gatherind such as target group interviews or questionaries. The finding are collected and shared at a group meeting to allow the team to evaluate the assignment in terms of any drawbacks such as risks or problems in the application area. It is also necessary to set goals for the project at this stage, to ensure taht all the team members share a common aim. Experience in this previosu phases will also provide the members of the team with a shared understanding of the background of the project. This helps in the design phase, most of which can be done separetly. During this goal definition phase the general requirements for the application are also set. These may include the limitation of extra weight in the clothing or involve matters concerning the operating lifetime of the system with one batter charge. The requirements set in the phase guide the execution of the sub design.

At the enxt stage the design of the smart clothing application can be split into subdesign project. These Typically includes areas such as use comfort and usability design; information technology design involving electronics, software, and telecommunication; textile and clothing design; and industrial design. The various parties make their own design decisions and are responsible for the funtionality testing. Since the seperate projects all forms part of a bigger project schedule, problems and challenges, arising during the design, and the compatibility of subcomponents.In addtion, clear interfaces need to be established between the parties working in sahred projects such as between an encasing designer and an electronic designer.

After making parallel design, the team can also meet to collabrate on some funtionality testing to double check that the system is ready for integration. If this funtionality testing fails, problematic part will be redesigned. Preliminary usability or user comfort testing can also be done to ensure the proper integration the clothing. In addtion, throughtout the design process there is continuous evaluation of the usabiltiy of UI devices whenever something new is introduced. After these evaluations, the system ready for integration. Clothing specialists are normally responsible for thsi final integration.

After the integration, the prototype should firdt be tested undeer the labaratory conditions and also in authentic usage anvironments to ensure basic functionality. If the funtionality test shows the system to be mostly funtional, usability tests can be conducted to evaluate UIs and the overall wearing comfort of the system. Failures are often due to compability problems between different sub-designs. Sucjh problems need to be solved before usability evaluations. After testing, it is possible to determine ehther the system fulfills the requirements. If it does not, it will be necessary to make reapirs to sub designs. In this loop the design process can be proceed., provvided the goals are achieved. Finally, the first prototype is implemented.

After these tests, the results will need to be analyzed, particularly when it is planned to continue the development. After the first prototype has been designed, implemented, and evalueted, the next prototype generation starts by defining a new goal and continuing the loop as presented in below figure. The process describedabove aims at the development of the research prototypes. However, if the goal is comemrcial product implementation, other elements, must be also be considered in the process along side other sub-design issues. Such elements include manufaturability, consumer culture and associated aesthetics, and recycling (Hannikainen, 2006)



3.2 SMART CLOTHING DESIGN REQUIREMENTS

Smart clothing application designers decide on the functşionaltiy of the applications according to a number of factors such as assignments and potantial end user needs. Thse funtionality greatly affect the users' decisions to adopt the application. However funtioanlity is not the only measure by which to evaluate the importance of the application in question. Parameters affecting the application and its accaptance are presented in below figüre, which is applied from.

First, funtioanlity provides solutions to the problems for which is the application intended. This functionality is different in each application, at the same time varying the complexity of the system. The rest of the parameters are attributes of the functionality and are always present in differant forms.

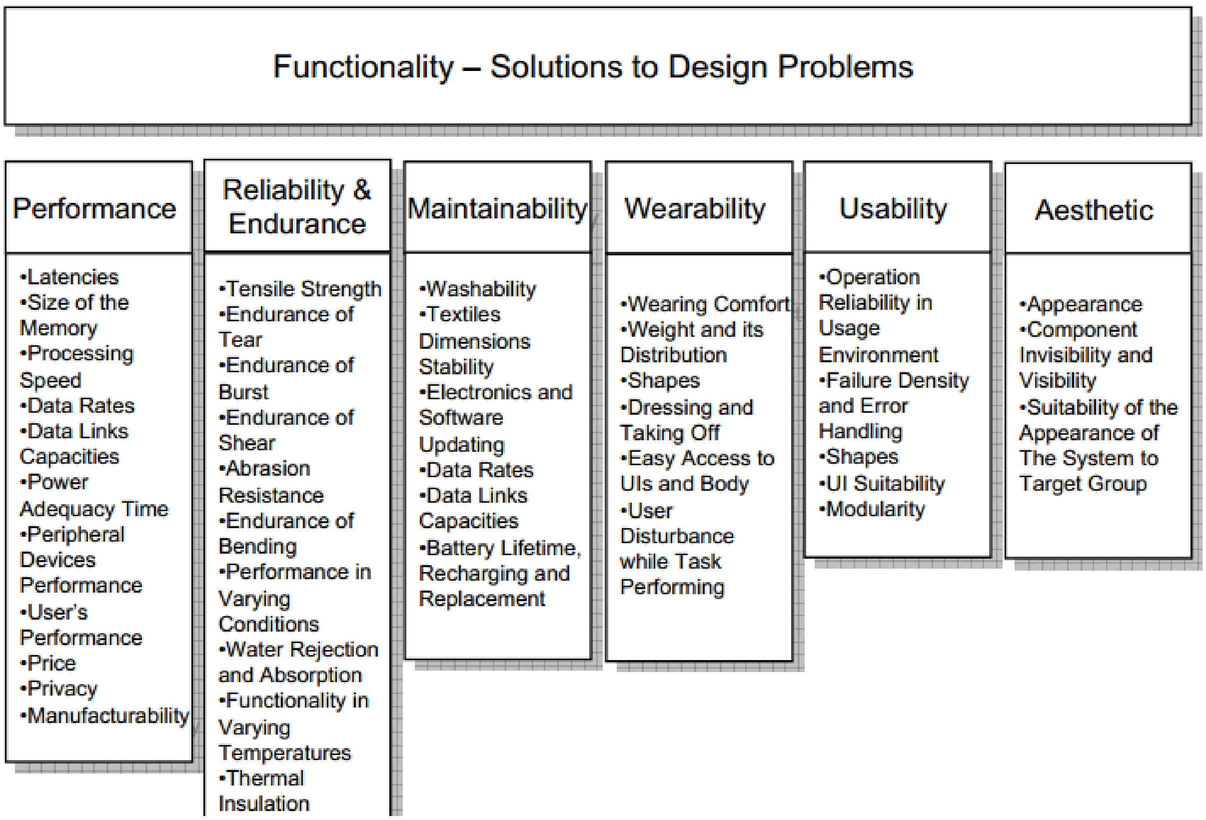
For the most part, perfromance attributes decribe the efficiency of the systems electronics. However smart clothing form are integrated complex and therefore, it is diificult to divide attributes for clothing and electronics into dicrete parts. Depending on the application, the requirements for system performance varies. However it is usually possible to measure the system accroding to its latencies, data rates, data link capacities, data transfer latencies, pwer adequesy time and other performance metrics depending on perihereal devices needed in funtionality implementations. In addtion, size , shape and weight, affect the way in which the system is used and therefore the users performance with the system. For users price and privacy protection are also imprtant considerations, and while production issues , such as the manufacturability of the system are of major importance.

Reliability and endurance apply to both clothing and electronics, especially their mechanical rebustness in use. For clothign metarials, a variety of tests can be made to determine such properties as tensile strength, their endurance of tear, busrt and shear as well as abrassion resstance in order to estimate durability in usage conditions.on the basis of these refsults, good quality metarials can be selected for clothing applications. These same properties are also essential in the electronics placed into cclothing. In clothing especially, different connections are subjected to severe stress and therefore tensile strength plays as essential role as well as robustness against bending and abrassion. Performance under the different conditions is common to both clothing and electronics. The abilites of metarials to absorb or repel water are important since additional moisture may cause corrosion and unreliable funtioning of electronics . Electronics functioanility in differen temğeretures must be assured and the thermal insulating capacity of textiles is esential, especially in cold environments.

Maintainability of the clothing involves care procedures such as cleaning. This covers issues such as washability, part needs to be detached during washing, and behaviour after washing such as textiles shrinking and dimension stability properties. Other important issues to be dealt with are electronics and software updating possibilities, battery lifetime, recharging, and replacement as well as maintainance of tyhe entire sytem before the smart clothing applications reach the market.

Wearability relats to the wearing of smart clothing and involves such issues as comfort, weight and its distribution, shape, ease of dress and undress. Other important aspects of wearability are easy access to the body and user interfaces, as well s interfrence while performing other tasks. Wearability is closely related to the usability of the system in the target environment. It includes electronics and clothing operation reliablity in usage condtions, failure density and error handling, UI suitability for the target group and the surrounding conditions and modularity of the overall system. Electrical characteristics such as electirical Static discharge protectionm and ElectroMgnetic interference resşistance affect the reliability of fucntions in desired conditions. The capacity of the clothing to transport moisture away from the skkin area or protecting the user from the rain, are examples of clothing characteristics affecting wearing comfort ans usability

The last attribute is the aesthetics, which describes the appearance or attractivenes of clothing. The concept indicates for example, how well the design can conceal unwanted additional parts and what makes the looks interesting in expressing the smart clothing concept to users. Cultural appearance of the clothing suitabality to the target group and the community. The appearance of the wearable systems also has a major impact on the general acceptability of the systrem. Small gadget type devices can make the transation from tools accessories easier. (Hannikainen, 2006)



4. INTRODUCTION TO SMART WEARABLE GLASSES

Smart glasses are computing devices worn in front of the eyes. Evidently their displays move with the users head, which leads to the users seeing the display independently of his or her position and orientation. Therefore smart glasses or lenses are the only devices which can alter or enhance the wearers visionno matter where he\she is physically located and where he\she looks. There are three paradigms of how to alter the visual information a wearer perceives. Those three are introduced here. (Hermann , 2014)

- Virtual Reality: The goal is to create a fully virtual world for the user to see, interact with and immerse into. The user sees this virtual world only any other light sources are not affecting the eye. One significant difference to a simple simple screen is that the actions of the user affect the virtual world. In example movement affects what virtual content the user sees. A famous finctional example of a device creating a virtual world is the Holodeck from Star Trek.

- Augmented reality: The world is enhanced or augmented by virtual objects as seen in figüre one. The user can see the real world also percieves virtual content created by a computing device and displayed by an additional light source which does not prohibit the perception of the real world. Interaction with those virtual objects is a way of communicating with the computing devices.

- Diminished reality: Object are substracted from scenes by filtering the light reflected or emitted by those objects towards the eye. This is most offen used in combination with augmented reality to replace the diminished objects by some virtual objects.

Like some other smart devices, smart glassses will offen also have a camera. Significant differences to other camera devices are that pictures or the vides are taken from the users point of view, there is no need for the user to hold the device in his hands and the vision of the user is not occluded . This camera can see the wearer what the wearer sees at any time. In combination with eye tracking technology and devices can determine exactly what the wearer is looking at. This allows the device to get crucial information about the users interest, activities,surrondings and occupations.

Those fundemantal differences to other computing devices are what make smart glasses unıque and interesting. They enable new applications which could not be easily relized with other devices.

4.1. DEVICES

All the applications in the world are useless without the right hardware to run on.that is why an overview of different smart galsses which have been released recently or should be released in the next few years is provided. Those gşasses are developed by different companies and often trying to achieve different goals and appeal to different consumer markets. Therefore tehy do not all stands in direct compatition and should not be compared as such.

4.1.1.DEVICES WITH ONE DISPLAY

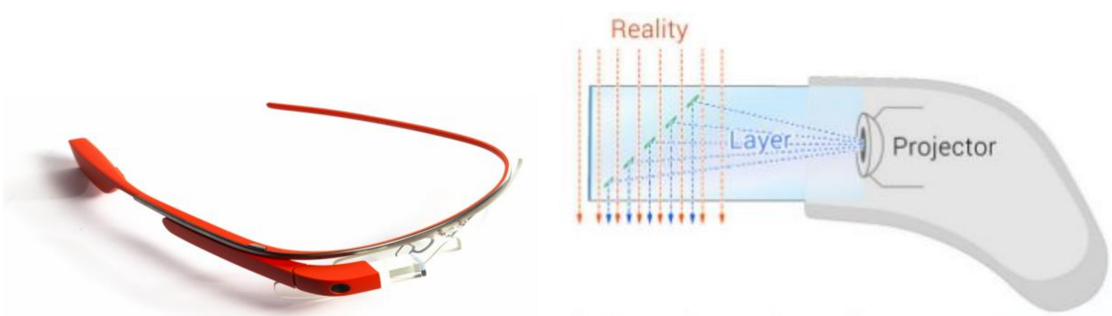
There are smart glasses with a single display which is placed in the peripheral vision of the user. Those displays can be used to display information to the user. Unfortunately they can not be used to create a diminished or vitiual reality becuase sight on eye is not affacted. They also cannot be used to create an interactive augmented reality because virtual objects can only be seen in peripheral vision.

5. GOOGLE GLASS

One example of smart glasses with one display is Google Glass which runs the Android operating system. Its spesifications are the following; (Hermann , 2014)

- Weight: 50 gr.
- Processing; 1.2. DHZ Dual core ARM Cortex-A9 CPU; Power VR SGX 540 GPU:16 Gb strorage682 MB RAM; thats really equavalent to the hardware Iphone4
- Camera: 5MP still (2528x1856 pixels) or 720p video. There is no flash
- Display: It is a color prism projector with a resolution of 640x360 pixels
- Sensors: microphone, accelerometer, gyroscope and compass
- Interaction: There is a long an narrow touch pad which supports swipe and tap gestures. The camera can be trigered by a button.
- Audio: There is a bone conduction transducer for audio. Sound reaches the inner ear in form of vibrations on the scull. Note that this technology is audible by the hearing impaired as well as persons with normal hearing.
- Communication: It has no cellular modem which means it can not make phone calls on its own. It does have Bluetooth and WLAN 802.11b/g.

Google glass is supposed to be used in combination with a smart phone and one of its mains uses to its displays notifications in a convenient and quick way. It si supposed to be priced similarly to a high end smartphone but there are no official announcements concerning the exact price or release date.



5.1. GOOGLE GLASS AND WAREHOUSING MANAGEMENTS SYSTEM PROCESS AND PRACTICES.

We can use google glass with picking up, transhipment and replacing, delivery process in warehouse;

- The informaiton can be shown in the glass and pickers can pick up the goods with his two hands.
- With the cam in the glass , the goods photo can be taken. So that the defected goods can be recorded.
- On the package of the good ıf there is any unknown item or language can be asked by the glass as linking to the google or yandex specification.
- The warehouse plan which is seen on the glass can make it easy to collect the goods which personnal really is new in the warehouse.

- Repaering the goods, the glass can make order to the user and make it availbele to mend it by showing the way of it.
- Unloading and loading process can be easier with checking the goods from the glass with the real stocks.
- In Unloading and loading process, the instructions which must be taken into considiration may seen on the scene of the glass.
- Import and export documents can be scanned and the search in word can be done.
- The goods can be scaned by spesifications to the system and it can be seen on the glass easily. So that the replacement in the warehouse and loading to the truck can be done by confidance in optimal.
- The first time gone address can be seen on the scene of the glass, and can be recorded also when the internet is off and it is impossible to search on GPS so taht google glass may help.
- The packages location can be seen in the truck. So that during the delivery process, the complex of the goods can be easily found.

6. THE PRACTICES FOR THE GOOGLE GLASS IN THE WORLD

A Hospital has used google glass with some modifications in Boston, USA.With the help of this software, glass provied to reach the records and the timetables of the patiences.The doctors are determined as the potantial users in the begining of the research. IT aims especially in medical operations and the history of the patience has started to come into true in some aspects.

7. EKOL LOGISTICS AND HIS SYSTEM TO ADAPT TO GOOGLE GLASS.

Ekol has his own R&D department to improve his warehousing operations management system and not eager to adapt his system to other outside developments since according to Company vision the own requirement is varied from the others. Some principles for Ekol warehousing operations management are acting for the needs accordingly. Here some software for his own warehouse sytem, one is pick by light and put by light system. Also a great stocking and warehousing system was at the depot called as Krane Otomation system. Adressimg the goods to the correct place and delivery stores also a system being used called as Kardex.

All system is adapted to the software of own called Rainbow. At the same time, all information which have done via those above are flowing to the system quickly. This software-rainbow- is Ekols own software and all warehousing and dispatch operations information flow are being done through it.

To critisize the system, There are to many steps are being done for one operation. And Google Glass may help the system to provide to work easier. For all steps can be done with one glance by the glass.

However, during the process of warehousing at Ekol, Google glass may help the operations indeed. For instance, Workers at the depot uses a tool called “aref” for addressing the goods to relating stores in the warehouse. This is being used by hand power. So that adapting google glass may help the workers to record the goods to concerning fields in depot and also may notice the damaged goods status by the help of google glass. Also Google glass may help automatically stocking and control mechanism of the stocks. Addressing the goods may be shown in the cam during the process and in case of mistake, glas may warn the user.

By the time, Google glass needs to be an expensive investment. Ekol may afford that but having its own R&D department and when the all costs calculated. It may be for the moment, seems not possible. To adapt, all cost of R&D and new software invesmtent may be compared soon and can be agreed or disagreed.

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IMPLEMENTATION OF THE WEARABLE TECHNOLOGY IN WAREHOUSE MANAGEMENT SYSTEMS

Aykut Koymen[181], Batuhan Kocaoglu[182]

Abstract–Forming the largest cost item in processes performed in the warehouses, picking makes integration of technology in warehouses inevitable as a result of constant developments in technology. Implementation of wearable technology in warehouse management intends to ensure picking in a quick and proper way. With the use of such technology, accuracy in picking orders, efficiency of warehouse operator has increased and the time for picking has decreased. In this study, the utilized technologies were described, their advantages and risks were determined, case study/studies were included and its feasibility in our country was mentioned.

Keywords– Wearable Technologies, Voice Picking, Smart Glasses, Barcode Scanner, Augmented Reality.

INTRODUCTION

Warehouse/warehouse management is the second cost item after transportation in logistics industry. Among storage activities, order picking processes are the most expensive process of warehousing activity. Since corporations are in search of decreasing such cost and thanks to the constant developments in information technologies, recent technologies have begun to be used in picking processes. The most important objective of picking is that warehouse operator collects the ordered product/products realizing the quickest, the most proper and the shortest routing and delivers them to dispatch area. In the light of these expectations, efficiency of warehouse operator will increase, the rate of fulfilling orders will increase and the accuracy in picking will be ensured with the use of “wearable technologies”. The first technologies used in warehouse/warehousing processes that spring to mind include "Voice Picking/Voice Recognition Systems", "Smart Glasses/Google Glasses" and "Wireless Barcode Scanners" which is most widely used today(1).

OBJECTIVE AND METHODOLOGY

The objective of our study is to carry out picking process, which is the most costly item of warehouse/warehousing in logistics sector, in the quickest, most accurate and most efficient manner, to give information about ‘wearable technologies’’ used in picking and explain in which processes such technology is used in warehouses. Mentioning also about “Augmented Reality” technology, it was aimed to inform readers about this issue and with the sample study provided, it was tried to explain in which processes such technology is used in logistics sector and warehouses.

In the study, a literature review was primarily conducted in Google search engine with the key words "Wearable Technology, Voice Picking, Smart Glasses and Barcode Scanners and Augmented Reality" including the studies between 1997-2015 in which scientific studies of wearable technologies started. Following the review of opening pages, it was observed that the investigations included within the scope of the study should have the following peculiarities:1) They should be field research, 2) They should be detailed, 3) Study results should be well-stated,

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4) They should be reports mostly in the form of pdf format. These were acknowledged as the election criteria for the resources. Figures from prior and posterior status analysis in the case studies and service providers and the studies conducted together by the corporations were mainly utilized.

LITERATURE RESEARCH

Wearable technologies started to be efficient in several industries in 1940;today it is used by auto manufacturers in vehicle test drives and tracking of test vehicles(2). Wearable technologies started to be used in 1960s, and maintained in 1990s, implementation area then was for military purposes, e.g., it was used in a way where a headset and microphone were assembled over the head and helmet of the user(3). 1960s can also be considered as a beginning for Augmented Reality (AR). Sutherland had used AR to see the inside of HDM and 3D graphics (4). Azuma et al., started international workshops regarding Augmented Reality, Mixed Reality, symposiums and environmental design studies with respect to AR in 1990s(4). First workshop of wearable technologies was conducted in 1996 under the sponsorship of USA Ministry of Defence Advanced Research Projects Agency (DARPA), then a workshop called "Wearable Proceedings Workshop in 2005" was conducted and researchers, universities and military visionaries took part in the workshop(5). Azuma published the first research related to Augmented Reality in 1997; he defined the sphere of AR in this research, specified the problems and summarized the points to be enhanced(6). In their research in 1997 Bass at al., stated that wearable technologies could be used in maintenance works of complicated machines(7). A similar Project was performed by Turkish scientific and Technologic Research council of Turkey (TÜBİTAK) in 2004-2009, and it was remarked that a system was established which is able to issue commands through voice and movements in order to eliminate the problems such as necessity for reaching the correct information instantly and increase in efficiency was stated(8). In the "First International Wearable Computers Symposium" in 1997, Mann stated that mobile computers should be wearable, they should be accepted as a part of the user/operator, the control should be held by the user, they should be designed in a way to be available all the time both during operation and other modes and that they should be real-timed and be in interaction with the operator/user at any time(9).

In 2000s, the fastest growing technology was undoubtedly barcode readers and it was stated that the biggest advantage of this technology was that it is easy to use and ergonomic for the user(10). Kendall (2002) stated that barcode labels should be physical objects such as RFID labels which can be read by other machines, and that they should be labelled in a manner to be processed by computers(11). TESCO firm started to use mobile technologies in its own distribution network in 2004, measured the efficiency of the system between 2007-2012, and concluded that employees acted 18% less in picking operations(12). In the research performed by Vocollect Inc. Company, 22 distribution centres were selected as pilot area, paper based picking and voice based picking was compared, and it was specified that voice based picking is 50-60% more efficient and that 99.9% accuracy in total was reached in picking(5). In his declaration in 2006, Ackerman stated voice recognition systems to be the most important development beyond dispute, of last 20 years in warehouse and distribution operations(13). In the study by Aberdeen Group in 2007, it was remarked that voice recognition technology is not only used in picking, but it is also used in other warehouse operations, the rate of use of voice recognition technology is 68%in picking, 44% in order replenishment, 42% in dispatch, 40% in inventory control, 38% in product delivery, 36% in packing, 32% in reverse logistics, 31% in product put away, 31% in quality assurance applications and 27% in value added operations(14). In 2009, Canadian retailer, Longo Brothers integrated voice picking and barcode scanner, which are wearable technologies, and used such in picking and packaging, and stated that they ensured a 14% increase in efficiency(15).

In the study conducted by Vocollect Inc. Company in 2010, some cost estimations were made in the warehouses and distribution centres where voice recognition technologies are used, it was estimated that training period before usage was twenty (20) minutes less, voice picking equipment usage was 8 hours maximum in a day and 360 days in a year for a user, it was 200 pieces for a warehouse operator, defective product recognition period was 3,5 seconds and that 20 dollars ($) less payment in an hour was made in the salaries to the employees(16). In the report, dated August 2012 by Aberdeen Group, it was stated that business enterprises executed warehouse optimization in order to reduce the expenses in warehouses, technologies with mobile technology (voice based technology) in which real-time information transfer is carried out is preferred, and that key points in such selection were efficiency and integration of order and delivery(17). According to Knapp AG Company in 2014, stocking and picking were considered as a positive step in picking sector as a result of benefits provided by smart glasses and it is thought that smart glasses can be a perfect solution for ensuring serial picking opportunities, revisions to increase efficiency and eliminating staff mistakes(18). In its notification in 2014 by Accenture Technology Laboratory,it was specified that wearable technologies should be assessed in four (4) fundamental points, and such should provide free hand, compliance with human body, indicate related information and give computer based images(19). In the notification published in March 2015 by Vocollect Inc. Company, it was stated according to the feedbacks from the customers that order accuracy of distribution centres where voice based picking is used, has increased from 98% to 99.9%, flexibility in the tasks of employees was ensured and that there was a decrease more than 20% in working period (20).

WEARABLE TECHNOLOGIES USED IN WAREHOUSES

The most costly item of warehouse processes, picking constitutes 40% and 60% part of warehouse/warehousing budget(2). Technological innovations employed in warehouses increases picking and efficiency, decreases costs of labour, increases stock follow-up and order renewing periods either, and raises order accuracy to an extent such as 99,9%(21). Work flow from customer order to warehouse operator, of mobile technologies integrated in WMS(Warehouse Management System)is provided below.

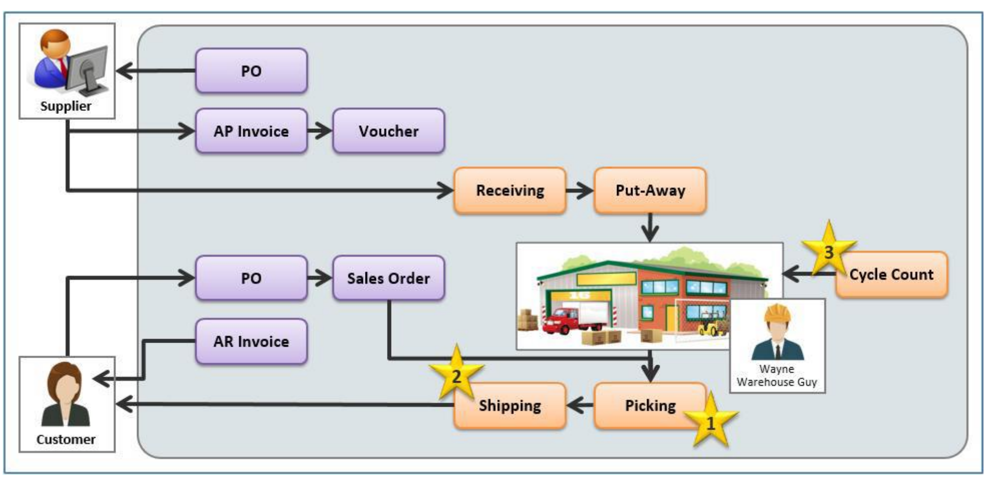

Figure19. Integration of Wearable Equipment in Warehouse Management(12)

There are 3 main different kinds of wearable technologies in warehouse management. Such kinds are used in an integrated manner just as they can be used individually. Utilized technologies are as follows:(12): 1) Voice Recognition Systems; 2) Smart Glasses; 3) Barcode Scanner. Wearable technological products are used with body movements (barcode scanner), voice command (voice recognition) and touching (smart glasses). In addition to such technologies, Augmented Reality technology, which has recently been started to be used, is like a great revolution as well as such innovations.

Figure20. Voice Recognition Equipment(22)

1) Voice Recognition Systems: Voice recognition systems are considered to be the greatest technological investment within warehouse and distribution organizations after barcode scanning technology(23). When the history of voice recognition systems is reviewed, it is seen that it was first started to be used in cold storages about 20 years before now(21). The main goal of voice recognition technology is defined as decrease in costs of workmanship, operational efficiency, and fast and accurate delivery(2). Two main components of voice recognition technology within WMS are 1) Warehouse operators and 2) WMS software. The biggest **advantage** of voice recognition system is that warehouse operator is in compliance with eyes-free and hands-free principle; he should not carry any equipment such as order list, portable terminal etc., and that he doesn’t carry a constant order list. Voice recognition system is not only used in picking but it is also utilized in other processes of warehouse operations. It was stated in the Figure below, in which operations and to what extend it is used after required infrastructure arrangements and integration are performed in WMS.

In a study conducted in a cold storage sponsored by Vitech Business Group, picking periods of voice recognition system and barcode scanner were compared, and voice recognition system completed picking procedure earlier than barcode scanner with a 35% difference approximately(24). The same company compared paper based picking and voice based picking(25). Numeral values of these enhancements are as follows: 99.9% accuracy in picking; An increase minimum 15-20% increase in efficiencies of warehouse operators; approximately 1.3 million dollars ($)saving of the business enterprise where voice picking was utilized (based on company and the sector), that return speed of investment reaches up to an amount like 50%, (2); the number of quality control members is decreased from 17 to 5 in warehouse processes; lost time in training period is decreased with the use in other languages and that training period is decreased from 2 weeks to 3-4 days(26). There are also some **risks** of voice recognition system just as it has many advantages. The studies have shown that the biggest risk of this system is radiation in terms of users/operators(27). However; that the users do not use their own skills is defined as another risk. When it is considered from the point of business enterprises, the biggest risk that information about the personnel, product and business enterprise may be stolen(28).

Figure21. Implementation of Voice Recognition Technology in Warehouse Processes and the Rates(29)

2) Smart Glasses: Smart glasses are a computer technology without keyboard use, designed as wearable technology product, integrated with the small camera on the glasses and wireless technology. (30). Smart technology is basically a technology in which hands are not used; the information is reached through visualization of information. Smart glasses are the forms of using augmented reality and virtual reality together(31). Smart classes can also be considered as the modernized form of the use of camera-microphone installed on the head in the past. Smart glasses are used in three different ways through wireless internet connection (WIFI), voice, touching and head movements of the user/operator(32). Equipment of smart glasses replaced instead of the glasses is seen in the following picture.

Smart glasses have many **advantages** since they can be used in different sectors. Thanks to the microphone on the glasses or details of order seen on the screen of the glasses, they state that picking is fulfilled thereby directing the commands from WMS, warehouse operator to the shelves where material/product is on and taking the requested order and having the product code read through QR code on the glasses and barcode scanner. A similar practice is also applicable for voice recognition and picking. While the warehouse operator gives approval in voice recognition system through voice when the picking is completed, picking is completed in smart glasses through having the QR code or barcode of material/product read(33). Smart glasses are more dynamic than voice recognition in terms of data communication (34). In addition to many advantages of smart glasses technology, there are also some risks. The first of these risks to come to the mind is that confidentiality is violated by the user. Another risk of smart glasses in terms of usage is that its charge is not long-lasting(34).

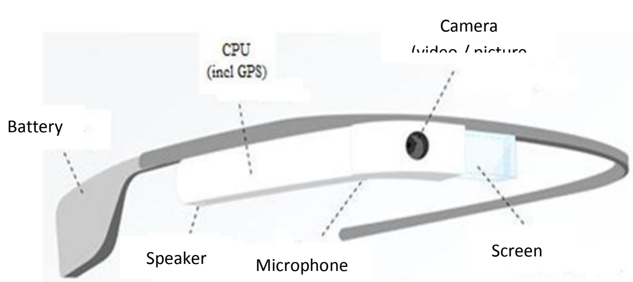

Figure22. Smart Glasses(35)

3) Barcode Scanner: Barcode scanners have constituted the spine of logistic sector since 1980s. Barcode scanners are the most preferred technology in warehouse operations(36). Furthermore, barcode scanners can be integrated both with voice recognition technology and smart glasses(37). Barcode scanners allow the users ease of use beyond the estimations. In warehouse processes, barcode scanner worn on the arm or on the belt on the waist (generally the one worn on the arm is preferred) are utilized. Barcode scanner accelerates real time data collection and inventory follow-up. The user is able to see order commands from WMS through the terminal on his arm, and prepares the orders with the incoming order commands. Other than picking in warehouses, barcode scanners are used in product acceptance (performing fast entry into inventory through having the barcode on the incoming product read); Product Replacement; Packaging; Dispatch; and in Reverse logistics (38). To some up its **advantages**: it is cost efficient, easy to use, helpful to collect data fast and it has type standards(39)(40). Limited range of visibility, limited traceability and that barcode label is easily affected against environmental effects are accepted as risky aspects among the weak sides(41).

Figure23. Barcode Scanner(37)

4) Augmented Reality: Augmented Reality (AR) can also be defined as the point where digital world meets with reality, data is made valuable(42). Four basic components are required for the operation of AR technology. The first requirement is software, then a mobile device with a camera and (e.g.: it may be a mobile phone), a mobile device installed with AR application and internet connection is required. The basic element is AR software in order that AR technology is successful(42). AR technology is encountered in three kinds when it is classified. These are: **1) Worn on head:** The type of use integrated with smart glasses. Images come infront of the eye of the user. **2) Hand-held:** A hand-held design with LCD screen (tablet pc). The screen is like a magnifying glass. It shows the images on the screen. **3)Projection:** In this kind, requested data are projected through physical objects. There is no need for special glasses(4). AR technology undoubtedly seems to take place much more in logistics sector in the future in terms of service level. AR technology renders service today only through **four basic service**. These are: Warehouse and distribution operations; Transportation optimization; Last mile delivery; Enhanced added value services(33).

IMPLEMENTATION OF WEARABLE TECHNOLOGIES IN LOGISTIC PROCESSES

Thanks to the integration of wearable technologies in logistic processes, transition from wired and paper based information technologies to wireless and mobile technologies was ensured. It increased profitability status of enterprises ensuring operation speed, new work flows and increase in efficiency with instant data entry. Logistic service providers making use of this technology rendered better service making cooperation with the firms for which they render service and thus ensured customer satisfaction thereby providing transparency in their processes(43). Usage of wearable and mobile technologies in logistic processes was presented below as a table.

Table21.Use of wearable Technologies in Logistic Processes(43)

PROCESS	Paperless Workflow	Wireless Data Entry	Goods Transportation	Work on Site	Real-Time Access
Procurement	X				X
Inventory Management	X	X			X
Warehousing and Distribution	X	X	X	X	X
Fleet Management			X		X

With the start of proliferation of use of wearable technologies, it is also possible to see them in other processes of logistics

IMPLEMENTATION OF WEARABLE TECHNOLOGIES IN OUR COUNTRY/IMPLEMENTATION CASES

Logistic service providers are the leading sectors among those implementing this technology in our country. The companies implementing this technology among logistics service providers use voice recognition technology in fast moving consuming goods. Among these, EKOL Logistics Company primarily uses voice recognition technology in Ankara Lavender warehouse(44). Voice recognition technology here prepares orders for retail sector.

Assigning order　　Verifying order　　Picking and packaging

Figure24.Use of Wearable Technologies in our Country(44)

Another logistics company, AKÇA Logistics stated that it uses Italian origin "StockSystemEvolutionWMS" software for retail, food and production in İstanbul and Ankara warehouses(45).

FINDINGS

In the reviewed studies, technological specifications of wearable technologies were described, examples were given from case studies, status comparison regarding then and now of the enterprises making use of this technology was included, and the criteria should be observed by business enterprises while choosing wearable technology were revealed. Seven basic steps came to the forefront at the end of the research. These are:1)

Prerequisites, 2) Selection process, 3) Performance criteria, 4) Cost, 5) Project process, 6) Integration, and 7) Implementation and operation steps. These issues will be described in result and recommendations section.

Above mentioned criteria constitute critical achievement factors determined by service providers and the enterprises using this technology.

RESULTS AND RECOMMENDATIONS

It was proved that wearable technologies provide material benefits in the sectors where they are used. Although there are some disadvantages of smart glasses, they are seen the equipment of future as its application is limitless. The reason why it should be preferred by enterprises is that it can be implemented in any sectors. Among the processes which should be primarily paid attention by the enterprises that would like to use wearable technology are: 1) prerequisites', 2) selection criteria, 3) performance criteria, 4) cost scale, 5) project process, 6) integration of the technology to be used into enterprise processes and 7) implementation phase are the first to come to mind(46). Information obtained as a result of this research was summarized below:

1) Project Prerequisities: The first thing to do perform IT infrastructure analysis within the business enterprise during technology transition. Following the analysis, transition to this technology will be proper after the required hardware is supplied if the enterprise has the suitable infrastructure. When prerequisites of wearable technologies are analysed: 1) There should be WMS, 2) Wireless Network infrastructure should be durable, 3) Physical status of work environment should be suitable, 3.a) There should be no metal reflector in the environment where wearable equipment will operate, 3.b) There should be no high noise in the environment where voice recognition system is to be used, 3.c) Cleaning conditions of working environment should be adequate so that the equipment to be used could be long-lasting. 4) Project organization should be made, 5) There should be a project plan.

2) Selection Criteria: Installation cost, ensuring labour force saving, energy consumption of equipment during operation, service life of equipment, favourable references of the company from which service will be taken, ensuring work safety are among the leading subjects encountered that business enterprises should consider. Furthermore, there are expectations from service providers which are: Guarantee period; Completing implementation process of the system; Logistic consultancy, Technical services; Training for users; Adapting specification to the system; Software need; Hardware need; Integration of enterprise with the system(47).

3) Performance criteria: Some of them are encountered such as: Material return period of the system; Abstract return period of the system(48). As well as these criteria; Inventory saving; Accuracy in stock level and stock amount; Space saving in the warehouse; Impact on placement inside the warehouse; Labour force saving (may be accepted as the most important criteria); Equipment saving; repair and maintenance costs of the equipment before the system is installed and other expenses; Impact on the sales through ensuring customer satisfaction (48), impact of technology on the costs of workmanship, order cycle time and accuracy in picking(49). In the research on return period of investment cost; some measurements were made after performance criteria were fulfilled in the case study conducted by Forte Company in the business organization sponsored in 2004. Among these, efficiency, order accuracy, return period of investment, the number and accuracy of daily picking of orders are based on as key points. These include, decreasing picking from 2 days to just 10 minutes; increasing order accuracy from 89% to 99,5%; increasing efficiency 25%; increasing the number of daily picking from 1500 to 3000 based on product; and return of investment shorter than 2 years(46).

4) Cost: The most important factor for the enterprises as regards the selection of wearable technologies is how much the cost will be and in how much time return will take place. Studies indicate that this period is between 6-12 months and 12-18 months(21). In the research by MWPVL Supply Chain and Logistics consultancy firm in Montreal, Canada, the company calculated for a warehouse with 20000 SKU capacity that the investment should be a led lighting system investment of $100-130 for each location; this requires purchase of one led light for each different product, initial cost is 50000 dollars ($)to 100000 dollars ($) (including software integration, equipment and system installation), and total cost is more than 300000 dollars ($). As for voice picking, it was calculated a labour force for picking consisting 25 persons for a warehouse with a capacity of 20000 SKU, and the total cost was calculated to be 188000 dollars ($) to 280000 dollars ($) (including software integration, equipment and system installation) (50). As can be understood from this point, voice picking proves to be how much advantageous a technology even in initial cost of investment.

5) Project Planning Process and Project Steps: In Project planning process, companies should primarily evaluate the infrastructure, building and location where they are in. And the most crucial stage of project planning process is addressing. Here the most severe problem encountered is placing the products on the right location, and ensuring that picker can work efficiently. Placement inside the warehouse is also important in the selection of wearable technology. The first step of placement inside the warehouse is a placement plan to ensure efficiency. The important point is to be able to reach the order with just a single command from WMS(46). Fundamental project steps are listed as follows: 1) Ensuring technical equipment, network substructure, 2) Making health operation of integration with the available software, 3) Determining the rules peculiar to the enterprise, making adaptation of such to the system, 4) Performing project tests, 5) Creating failure case scenarios, 6) Creating training plan, 7) Preparing usage document, 8) Preparing required reports (failure, final user etc.), 9) Specifying routine executive operations to be performed after the transition, and 10) Carrying out project finishing. Above listed basic steps constitute the steps in project process of such a comprehensive technological transformation. Another topic of wearable technologies is integration process. Planning phase of the system includes a time period for 10-12 weeks, and installation phase may be a time period approximately for 16 weeks (such period may vary based on the corporation and the processes to be implemented)(46).

6) Integration: Here it is an important point, integration with current ERP and WMS. There are four basic levels within integration stage. These include that: 1) Selected software should make contribution to customer services; 2) It should ensure stock accuracy; 3) It should increase efficiency of picking; and 4) It should ensure competition advantage(51). Easy implementation; Wireless connection; IT support must be considered as the contributions to the speed of picking with respect to the topics to be paid attention in the integration phase of wearable technologies for warehouses and distribution centres(52).

7) Implementation and Operation Steps: When it comes to implementation stage, planning is reviewed for the last time when above mentioned stages are completed. What is a critical point here is the training of warehouse operators, users or the staff members of enterprises (such as repair-maintenance personnel) using such technologies in other sectors(46). Suitability of the system in the testing stage is a topic to be paid attention for the integration of ERP or WMS and fitting of equipment. The way to be followed during testing stage should be as follows: Testing stage should start in pilot area in order to reduce risks; Utility of the system should be measured; The problems to arise during test stage should not be ignored and such should be eliminated; A team should be created during test stage from IT personnel and service providers of the enterprise(51). In the following picture, the dialogue taking place between voice recognition system and WMS is given as a sample implementation in picking process.

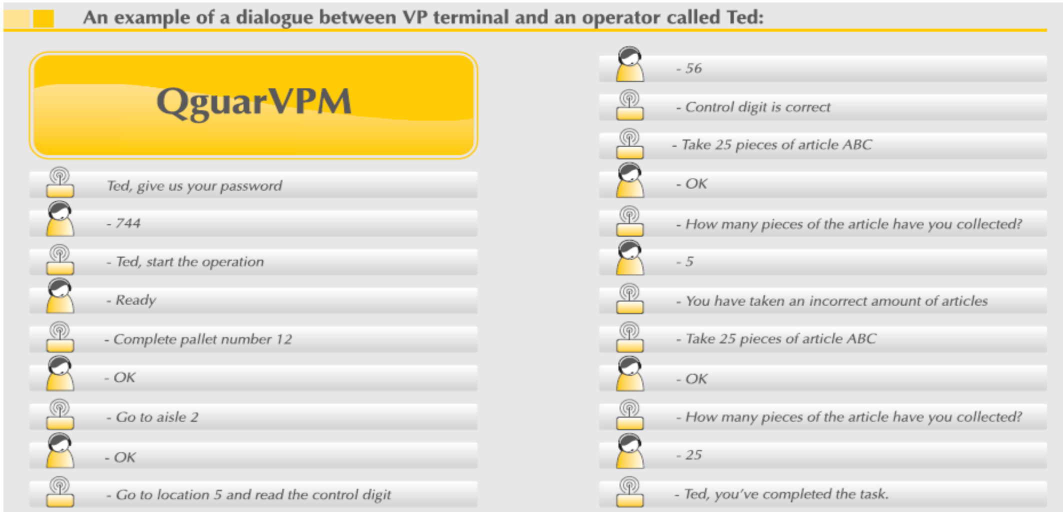

Figure25.Example: Picking Dialogue Taking Place Between Voice Recognition Terminal and Operator Ted (53)

Upon completion of selection process and testing stage, the system will start to be used. It may not be that much health to consider wearable technologies as a technology. Since it is a constantly developing technology, it will be a more accurate approach that enterprises consider such technologies as a ''Project'' such as ERP, WMS implementations. It will both ensure selection of correct system and accelerate return in terms of cost to pay attention to abovementioned issues. As the samples and suggestions provided were implemented and their benefits were materially proven, adaptation of such studies to other enterprises will gain great favours today.

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PULL-OFF TABLE METHOD IN CAR SEQUENCING PROBLEMS AND AN EXAMPLE

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Abstract _ Scheduling problems are very important in industrial area. Some applications of scheduling procedures are used in car manufacturing systems. The manufacture of automobiles is characterized by the fact that the cars produced in a single day on a single assembly line are not homogeneous each car may require a slightly different set of options. For instance, one car may require air conditioning while another one may require sun roof. lt is unreasonable to require that the assembly line moves slowly enough to allow every option to be put on every car. Instead the line has to be designed in such a way that it can handle a predetermined ratio of cars for each option. There are different methods to schedule the manufacturing of car with different options. In this study, we have examined pull-off table method in car sequencing problems and showed an example.

Keywords _ *Assembly line, car sequencing, pull-off table, scheduling.*

INTRODUCTION

Within the scope of this study, car sequencing problems (CSP) and car resequencing problems (CRSP) has been examined. The issue is treated in five sections.

In the first section, car sequencing problem (CSP) and car resequencing problems (CRSP) will be explained. The characteristics of problems, the indices and sets used mostly in CSP/CRSP will be mentioned. In the second section, a sequencing problem with 10 cars and five possible options will be handled. In the third section solution procedure will be presented and in the fourth section the problem of sequencing ten car will be solved by hand. In the fifth section discussion and the study which can be implemented in the future will be explained and the study will be put an end with references which takes place in the last section.

DEFINITION OF CSP AND CRSP

The manufacture of automobiles is characterized by the fact that the cars produced in a single day on a single assembly line are not homogeneous each car may require a slightly different set of options. For instance, one car might require air conditioning while another one can require sun roof. lt is unreasonable to require that the assembly line moves slowly enough to allow every option to be put on every car. Instead the line has to be designed in such a way that it can handle a predetermined ratio of cars for each option.

Mixed-model assembly lines like they are applied in automobile or electronics industry, require the solution of a short-term sequencing problem, which determines the succession of product models launched down the line. A widespread approach for this decision task is the car sequencing problem (CSP), which is based on a set of sequencing rules. These rules of kind Ho : No restrict the occurrence of a labor-intensive option o, a sun-roof, to at most Ho within any subsequence of No successive models and CSP aims at model sequences, which minimize rule violations. [4]-[5]

Sometimes cars are lined to the assembly line and produced in order. But sometimes there is another process before production. In this process cars are resuffled and resequenced in order to minimize or remove the violence of rules (Ho:No).

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The vast majority of papers on sequencing mixed-model assembly lines treats initial sequence planning, where a desirable production sequence (with all degrees of freedom) is determined and communicated to part suppliers. However, in real-world applications there sequencing problem, where a given sequence is to be reshuffled with the help of a resequencing buffer or selectivity banks or pull-off tables, etc.

On the one hand, typically multiple departments, e.g., body-shop, paint-shop, and final assembly in automobile production, having different sequencing objectives participate in production. Then, are sequencing between these departments allows for an individual sequence reshuffled with regard to each shop's individual objective instead of producing one joint and unchanged compromise sequence. On the other hand, disturbances like material shortages, machine break-downs or workpiece defects mixing up the initially planned sequence might occur. In automobile production, especially the paint-shop is a major source of (unplanned) sequence alterations due to rework of paint defects. Again, resequencing buffers can be applied to regain a desirable model sequence. [1]

In CSP and CRSP, the sets and indices used generally are presented below [2] [3].

T = Number of productioncycles(index *t* or *i*)

O = Set ofoptions(index *o*)

a_{oi} = binary variable 1, if model *i* requires option *o*, 0 otherwise.

Ho:No = Sequencing rule, at most Ho out of No successively sequenced models may require option *o*

x_{itm} = binary variable: 1, if model number *m* at cycle *i* before resequencing is assigned to cycle *t* after resequencing, 0 otherwise

y_{ot} = binary variable: 1, if sequencing rule defined for option *o* is violated in window starting in cycle *t*.

There are a lot of different indices and notations for different problems. Generally, objective function is set to minimize the violence of the rule determined for related problem, like below:

Minimize $\sum_{o}^{O} \sum_{t=1}^{T} z_{ot}$

PROBLEM DEFINITION

The problem is taken from the literature, authors are Dinçbaş, Simonis and Van Henteryck (1988) [4]. In the problem, there are ten cars and five options which the cars may have. These are; air conditioning (AC), sun-roof, cruise control, park sensor and anti-lock brake system (ABS). Line capacities (Ho : No) tells us that there is a restriction the occurrence of a labor-intensive option o, to at most Ho within any subsequence of No successive models.Line capacities, required options are presented in Table 4.1.

Table 22. Data for the Problem

Option	**Capacity**	**Car 1**	**Car 2**	**Car 3**	**Car 4**	**Car 5**	**Car 6**	**Car 7**	**Car 8**	**Car 9**	**Car 10**
AC	1/2	1	0	0	0	1	1	0	1	1	0
Sun-roof	2/3	0	0	1	1	0	1	1	0	1	1
Cruise control	1/3	1	0	0	0	1	0	0	1	0	0
Park sensor	2/5	1	1	0	1	0	0	0	0	0	1
ABS	1/5	0	0	1	0	0	0	1	0	0	0

The problem is to sequence the cars according to line capacities without violence or with minimum violence.

PROPOSED SOLUTION PROCEDURE

In solution of the problem pull-off tables will be used. We will have an initial sequence and we will use only one pull-off table.

First of all we cluster the cars according to options they require. After we start the resequencing by using the algorithm below:

Algorithm

Step 1 : Process the first car of the initial sequence

Step 2 : Check the second car and first car of the initial sequence in terms of option rules. If rule is violated take the second car to the pull-off table (2a). If rule is not violated, process the second car (2b).

Step 3 : There are two situations:

Step 3a: If 2a happened in the step 2 check the following car and first car in terms of option rules.

Step 3b: If 2b happened in the step 2 check the following car and the cars processed in terms of option rules.

Step 4 : If any option rule is completed, (for example when two car processed, it means rule 1/2 is completed) don't consider the processed cars for that option.

Step 5 : Apply the step 3 for all cars in the sequence and when all the cars are resequenced STOP.

COMPUTATIONAL STUDY

Let's solve the problem according to algorithm presented above. First, we have to cluster the cars according to their options. We have to find the cars with same options. In the Table 4.1

- ✓ Car 3 and Car 7
- ✓ Car 4 and Car 10
- ✓ Car 5 and Car 8
- ✓ Car 6 and Car 9 have the same options.

Car 1 and Car 2 has different options. Now we have six class of car. We reduce the variability from 10 to six. Our classes are numbered 1 through 6. Classes and options they have are presented below.

Table 23. Cars And Options

	Class2	Class3	Class5	Class6	Class4	Class1	Class5	Class3	Class4	Class6
Opt-1 AC	**0**	**0**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**1**
Opt-2 Sun-roof	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**1**	**1**
Opt-3 Cruise Cont.	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**0**
Opt-4 Park sensor	**1**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**0**
Opt-5 ABS	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**

Now that we have cluster the cars, we can proceed the algorithm.

Step 1.

	Assembly Line								Check Point (Occurance of the Options)	Pull-off Table		Total Occurance of the Options	Ho:No
	C2	C3	C5	C6	C4	C1	C5	C3	C4		C6		
Opt-1	0	0	1	1	0	1	1	0	0		1	1	1--2
Opt-2	0	1	0	1	1	0	0	1	1		1	2	2--3
Opt-3	0	0	1	0	0	1	1	0	0		0	0	1--3
Opt-4	1	0	0	0	1	1	0	0	1		0	1	2--5
Opt-5	0	1	0	0	0	0	0	1	0		0	0	1--5

In this step, we have a initial sequence. Firstly, car class 6, first car class of the initial sequence, is processed. And following car class, C4, and C6 evaluated in terms of option rule (Ho:No). As there is no violation C4 is processed.

Step 2.

	Assembly Line							Check Point (Occurance of the Options)	Pull-off Table			Total Occurance of the Options	Ho:No
	C2	C3	C5	C6	C4	C1	C5	C3		C4	C6		
Opt-1	0	0	1	1	0	1	1	0		0	1	1--2	1--2
Opt-2	0	1	0	1	1	0	0	1		1	1	3--3	2--3
Opt-3	0	0	1	0	0	1	1	0		0	0	0--3	1--3
Opt-4	1	0	0	0	1	1	0	0		1	0	1--3	2--5
Opt-5	0	1	0	0	0	0	0	1		0	0	1--3	1--5

In this step, following car class, C3, C4 and C6 evaluated in terms of option rule (Ho:No). As there is a violation at option 2 (There must be at most 2 out of 3 cars but all three cars have the option 2, sun-roof). C3 is not processed.

Step 3.

	Assembly Line						Check Point (Occurance of the Options)	Pull-off Table			Total Occurance of the Options	Ho:No
								C3				
	C2	C3	C5	C6	C4	C1	C5		C4	C6		
Opt-1	0	0	1	1	0	1	1		0	1	1--1	1--2
Opt-2	0	1	0	1	1	0	0		1	1	2--3	2--3
Opt-3	0	0	1	0	0	1	1		0	0	1--3	1--3
Opt-4	1	0	0	0	1	1	0		1	0	1--3	2--5
Opt-5	0	1	0	0	0	0	0		0	0	0--3	1--5

In this step, C3 is pulled to the pull-off table and C5 is evaluated with C6 and C4. As there is no violation C5 is processed. Note that for option two, we don't consider C4 and C6 any more.

Step 4.

	Assembly Line						Check Point (Occurance of the Options)	Pull-off Table			Total Occurance of the Options	Ho:No
	C2	C3	C5	C6	C4	C1	C3	C5	C4	C6		
Opt-1	0	0	1	1	0	1	0	1	0	1	1--2	1--2
Opt-2	0	1	0	1	1	0	1	0	1	1	1--1	2--3
Opt-3	0	0	1	0	0	1	0	1	0	0	0--1	1--3
Opt-4	1	0	0	0	1	1	0	0	1	0	1--4	2--5
Opt-5	0	1	0	0	0	0	1	0	0	0	1--4	1--5

In this step, C3 is evaluated again with C6, C4 and C5. Note that for option three we don't consider the C5, C4 and C6. As there is no violation C3 is processed.

Step 5.

	Assembly Line					Check Point (Occurance of the Options)	Pull-off Table				Total Occurance of the Options	Ho:No
	C2	C3	C5	C6	C4	C1	C3	C5	C4	C6		
Opt-1	0	0	1	1	0	1	0	1	0	1	1--1	1--2
Opt-2	0	1	0	1	1	0	1	0	1	1	1--2	2--3
Opt-3	0	0	1	0	0	1	0	1	0	0	1--2	1--3
Opt-4	1	0	0	0	1	1	0	0	1	0	2--5	2--5
Opt-5	0	1	0	0	0	0	1	0	0	0	1--5	1--5

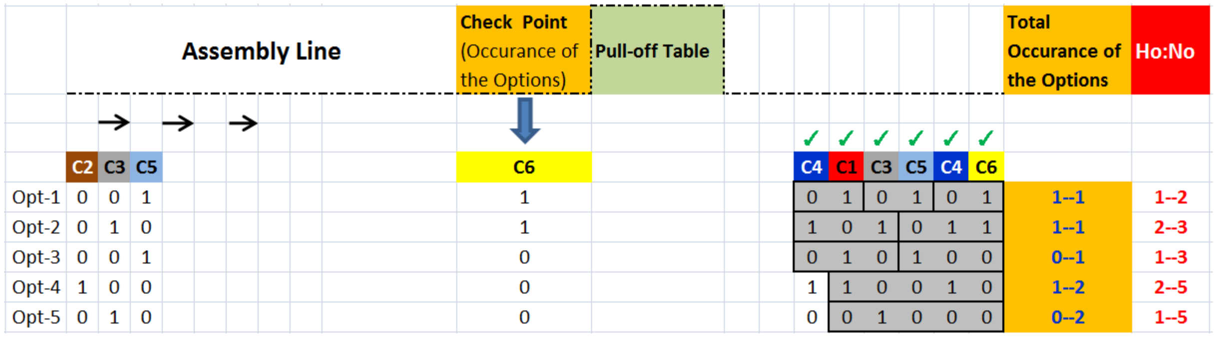
In this step, following car class, C1, is evaluated with C6, C4, C5 and C3. As there is no violation C1 is processed.

Step 6.

	Assembly Line				Check Point (Occurance of the Options)	Pull-off Table					Total Occurance of the Options	Ho:No
	C2	C3	C5	C6	C4	C1	C3	C5	C4	C6		
Opt-1	0	0	1	1	0	1	0	1	0	1	1--2	1--2
Opt-2	0	1	0	1	1	0	1	0	1	1	2--3	2--3
Opt-3	0	0	1	0	0	1	0	1	0	0	1--3	1--3
Opt-4	1	0	0	0	1	1	0	0	1	0	1--1	2--5
Opt-5	0	1	0	0	0	0	1	0	0	0	0--1	1--5

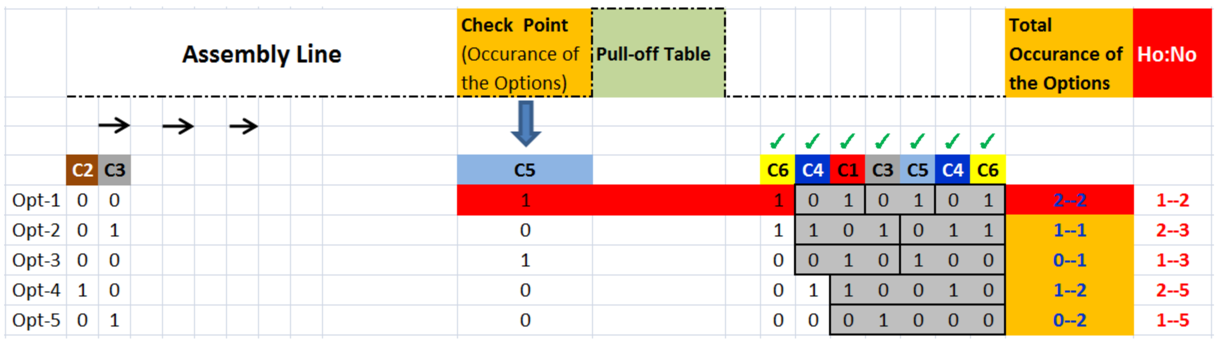
In this step, following car class, C4, is evaluated with only C1 and C3 in terms of option rule 1, 2 and 3. As there is no violation C4 is processed.

Step 7.



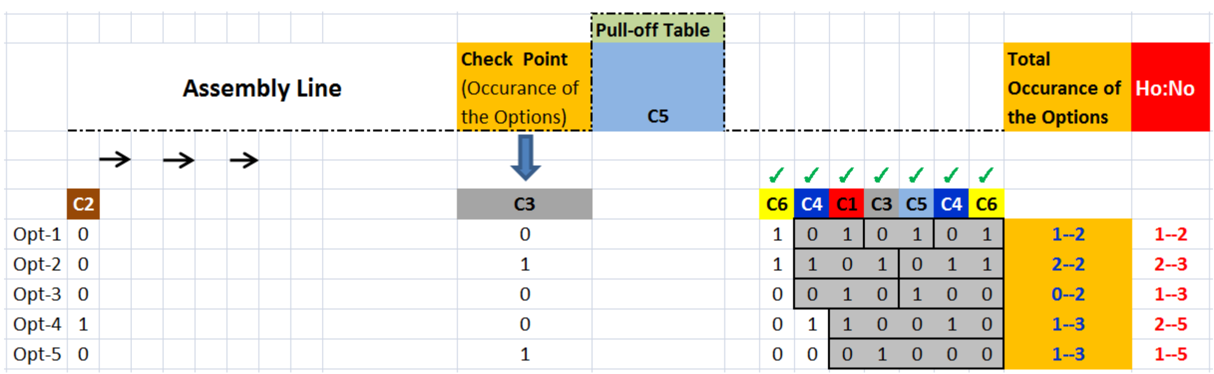
In this step, following car class, C6, is evaluated with only C4. As there is no violation C6 is processed.

Step 8.



In this step, following car class, C5, evaluated with C4 and C6 in terms of option rule (Ho:No). As there is a violation at option 1 (There must be at most 1 out of 2 cars but both two cars have the option 1, Air conditioning). C5 is not processed.

Step 9.



In this step, C5 is pulled to the pull-off table and C3 is evaluated with C6 and C4. As there is no violation C3 is processed.

Step 10.

	Assembly Line	Check Point (Occurance of the Options)	Pull-off Table								Total Occurance of the Options	Ho:No
	C2	C5	C3	C6	C4	C1	C3	C5	C4	C6		
Opt-1	0	1	0	1	0	1	0	1	0	1	1--1	1--2
Opt-2	0	0	1	1	1	0	1	0	1	1	2--3	2--3
Opt-3	0	1	0	0	0	1	0	1	0	0	1--3	1--3
Opt-4	1	0	0	0	1	1	0	0	1	0	1--4	2--5
Opt-5	0	0	1	0	0	0	1	0	0	0	1--4	1--5

In this step, C5 is evaluated again with C3, C6 and C4. As there is no violation C5 is processed.

Step 11.

Assembly Line	Check Point (Occurance of the Options)	Pull-off Table									Total Occurance of the Options	Ho:No
	C2	C5	C3	C6	C4	C1	C3	C5	C4	C6		
	0	1	0	1	0	1	0	1	0	1	1--2	1--2
	0	0	1	1	1	0	1	0	1	1	0--1	2--3
	0	1	0	0	0	1	0	1	0	0	0--1	1--3
	1	0	0	0	1	1	0	0	1	0	2--5	2--5
	0	0	1	0	0	0	1	0	0	0	1--5	1--5

In this step, following car class, C2, is evaluated with C5, C3, C6 and C4. As there is no violation C2 is processed.

Now we have no car to sequence. Assembly line is presented below.

Assembly Line	Check Point (Occurance of the Options)	Pull-off Table										Total Occurance of the Options	Ho:No
		C2	C5	C3	C6	C4	C1	C3	C5	C4	C6		
		0	1	0	1	0	1	0	1	0	1	1--2	
		0	0	1	1	1	0	1	0	1	1	0--1	
		0	1	0	0	0	1	0	1	0	0	0--1	
		1	0	0	0	1	1	0	0	1	0	2--5	
		0	0	1	0	0	0	1	0	0	0	1--5	

We get the final sequence presented below.

Final Sequence

Class 2	Class 5	Class 3	Class 6	Class 4	Class 1	Class 3	Class 5	Class 4	Class 6

CONCLUSION AND FUTURE STUDY

In this study, we examined the car sequencing problems. And we find out car resequencing problems as well. This kind of problems are very common in industrial area. This problems are mostly based on capacity constraints of the assembly line. In order not to cause labor intensive work environment and high prices, an effective sequence is needed.

The car resequencing problem, where a number of pull-off tables can be used to reshuffle an initial sequence of car models in such a way that violations of car sequencing rules are minimized. To further speed up search, develop a lower bound as well as a dominance rule which both can be used for fathoming nodes in the search graph. We solved a basic problem by using an algorithm and pull-off table by hand. In future study we can solve more complicated problems by using a software.

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OPERATIONS RESEARCH IN CMC

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Abstract – *This study focuses on operational research methods which can be used for solving CMC problems. In most studies, encountered in the literature, mentioned a tradeoff between repositioning empty containers and transportation of loaded containers. In this study transportation problem was suggested for minimizing opportunity cost of empty container maritime repositioning. Semi-structured interview was performed with a CMC employee in order to understand limit and cost of empty container repositioning for both maritime and inland repositioning. A proposal for inland container repositioning couldn't be developed due to inability of determining limits and cost of empty container inland repositioning.*

Keywords – Operations research, CMC

LITERATURE REVIEW

There are two type of ports, ports is called 'demand port' and ports is called 'supply port' [1][4]. Demand ports demand empty containers and liners have to satisfy empty container demand at demand ports in order to run their businesses. On the other hand supply ports provide empty containers and there is empty container surplus. Imbalance between demand ports and supply ports was mentioned in many studies [1][2][3][4][7][8]. A similar imbalance occurs among depots in an inland system. Many studies focus on empty-container repositioning between seaports, but limited research has been done about inland depot system of empty-containers. The challenge for the shipping company is to successfully allocate empty containers between multi-depots and to lease the minimum possible number of empty containers. Dang et al also highlight an efficient method of positioning empty containers between depots minimizes the expected total cost [1].

Dong and Song' s study focuses on container fleet sizing and repositioning empty containers between seaports. Efficient container repositioning may be equivalent increase fleet capacity and large fleet capacity may decrease requirements of empty container repositioning. Container fleet size and repositioning is related from point of view Dong and Song. Repositioning may decrease waiting time for empty containers and increase container utilization. On the other hand repositioning empty containers occurs handling costs and occupies slots on vessels[2]. Opportunity cost of repositioning an empty container maritime repositioning is losing a slot on vessel that can be used for transportation of loaded container [2][7].

Choong et al studied tactical management of empty containers for barge transportation networks. They described two variables that affect the empty container supply and demand as cost of building -leasing new containers and cost of repositioning empty containers. According to Choong et al steel and energy prices affects new building and repositioning of empty containers. A computational analysis was developed by Choong et al which minimize total cost related to moving empty containers in order to meet requirements for moving loaded containers [3].

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A decision support system was proposed by Shen And Khoong which aims to solve distribution problem. Shen and Khoong described the decisions that removes imbalance situations. These decisions are leasing in, off-leasing, positioning in, positioning-out. Leasing-in is leasing containers from a leasing company. Off- leasing is returning containers to a leasing company. Positioning in is bringing containers from other ports. Positioning-out is moving containers to other ports. There are restrictions on the number of vessel slots allocated for empty containers as stated by Shen and Khoong[4].

According to Olivio et al two topics were studied about empty containers in the literature. These topics are empty container repositioning and routing of trucks. Scarcity of paper about inland container repositioning was underlined by Olivio et al. In comparison with Crainic et al, containers may transit through inland depots due to lower storage fees. Transferring empty containers from import customer to export customer is possible but many customers have to pick up empty containers from closest empty container depot and their study focuses on subject customers. Main objective of Olivio et al is optimizing cost of inland repositioning for empty containers and determining the volume of empty containers to-from ports [8].

Crainic et al proposed models for empty container allocation in a land distribution system. According to Crainic et al every loaded container movement almost causes an empty container movement. Land movement of empty containers directly between depots was described as balancing flow by Crainic et al. %40 of total land movements were empty containers for major European Shipping Company who performed over 300000 land movements in 1986 . According to Crainic et al shipping companies needs to plan container management at several planning levels. These levels are strategical, operational and tactical levels hence they can’t be represented by a single model[5].

Mittal et al studied determining optimal depot location under stochastic demand. Empty containers regional repositioning includes movements between importers, terminals, depots and exporters. According to Mittal et al there will be capacity problem occurred if measures not taken[9].

Two problems was studied in Feng and Cheng' s study . First problem is estimate the empty container stock at each port and the second is empty container reposition planning. Occupying vessel slots during repositioning was also underlined by Feng and Cheng. They implied safety stock in their model. According to Feng and Chang empty containers are repositioning within a geographical region. Main aim of their study is developing empty container repositioning techniques and minimizing cost of empty container repositioning[7].

A genetic based optimization procedure was developed in Dang et al’ s study in order to minimize the expected total cost. Inland repositioning was also studied in subject study[10].

METHODOLOGY

Semi structured interview was performed in order to find out limits and decision making criteria for empty container repositioning. Semi- structured interview was preferred due to getting new ideas during the interview. Minimizing opportunity cost of empty container maritime repositioning is main problem for transportation problem usage proposal.

RESEARCH FINDINGS

According to interview with an anonymous CMC department employee empty container requirements are planned on weekly basis. Stock levels are checked on daily basis by CMC employees. Arrival of empty containers is taken into consideration while planning weekly empty container requirements. Agencies make agreement with depots based on certain number of containers hence paying storage fee per container is a rare exception. Road transport and railway are not preferred for repositioning of empty containers. Road transportation of empty container is an expensive way of repositioning of empty containers hence main transportation method for empty containers is maritime transportation. Road transportation may be preferred for close range in case of urgency. Export customers may rarely demand to pick up empty containers from certain empty container depot. Empty container requirement is predictable for two weeks before and calculated as new arrivals plus return equipment. Historical data and statistical forecasting techniques are used for demand forecast. Empty container demand fluctuations are rare occasions but possible due to booking fluctuations. According to interview personal assessment is the only method that is used for managing empty containers. Lines reposition empty containers considering demand and forecast of their agencies.

Variables

c: opportunity cost of container repositioning from a supply port to demand port.

t: longest transit time from a supply port to demand port

d:estimated total demand of empty container

s: estimated total supply of empty container

a: estimated container quantity that is returned by importers at demand port

e: estimated container quantity that is needed by exporters at supply port

x: decision variables

Assumptions

- There are weekly services from supply ports to demand ports
- Leased containers are ignored
- Vessels have enough empty slots for assigned empty containers
- Supply and demand are estimated
- Empty container requirements at supply port and return equipment at demand port are estimated
- All estimations are based on the longest transit time from supply ports to demand ports considering empty containers will be available once vessel is arrived

Adopted transportation problem formulation based on Hillier and Liberman' s

Minimize $Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$

Subject to

$\sum_{j=1}^{n} x_{ij} = (s_i - e_i)_t$ for i=1,2,3.....m

$\sum_{i=1}^{m} x_{ij} = (d_j - a_j)_t$ for j=1,2,3.....n

And

$x_{ij} \geq 0$ for all i and j

CONCLUSION

There may not be an inland container repositioning problem considering rarely preferred road transportation and unavailability inland waterways in Turkey. Probable cause of this situation may be attractiveness of direct door to door road transportation considering relatively high rates and transit time of door to door containerized transportation due to unavailability of inland waterway and poor railway network.

Transportation problem models may be used for minimizing opportunity cost of empty containers maritime repositioning. According to Hillier and Lieberman transportation problems may imply any problem that provides transportation model parameters. Hillier and Lieberman's transportation formulation was adapted to minimizing opportunity cost of empty container repositioning [11].. Opportunity cost of an empty container repositioning may be found out average revenue for subject voyage minus average fixed and variable costs for subject voyage then result should be divided by average occupancy rate. Return equipment should be considered while estimating demand of empty container that will be satisfied by new arrivals. Empty container requirement at supply port was assumed hence supply of empty container should be calculated empty container surplus at supply port minus estimated empty container requirement for exporters at supply port. All estimations should be based on longest transit time from a supply port to any demand port in model considering arrival of empty containers should be taken into consideration.

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A RESEARCH ON CORPORATE SOCIAL RESPONSIBILITY PERCEPTIONS: ATAKO EXAMPLE

Umut Güloğlu[188], Mehmet Miman[189], Köksal Hazır[190], Linda Küçük[191]

Abstract–In today's competitive and global environment, it is very important for enterprises to be socially responsible. This study investigates the corporate social responsibility perception of employees in a logistics firm, ATAKO, specialized in transportation and shipping. It is found that, employees find their company honest and reliable for customers most while regard it unlikely to support developing/poor countries. Their salary, education, most influential factor to select their job and factor to change in their job most are found to be significant on their perception. The findings can be utilized in the sector to improve the companies' image, productivities and competitiveness.

Keywords–corporate social responsibility perception, ATAKO

INTRODUCTION

In today's world, economical concerns are not enough themselves for a company to be successful. The importance of social responsibility in business success increases each day. The concept of responsibility of enterprises towards the society is based on the ideas of Bowen who indicates that enterprises act and decide in accordance with the benefits and values of the society in which they are operating [1]. In the literature, there is a variety of definitions for the corporate social responsibility. For instance, according to Friedman, the social responsibility of enterprises means that the satisfaction of legal economic responsibilities of companies, [2]. On the contrary, McGuire [3], Davis [4], Stone [5], Carroll [6], Frederick [7] and many others argue that not only do enterprises have economic and legal responsibilities; they have also responsibilities towards the society beyond them.

Carroll [6] categorizes the social responsibilities into four groups as economic responsibilities, legal responsibilities, ethical responsibilities and discretionary responsibilities in the order of their relative magnitudes. Economical responsibilities indicate the balance between the enterprise's profit and costs they face to obtain this profit, [8]. Legal responsibilities can be handled in three ways: ethics, process and structure, [9]. Ethical responsibilities provide enterprises to operate in an ethical framework, [9]. Among discretionary responsibilities there are activities such as providing education that are conducted voluntarily, [10].

Özkol *et al*. (2005), [11], indicate that awareness of social responsibilities provides enterprises several opportunities such as increase in their brand and market values, increase in corporate learning and creativity, advantages to enter new markets and obtain customers' loyalty, assistance in providing better quality products and services, effectiveness in risk management and importance given by society and authorities on enterprises' opinions. According to Robins (2005), [12], the expectations of stakeholders, such as customers, employees, etc.., from enterprises and enterprises' responsibilities vary according to the development level.

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This study investigates the corporate responsibility perception of employees in ATAKO, which is the one of the largest transportation company in Turkey based on 57 participants selected through convenience sampling from employees that are working in ATAKO.

RESEARCH MODEL AND METHODOLOGY

This study investigates the corporate social responsibility perception of employees in ATAKO descriptively and effects of demographic characteristics of them on their perception based on convenience sampling of size 57. The questionnaire applied to collect data consists of two parts. First part is related to the demographic characteristics of the participants such as age, position in the company, department in which they are working, monthly salary, education level, marital status, number of children they have, experience level in the company, weekly hours they work, factor to select their job and the thing they want to change in their work. The second part is a 5-Likert scale developed in this study and inspired from "Perceived Corporate Social Responsibility Scale" by Swaen and Chumitaz (2008), [13], to evaluate the levels of agreements of participants on 18 items (Table 3) related to the corporate social responsibility. Participants indicate their level of agreements marking one of the options: 1:Absolutely disagree, 2:Disagree, 3: Neither agree nor disagree, 4:Agree and 5:Absolutely agree. The data collected are inputted into and analyzed by SPSS v22. First the demographical characteristics of the participants are analyzed descriptively. Later, the reliability of 18 items related to corporate social responsibility are measured through Cronbach's Alpha coefficient followed by a descriptive item analysis though frequency distributions of responses of participants to these 18 items. Finally the most agreed two items and the least agreed two items are analyzed in terms of effects of demographic characteristics of the participants through Fisher's Exact Tests as for all demographic factors there is at least one cell who has an expected count less than 5, [14]. For all tests, the significance levels are assumed to be $p<0,05$ or $p<0,1$.

FINDINGS

This section provides the results of study to reflect the corporate social responsibility perception of employees in ATAKO. First, demographic characteristics of the participants of this study are presented. This is followed by the reliability analysis of 18 items related to the corporate social responsibility and their descriptive item statistics.

Demographic Characteristics

In terms of their demographical attributes, the majority of the participants are aged between 21 and 30 (70,2%), have a position of worker (82,5%), work in other departments (49,1%), have a monthly salary of 1001-2000 TL (52,6%), have an undergraduate or graduate degree (45,6%), are single (56,1%), have 0-1 child (89,5%), have an experience of 0-3 years (57,9%), have 41 or more weekly working hours (63,2%), selected their jobs by their own will (68,4%) and want to change economic conditions most related to their job (59,6%).

Reliability and Item Analysis

The reliability analysis indicate that 18 items used in this study have an internal consistency of 0,917 where item no 5 needs to be removed as both it would increase the reliability and it has a corrected item-total correlation value of 0,191 i.e. less than 0,25 (Table 2). In table 2, the final results after the removal of item 18 are shown in parenthesis and bold. The new Cronbach's alpha value is found to be 0,926, thus, these 17 items can be regarded as highly reliable for evaluating corporate social responsibility of a company according to interpretation of this value by Özdamar (1997), [15]. Considering these 17 items, if one of them was deleted, the Cronbach's Alpha value would be between 0,918 and 0,927 indicating that all of these 17 items are necessary. Each of the corrected item total correlations of these items (indicated bold in Table 2) are greater than 0,25 now implying that all of these 17 items are related to each others.

Table 24. Demographic Characteristics of the Participants

Demographic Factors		**f**	**%**	**Cumulative %**
Age	21-30	40	70,2	70,2
	31 and above	17	29,8	100,0
Position	Worker	47	82,5	82,5
	Chief	6	10,5	93,0
	Manager	4	7,0	100,0
Department	Operations	14	24,6	24,6
	External Trade/Logistics	15	26,3	50,9
	Other	28	49,1	100,0
Salary	0-1000 TL	16	28,1	28,1
	1001-2000 TL	30	52,6	80,7
	2001 TL and above	11	19,3	100,0
Education	High School or below	14	24,6	24,6
	Associate Degree	17	29,8	54,4
	Undergraduate or above	26	45,6	100,0
Marital Status	Married	25	43,9	43,9
	Single	32	56,1	100,0
Number of Children	0-1	51	89,5	89,5
	2 and above	6	10,5	100,0
Experience	0-3 years	33	57,9	57,9
	4-7 years	16	28,1	86,0
	8 years and above	8	14,0	100,0
Weekly hours	0-40 hours	21	36,8	36,8
	41 hours and above	36	63,2	100,0
Factor for Selection	Own-will	39	68,4	68,4
	Others	18	31,6	100,0
What to change	Economic Conditions	34	59,6	59,6
	Others	23	40,4	40,4

Table 2. Item Total Statistics

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
I1	66,21 (**63,36**)	99,13 (**93,84**)	,640 (**,617**)	,912 (**,922**)
I2	64,98 (**62,14**)	98,62 (**93,08**)	,597 (**,590**)	,913 (**,923**)
I3	66,17 (**63,33**)	98,93 (**93,65**)	,569 (**,548**)	,914 (**,925**)
I4	65,33 (**62,49**)	95,65 (**90,07**)	,761 (**,761**)	,908 (**,918**)
I5	66,19 (-)	105,80 (-)	,191 (-)	,926 (-)
I6	65,26 (**62,42**)	100,19 (**94,42**)	,595 (**,599**)	,913 (**,923**)
I7	65,56 (**62,71**)	98,92 (**93,34**)	,637 (**,632**)	,912 (**,922**)
I8	64,71 (**61,87**)	101,59 (**95,82**)	,678 (**,680**)	,911 (**,921**)
I9	64,59 (**61,75**)	101,17 (**95,33**)	,620 (**,627**)	,912 (**,922**)
I10	64,57 (**61,73**)	103,35 (**97,30**)	,552 (**,572**)	,914 (**,923**)

I11	64,73 (**61,89**)	100,84 (**94,95**)	,605 (**,616**)	,913 (**,922**)
I12	64,91 (**62,07**)	100,33 (**94,31**)	,674 (**,695**)	,911 (**,921**)
I13	64,59 (**61,75**)	104,38 (**98,15**)	,479 (**,510**)	,915 (**,925**)
I14	65,03 (**62,19**)	96,74 (**91,12**)	,730 (**,732**)	,909 (**,919**)
I15	65,05 (**62,21**)	97,62 (**91,77**)	,675 (**,687**)	,910 (**,920**)
I16	64,68 (**61,84**)	99,64 (**93,49**)	,732 (**,764**)	,910 (**,919**)
I17	65,07 (**62,22**)	100,31 (**94,32**)	,638 (**,656**)	,912 (**,921**)
I18	65,89 (**63,05**)	100,77 (**95,55**)	,496 (**,469**)	,916 (**,927**)

Table 3. Items Descriptions

Item	Description
I1	ATAKO Company helps to developing countries.
I2	ATAKO Company supports to social and cultural activities (arts, sports) in the region.
I3	ATAKO Company develops projects for poor countries.
I4	ATAKO Company supports to human reasons with its hospitality.
I5	ATAKO Company reduces to consumption of natural resources.
I6	ATAKO Company applies to environmentally friendly transportations.
I7	ATAKO Company uses ecological transportation systems utmost.
I8	ATAKO Company respects to customers rights (after transportation services, warranty, assurance, information).
I9	ATAKO Company behaves honestly to its customers.
I10	ATAKO Company gives correct information to its customer about transportation terms and methods.
I11	ATAKO Company behaves well to workers regardless their gender, ethnicity and zone discriminations.
I12	ATAKO Company creates jobs.
I13	ATAKO Company operates suitable with valid laws and provisions.
I14	ATAKO Company saves its staffs rights.
I15	ATAKO Company helps to all of its staffs who want to get more education.
I16	ATAKO Company guarantees all of its staffs' health and safety.
I17	ATAKO Company İS respectful to Human rights in all of the countries where it operates.
I18	ATAKO Company does not operate in countries where human rights are violated.

Table 4. Items Analysis

Item	Absolutely Disagree		Disagree		Neither Agree Nor Disagree		Agree		Absolutely Agree		$\bar{X}$	SD
	f	%	f	%	f	%	f	%	f	%		
I1	3	5,3	18	31,6	25	8	8	14,0	3	5,3	2,82	0,92
I2	2	3,5	3	5,3	7	12,3	23	40,4	22	38,6	4,05	1,02
I3	4	7,0	19	33,3	19	33,3	11	19,3	4	7,0	2,85	1,04
I4	2	3,5	5	8,8	13	22,8	25	43,9	12	21,1	3,70	1,01
I6	0	0,0	5	8,8	16	28,1	23	40,4	13	22,8	3,77	0,90
I7	0	0,0	9	15,8	21	36,8	18	31,6	9	15,8	3,47	0,94
I8	0	0,0	2	3,5	2	3,5	29	50,9	24	42,1	4,31	0,71
I9	1	1,8	0	0,0	5	8,8	18	31,6	33	57,9	4,43	0,80
I10	1	1,8	0	0,0	1	1,8	25	43,9	30	52,6	4,45	0,70
I11	0	0,0	3	5,3	5	8,8	21	36,8	28	49,1	4,29	0,84
I12	0	0,0	3	5,3	6	10,5	29	50,9	19	33,3	4,12	0,80
I13	0	0,0	1	1,8	4	7,0	21	36,8	31	54,5	4,43	0,70
I14	0	0,0	5	8,8	12	21,1	18	31,6	22	38,6	4,00	0,98
I15	1	1,8	3	5,3	13	22,8	19	33,3	21	36,8	3,98	0,99
I16	1	1,8	1	1,8	2	3,5	26	45,6	27	47,4	4,35	0,79
I17	0	0,0	3	5,3	12	21,1	26	45,6	16	28,1	3,96	0,84
I18	4	7,0	6	10,5	32	56,1	8	14,0	7	12,3	3,14	1,00

Table 4 shows the corporate social responsibility perception of employees of the ATAKO Company based on their levels of agreements on 17 items related to a firm's social responsibility. It also displays the average level of agreement ($\bar{X}$) and standard deviation (SD) of 57 participants' responses out of 5 descriptively. According to average levels of agreements, the two items that are agreed most are I10 (ATAKO Company gives correct information to its customer about transportation terms and methods.) and I9 (ATAKO Company behaves honestly to its customers.) with averages of 4,45 and 4,43 respectively. The total percentages of participants that agree with these items (Absolutely Agree + Agree) are 96,5% and %89,5 respectively. The least agreed two items are I1 (ATAKO Company helps to developing countries.) and I3 (ATAKO Company develops projects for poor countries.) with averages of 2,82 and 2,85 respectively. The total percentages of participants that agree with these items (Absolutely Agree + Agree) are 19,3% and 26,3% respectively.

Hypothesis Tests

This section investigates effects of employees' characteristics (age, position in the company, department in which they are working, monthly salary, education level, marital status, number of children they have, experience level in the company, weekly hours they work, factor to select their job and the thing they want to change in their work) on two corporate responsibility items that are agreed the most (I10 and I9) and the least (I1 and I3). The results are demonstrated in Table 5-8.

Table 5. Effects of Demographic Factors on Levels of Agreement with I10

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Age	21-30	f	1	0	0	19	20	40
		%	2,5	0,0	0,0	47,5	50,0	100,0
	30 +	f	0	0	1	6	10	17
		%	0,0	0,0	5,9	35,3	58,8	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,394							
Position	Worker	f	1	0	1	20	25	47
		%	2,1	0,0	2,1	42,6	53,2	100,0
	Chief	f	0	0	0	3	3	6
		%	0,0	0,0	0,0	50,0	50,0	100,0
	Manager	f	0	0	0	2	2	4
		%	0,0	0,0	0,0	50,0	50,0	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 1,000							
Department	Operations	f	0	0	0	5	9	14
		%	0,0	0,0	0,0	35,7	64,3	100,0
	ExternalTrade /Logistics	f	0	0	0	8	7	15
		%	0,0	0,0	0,0	53,3	46,7	100,0
	Other	f	1	0	1	12	14	28
		%	3,6	0,0	3,6	42,9	50,0	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,926							
Salary	0-1000 TL	f	0	0	1	8	7	16
		%	0,0	0,0	6,3	50,0	43,8	100,0
	1001-2001 TL	f	1	0	0	13	16	30
		%	3,3	0,0	0,0	43,3	53,3	100,0
	2001 TL +	f	0	0	0	4	7	11
		%	0,0	0,0	0,0	36,4	63,6	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,732							
Education	High School or below	f	0	0	1	9	4	14
		%	0,0	0,0	7,1	64,3	28,6	100,0
	Associate Degree	f	0	0	0	5	12	17
		%	0,0	0,0	0,0	29,4	70,6	100,0
	Undergraduate or above	f	1	0	0	11	14	26
		%	3,8	0,0	0,0	42,3	53,8	100,0

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Marital Status	Married	f	0	0	1	9	15	25
		%	0,0	0,0	4,0	36,0	60,0	100,0
	Single	f	1	0	0	16	15	32
		%	3,1	0,0	0,0	50,0	46,9	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,404							
# of Children	0-1	f	1	0	1	22	27	51
		%	2,0	0,0	2,0	43,1	52,9	100,0
	2 +	f	0	0	0	3	3	6
		%	0,0	0,0	0,0	50,0	50,0	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 1,000							
Experience	0-3 years	f	1	0	1	15	16	33
		%	3,0	0,0	3,0	45,5	48,5	100,0
	4-7 years	f	0	0	0	7	9	16
		%	0,0	0,0	0,0	43,8	56,3	100,0
	8 years +	f	0	0	0	3	5	8
		%	0,0	0,0	0,0	37,5	62,5	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,977							
Weekly hours	0-40 hours	f	0	0	0	8	13	21
		%	0,0	0,0	0,0	38,1	61,9	100,0
	41 hours +	f	1	0	1	17	17	36
		%	2,8	0,0	2,8	47,2	47,2	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,771							
Factor to select	Own-will	f	0	0	0	16	23	39
		%	0,0	0,0	0,0	41,0	59,0	100,0
	Others	f	1	0	1	9	7	18
		%	5,6	0,0	5,6	50,0	38,9	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,091*							
t to chan	Economic Conditions	f	1	0	1	18	14	34
		%	2,9	0,0	2,9	52,9	41,2	100,0
	Others	f	0	0	0	7	16	23

	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,103							

		%	0,0	0,0	0,0	30,4	69,6	100,0
	Total	f	1	0	1	25	30	57
		%	1,8	0,0	1,8	43,9	52,6	100,0
	Fisher's Exact Test p = 0,088*							

* p<0.10, ** p<0.05, significant relationship

According to Fisher's Exact Tests conducted, for the corporate social responsibility perception of employees in ATAKO, the relationships between some of their demographic characteristics (the most important factor to select their job and the most important thing they want to change) and the levels of their agreements on the expression of "ATAKO Company gives correct information to its customer about transportation terms and methods." are found to be significant at the 90% confidence level. In detail, the proportion of employees that select their job by their own who agree (absolutely agree + agree) with this item is bigger than that of those who select their job due to other factors (100,0% and 88,9% respectively). Similarly, the proportion of employees that want to change the other factors related to their job most who agree (absolutely agree + agree) with this item is bigger than that of those who want to change economic conditions related to their job most (100,0% and 94,1% respectively). This may imply that ATAKO is considerably honest in its trade and the slight variation on this may be resulted from emotional behavior of employees without a merit judgment.

Table 6. Effects of Demographic Factors on Levels of Agreement with I9

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Age	21-30	f	1	0	4	15	20	40
		%	2,5	0,0	10,0	37,5	50,0	100,0
	30 +	f	0	0	1	3	13	17
		%	0,0	0,0	5,9	17,6	76,5	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,303							
Position	Worker	f	1	0	4	16	26	47
		%	2,1	0,0	8,5	34,0	55,3	100,0
	Chief	f	0	0	1	1	4	6
		%	0,0	0,0	16,7	16,7	66,7	100,0
	Manager	f	0	0	0	1	3	4
		%	0,0	0,0	0,0	25,0	75,0	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,840							
Department	Operations	f	0	0	0	4	10	14
		%	0,0	0,0	0,0	28,6	71,4	100,0
	ExternalTrade /Logistics	f	0	0	1	8	6	15
		%	0,0	0,0	6,7	53,3	40,0	100,0
	Other	f	1	0	4	6	17	28
		%	3,6	0,0	14,3	21,4	60,7	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,228							
Salary	0-1000 TL	f	0	0	1	6	9	16
		%	0,0	0,0	6,3	37,5	56,3	100,0
	1001-2001 TL	f	1	0	3	10	16	30
		%	3,3	0,0	10,0	33,3	53,3	100,0
	2001 TL +	f	0	0	1	2	8	11
		%	0,0	0,0	9,1	18,2	72,7	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,935							
Education	High School or below	f	0	0	1	5	8	14
		%	0,0	0,0	7,1	35,7	57,1	100,0
	Associate Degree	f	0	0	2	3	12	17
		%	0,0	0,0	11,8	17,6	70,6	100,0
	Undergraduate or above	f	1	0	2	10	13	26
		%	3,8	0,0	7,7	38,5	50,0	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,743							

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Marital Status	Married	f	0	0	1	6	18	25
		%	0,0	0,0	4,0	24,0	72,0	100,0
	Single	f	1	0	4	12	15	32
		%	3,1	0,0	12,5	37,5	46,9	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,231							
# of Children	0-1	f	1	0	5	16	29	51
		%	2,0	0,0	9,8	31,4	56,9	100,0
	2 +	f	0	0	0	2	4	6
		%	0,0	0,0	0,0	33,3	66,7	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 1,000							
Experience	0-3 years	f	1	0	5	9	18	33
		%	3,0	0,0	15,2	27,3	54,5	100,0
	4-7 years	f	0	0	0	7	9	16
		%	0,0	0,0	0,0	43,8	56,3	100,0
	8 years +	f	0	0	0	2	6	8
		%	0,0	0,0	0,0	25,0,	75,0	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,525							
Weekly hours	0-40 hours	f	0	0	2	7	12	21
		%	0,0	0,0	9,5	33,3	57,1	100,0
	41 hours +	f	1	0	3	11	21	36
		%	2,8	0,0	8,3	30,6	58,3	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 1,000							
Factor to select	Own-will	f	0	0	3	11	25	39
		%	0,0	0,0	7,7	28,2	64,1	100,0
	Others	f	1	0	2	7	8	18
		%	5,6	0,0	11,1	38,9	44,4	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	8,8	31,6	57,9	100,0
	Fisher's Exact Test p = 0,288							
What to change	Economic Conditions	f	1	0	2	11	20	34
		%	2,9	0,0	5,9	32,4	58,8	100,0
	Others	f	0	0	3	7	13	23
		%	0,0	0,0	13,0	30,4	56,5	100,0
	Total	f	1	0	5	18	33	57
		%	1,8	0,0	1,8	43,9	52,6	100,0

	Fisher's Exact Test p = 0,867

* p<0.10, ** p<0.05, significant relationship

According to Fisher's Exact Tests conducted, for the corporate social responsibility perception of employees in ATAKO, there is no significant relationship between their demographic characteristics and the levels of their agreements on the expression of "ATAKO Company behaves honestly to its customers." at the 90% confidence level.

Table 7. Effects of Demographic Factors on Levels of Agreement with I1

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Age	21-30	f	3	14	14	6	3	40
		%	7,5	35,0	35,0	15,0	7,5	100,0
	30 +	f	0	4	11	2	0	17
		%	0,0	23,5	64,7	11,8	0,0	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,315							
Position	Worker	f	3	13	21	7	3	47
		%	6,4	27,7	44,7	14,9	6,4	100,0
	Chief	f	0	4	1	1	0	6
		%	0,0	66,7	16,7	16,7	0,0	100,0
	Manager	f	0	1	3	0	0	4
		%	0,0	25,0	75,0	0,0	0,0	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,686							
Department	Operations	f	0	3	7	4	0	14
		%	0,0	21,4	50,0	28,6	0,0	100,0
	ExternalTrade /Logistics	f	0	7	6	2	0	15
		%	0,0	46,7	40,0	13,3	0,0	100,0
	Other	f	3	8	12	2	3	28
		%	10,7	28,6	42,9	7,1	10,7	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,339							
Salary	0-1000 TL	f	0	2	10	2	2	16
		%	0,0	12,5	62,5	12,5	12,5	100,0
	1001-2001 TL	f	3	12	9	6	0	30
		%	10,0	40,0	30,0	20,0	0,0	100,0
	2001 TL +	f	0	4	6	0	1	11
		%	0,0	36,4	54,5	0,0	9,1	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,054*							
Education	High School or below	f	1	1	10	2	0	14
		%	7,1	7,1	71,4	14,3	0,0	100,0
	Associate Degree	f	1	7	3	4	2	17
		%	5,9	41,2	17,6	23,5	11,8	100,0
	Undergraduate or above	f	1	10	12	2	1	26
		%	3,8	38,5	46,2	7,7	3,8	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,046**							

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Marital Status	Married	f	0	9	11	4	1	25
		%	0,0	36,0	44,0	16,0	4,0	100,0
	Single	f	3	9	14	4	2	32
		%	9,4	28,1	43,8	12,5	6,3	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,662							
# of Children	0-1	f	3	17	20	8	3	51
		%	5,9	33,3	39,2	15,7	5,9	100,0
	2 +	f	0	1	5	0	0	6
		%	0,0	16,7	83,3	0,0	0,0	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,472							
Experience	0-3 years	f	3	10	15	3	2	33
		%	9,1	30,3	45,5	9,1	6,1	100,0
	4-7 years	f	0	7	5	3	1	16
		%	0,0	43,8	31,3	18,8	6,3	100,0
	8 years +	f	0	1	5	2	0	8
		%	0,0	12,5	62,5	25,0	0,0	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,570							
Weekly hours	0-40 hours	f	0	6	9	5	1	21
		%	0,0	28,6	42,9	23,8	4,8	100,0
	41 hours +	f	3	12	16	3	2	36
		%	8,3	33,3	44,4	8,3	5,6	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,427							
Factor to select	Own-will	f	0	13	16	8	2	39
		%	0,0	33,3	41,0	20,5	5,1	100,0
	Others	f	3	5	9	0	1	18
		%	16,7	27,8	50,0	0,0	5,6	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,026**							
What to change	Economic Conditions	f	3	9	18	4	0	34
		%	8,8	26,5	52,9	11,8	0,0	100,0
	Others	f	0	9	7	4	3	23
		%	0,0	39,1	30,4	17,4	13,0	100,0
	Total	f	3	18	25	8	3	57
		%	5,3	31,6	43,9	14,0	5,3	100,0
	Fisher's Exact Test p = 0,059*							

* p<0.10, ** p<0.05, significant relationship

According to Fisher's Exact Tests conducted, for the corporate social responsibility perception of employees in ATAKO, the relationships between some of their demographic characteristics (monthly salary and the most important thing they want to change) and the levels of their agreements on the expression of "ATAKO Company helps to developing countries." are found to be significant at the 90% confidence level while the relationships between some other demographic characteristics (education and the most important factor to select their job) and their levels of agreements with this item are found to be significant at the 95% confidence level. In detail, as monthly income of an employee increases, the proportion of employees that agrees (absolutely agree + agree) with this decreases. Finally, the proportion of agreement (absolutely agree + agree) with this item is higher for those who wants to change other factors most in their job compared to those that want to change economic conditions related to their job most (30,4% and 11,8% respectively).

Table 8. Effects of Demographic Factors on Levels of Agreement with I3

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Age	21-30	f	4	13	12	7	4	40
		%	10,0	32,5	30,0	17,5	10,0	100,0
	30 +	f	0	6	7	4	0	17
		%	0,0	35,3	41,2	23,5	0,0	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,541							
Position	Worker	f	3	15	15	11	3	47
		%	6,4	31,9	31,9	23,4	6,4	100,0
	Chief	f	1	2	2	0	1	6
		%	16,7	33,3	33,3	0,0	16,7	100,0
	Manager	f	0	2	2	0	0	4
		%	0,0	50,0	50,0	0,0	0,0	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,667							
Department	Operations	f	0	3	6	4	1	14
		%	0,0	21,4	42,9	28,6	7,1	100,0
	ExternalTrade /Logistics	f	0	6	6	2	1	15
		%	0,0	40,0	40,0	13,3	6,7	100,0
	Other	f	4	10	7	5	2	28
		%	14,3	35,7	25,0	17,9	7,1	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,638							
Salary	0-1000 TL	f	0	3	6	6	1	16
		%	0,0	18,8	37,5	37,5	6,3	100,0
	1001-2001 TL	f	4	10	9	5	2	30
		%	13,3	33,3	30,0	16,7	6,7	100,0
	2001 TL +	f	0	6	4	0	1	11
		%	0,0	54,5	36,4	0,0	9,1	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,199							
Education	High School or below	f	1	1	5	7	0	14
		%	7,1	7,1	25,7	50,0	0,0	100,0
	Associate Degree	f	1	5	8	1	2	17
		%	5,9	29,4	47,1	5,9	11,8	100,0
	Undergraduate or above	f	2	13	6	3	2	26
		%	7,7	50,0	23,1	11,5	7,7	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,018**							

Demographic Factors			Levels of Agreement 1	2	3	4	5	Total
Marital Status	Married	f	0	10	8	5	2	25
		%	0,0	40,0	32,0	20,0	8,0	100,0
	Single	f	4	9	11	6	2	32
		%	12,5	28,1	34,4	18,8	6,3	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,467							
# of Children	0-1	f	4	15	18	10	4	51
		%	7,8	29,4	35,3	19,6	7,8	100,0
	2 +	f	0	4	1	1	0	6
		%	0,0	66,7	16,7	16,7	0,0	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,703							
Experience	0-3 years	f	4	9	10	8	2	33
		%	12,1	27,3	30,3	24,2	6,1	100,0
	4-7 years	f	0	8	5	2	1	16
		%	0,0	50,0	31,3	12,5	6,3	100,0
	8 years +	f	0	2	4	1	1	8
		%	0,0	25,0	50,0	12,5	12,5	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,630							
Weekly hours	0-40 hours	f	0	7	8	5	1	21
		%	0,0	33,3	38,1	23,8	4,8	100,0
	41 hours +	f	4	12	11	6	3	36
		%	11,1	33,3	30,6	16,7	8,3	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,636							
Factor to select	Own-will	f	0	14	13	9	3	39
		%	0,0	35,9	33,3	23,1	7,7	100,0
	Others	f	4	5	6	2	1	18
		%	22,2	27,8	33,3	11,1	5,6	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,055*							
What to change	Economic Conditions	f	4	11	10	8	1	34
		%	11,8	32,4	29,4	23,5	2,9	100,0
	Others	f	0	8	9	3	3	23
		%	0,0	34,8	39,1	13,0	13,0	100,0
	Total	f	4	19	19	11	4	57
		%	7,0	33,3	33,3	19,3	7,0	100,0
	Fisher's Exact Test p = 0,232							

* p<0.10, ** p<0.05, significant relationship

According to Fisher's Exact Tests conducted, for the corporate social responsibility perception of employees in ATAKO, the relationship between the most important factor to select their jobs and their levels of agreement on the expression of "ATAKO Company develops projects for poor countries." is found to be significant at the 90% confidence level. In detail, the proportion of employees that agree (absolutely agree + agree) with this higher in those who select their jobs by their own-will rather than other factors (30,8% and 16,7% respectively).

RESULTS AND DISCUSSION

This study is an exploratory and descriptive study for corporate social responsibility perception of employees in ATAKO, which is a leading and international company in transportation logistics with an experience more than

50 years, [16]. The 17 items evaluated for this are found to be highly reliable. The most and the least agreed two items are found to be: “ATAKO Company gives correct information to its customer about transportation terms and methods.”, “ATAKO Company behaves honestly to its customers” and “ATAKO Company helps to developing countries.”, “ATAKO Company develops projects for poor countries.” respectively. When the effects of demographic characteristics of employees on their levels of agreements with items are investigated through Fisher’s Exact Tests, it is found that employees’ salary, education level, the most important factor in selecting their jobs and the factor that they want to change most in their job are found to be significant in their corporate social responsibility perceptions. Age, position department, marital status, number of children, experience and weekly working hours are not found to be significant on their perception regarded to these 4 items at 90% confidence level.

This study handles the investigation of effects of demographic factors on the corporate social responsibility perception on the item basis. Further studies can conduct factor analysis for these 17 items and determine the dimensions of them with a larger sample. In addition, the similar studies can be conducted in other logistics firms whose main activities are transportation and shipping. This would provide comparative results for the sector.

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BUILDING BLOCKS OF IRON SILK ROAD AND SUGGESTIONS FOR TURKEY

Özlem Koçtaş Çotur[192], F. Onur Uysal[193]

Abstract *− To revitalize ancient Silk Road is a dream for not only former Soviet Union members but also China, Russia, and Turkey. The new Silk Road is called Iron Silk Road which is the railway connection between China and Europe. China has been heavily investing to create alternative rail transportation routes to dominate rail traffic across Eurasia. And Russia and Kazakhstan are spending great effort to have shares from these alternative routes. They both not only investing in new railroad infrastructure but also redesigning the transshipment processes to decrease transit time to gain competitive advantage. Turkey has a crossroad position and targets for being a railway hub. Turkey invests in a number of projects to strength its position, such as Marmaray and Baku-Tbilisi-Kars railway. The aim of the study is twofold, firstly explaining the current situation of Iron Silk Road and its ongoing endeavors and giving some suggestions for Turkey.*

Keywords − Baku-Tbilisi-Kars railway, Iron Silk Road, Marmaray, One Road One Belt Policy

INTRODUCTION

China is known as homeland of some important inventions, such as silk, paper, tea, porcelain, gunpowder, compass, printing and chemistry. Spreading these products and production methods across the world makes China a leading merchandiser since ancient times.

The route, which China and other Asian countries had used for “a hub of exchange of goods, culture and technology between East and West”, was called “Silk Road” [19].

The ancient “Silk Road”, was originated from China and was in use between third century B.C and fifteenth century A.D. [5]. Silk Road, was not a single route, instead of this, it comprised of several alternative land and sea routes [19].

The Silk Road, which named by Ferdinand von Richthofen in mid-1800s [5], was the main commercial route for the trade emanated from China to reach mainly Asia Minor (Today Turkey), Middle East and Persia (Today Iran). Camel caravans and some sea routes on the shores of Indian Ocean and Mediterranean Sea had used to reach western recipients.

The dynamics of Silk Road region’s trade had changed as a consequence of collapsing some empires and establishment of new ones; beginning of “The Age of Discovery” and the advent of new transportation modes, therefore, the Silk Road became obsolete for centuries.

Dissolution of former Soviet Union causes to born independent states such as: Kazakhstan, Turkmenistan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. These countries suffered some economic obstacles because of broken trade links during their adaptation to being independent. They located geographically distant in central Asia and this situation causes some degree of isolation of the region. Oil, gas and mining sectors has boosted several central Asian country, in spite of this transport costs are high because of crossing multiple land borders and the lack of opportunity to use maritime transportation. To overcome the negative effects of remoteness and strengthen links to the international markets, a transformation had needed in transportation infrastructure [19].

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Landlocked countries have primarily three options for transporting goods; rail, road and air, namely. Air transportation is the most expensive mode and not suitable for several type of freight. By comparison with the road transportation, rail transportation is cheaper in long distance; has better environmental and safety records [7] and more resistant to weather conditions. Consequently investing in rail transportation is the most effective option for landlocked countries.

The need of reviving legendary Silk Road is a shared wisdom for not only former Soviet Union members but also China, Russia, and Turkey. A mutually agreed belief within these countries is, 21st century Silk Road has to connect via railways. Because of this, the new Silk Road has named as "**Iron Silk Road**".

Iron Silk Road comprises of several existing rail route alternatives and ongoing ones between China and Europe as a whole. However there is no consensus between either in academia or in policymakers about the whole scope of Iron Silk Road. In this study it is accepted that, Iron Silk Road is any railway network connecting China and Europe via several alternative routes. Any of these routes aligning to connect China to Europe such as Trans-Asian Railway (TAR), Trans-Siberian Railway (TSR), Trans-China Railway, Baku-Tblisi-Kars (BTK) is a part of Iron Silk Road, are accepted as links of Iron Silk Road.

The scope of the study is revealing the steps taken by China, Russia, Kazakhstan, Turkmenistan, Iran and Turkey to revitalize the ancient Silk Road, or in today's context "Iron Silk Road", and finally sharing some suggestions for Turkey.

IRON SILK ROAD(S)

Although the ancient Silk Road is known as the route connecting Far East to Mediterranean Sea, the Iron Silk Road is now understood as the railway connection between China and Europe. Different than the ancient times, the new roads are mainly differentiated on the departure point in Far East. There are 3 frequently-used railway connections between Far East and Europe which are shown in Figure 1, Figure 2 and Figure 3 respectively.

Korea/Japan Route

Mainly supported by sea connections from South Korea, Shanghai and Japan. The distance from Vostochny Port (Russia) to Brest (the border terminal between Belarus and Poland) is 10090 km. 9500 km of the total route is in Russia, mainly using Trans-Siberian railway (+1300 km for Duisburg/Germany). This route thas the advantage of having only one break-of-gauge, but also is longer compared with the others [14].

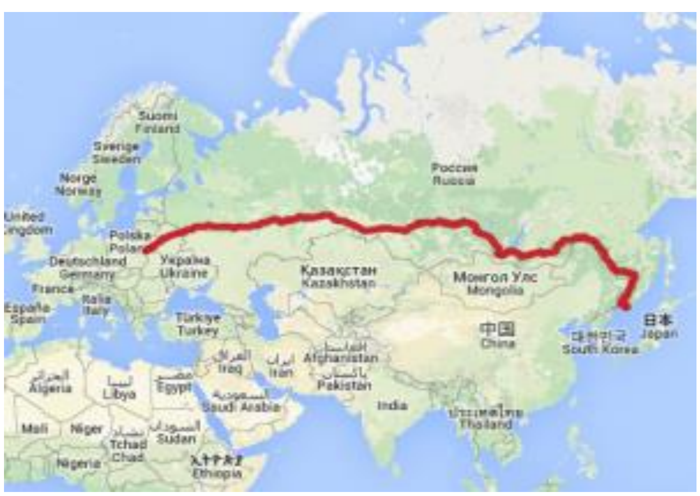

Figure 1. Korea/Japan Route Source: railturkey.org

North China Route

Mainly serving to northern regions of China (Changchun, Shenyang, Beijing etc). Route passes from China to Russia using the Manzhouli/Zabaikalsk border stations. There are two break-of-gauges on this route, between China-Russia and Belarus-Poland. The route is 8600 km from Changchun to Brest using again the Trans-Siberian railway. This route is mainly used for the Northeast China. Due to effective improvements especially in Trans-Siberian railway by Russian Railways, this route improved very fastly and got the biggest share in recent years [14].

Figure 2. North China Route Source: railturkey.org

West China Route

This route is mainly used by central regions (Chongqing etc) and north-west part (Urumqi etc) of China. The route used Dostyk border station in China/Kazakh border, and follows Kazakhstan, Russia and Belarus to reach to Brest border station of Belarus.

Similar to North China route, there are two break-of-gauges on this line. One is at China-Kazakhstan border. Other is at Belarus-Poland border. The distance to Brest is 5750 km from Urumqi (+3200 km from Chongqing). This route has been supported by China's "One Belt, One Road" program, which is also aiming to develop inner regions of China. Kazakhstan also heavily invested in improving the transit rail traffic which is helping this route to be competitive and faster. Thus, many of the new train services between China and Europe has selected this route to run on [14].

Figure 3. North China Route Source: railturkey.org

The trains running on these routes are generally organized by the consortiums of European, Russian and Chinese companies.

The routes are becoming even more efficient with the recently started eastward (from Europe to Far East) load flow. In 2014, 3 regular train services were announced to start, which will prevent trains running empty towards China [15].

Since the first trials from China to Europe in 2007, the train services become regular, more frequent and faster (15 days) in the following years. Trains are faster than sea and cheaper than air transport. Especially for the goods with a certain value, rail is the best solution. Especially electronic industry, retail and machinery sectors benefit from the rail advantages. Transit time for the speed train service is 14 days for Suzhou–Warszawa, 15 days for Suzhou–Hamburg and 16 days for Suzhou–Duisburg. The container traffic by rail between China and Europe reached to about 100 000 TEU in 2014 [22].

WHO IS DOING WHAT FOR IRON SILK ROAD?

China

The deep rooted tradition of trade might bring China its today's position in global economy. China is the world's biggest merchandise trader with imports and exports US $ 4,159 billion in total according to Word Trade Organization's (WTO) statistics in 2013 [26].

According to data provided by European Union (EU) trade statistics, trade from China to EU member countries is worth 302,579 million Euros. From EU to China is worth 164,730 million Euros, which is totally equals 467,309 million Euros. China is the ranked as top trading partner according to imports to EU [4]. The container traffic between China and Europe is worth approximately 20 million TEU (twenty foot equivalent unit) annually, and mainly has carried via maritime transportation [14]. However the share of rail transportation, which is also a "container friendly" transportation mode, between China and Europe is still in its infancy.

China's transportation system need to keep pace with economic growth of the country, thus several projects has been under development. China, as the trade leader of the Asia, elaborates existing transportation corridors thoroughly and develops projects to create alternative interconnected transport corridors across Eurasia. Intermodal accessibility is also an important issue to promote the expansion of underdeveloped regions of the country. Providing intermodal access to China's less developed western regions; greenfield maritime ports; fostering freight mobility and intermodal connectivity is essential to support global competitiveness of the country [20].

Maritime transportation has been using to connect from China to Europe predominantly over the years, which has approximately 90% share of China's foreign trade. However new diversified overland routes has needed between Asia-Europe for several reasons. Some problems has been occurred in land access to sea ports, which is encouraging to use intermodal solutions/rail connection; such as maritime traffic has been rising; risk of accidents increasing on ports and security problems might be occur.

China has been developing several arteries- not only to increase connectivity to Europe but also to promote economic integration via transportation corridors to reach Eurasian landmass and all its major peninsular extremities [6]. To ensure that, China has been launching a new concept called "One Belt, One Road" to revive ancient silk road again by using rail and maritime transportation instead of ancient Silk Road's camel caravans.

China's one of the main strategy is to become a policy maker in the integration process of Eurasia. To realize this, several steps has been taken by Chinese government. One of them is the establishment of Asian Infrastructure Investment Bank (AIIB) as a multilateral development bank to support infrastructure projects across Asia. The other is, the launch of One Belt One Road policy. The policy consists of two projects namely "the Silk Road Economic Belt" and "21st Century Maritime Silk Road" designed to tie 65 countries and 4.4 billion people together and to create prosperity and opportunities [6]. The policy is considered as a part of China's Greater Neighborhood Policy and has announced in 2013 [5]. According to plans of China, from the Atlantic to the Pacific region will be connected through The Silk Road Economic Belt.

The policy is not only to develop a large-scale regional strategy; "One Belt" involves nine regions, while "One Road" involves six regions of China; but also to enhance cooperation with neighboring economies. It is expected that the policy may result in a massive cross-border infrastructure development in countries located along the "belt" and the "road". To enhance regional connectivity by means of transportation, energy supply and telecommunication infrastructure Chinese companies has been promoting by government to invest in neighboring economies [10].

One belt is very similar to "Iron Silk Road" concept however China has developed "Economic Belt" policy to differentiate its vision from other Asian countries.

Russia

Russia is the main actor of China-Europe transportation network connection for land access. All three routes are passing through Russia, and Russian Railways was the first operator in region to improve its infrastructure and operations and get ready for fast and regular rail services.

Russian Railways (RZD) had set a road map for connecting east to west, not limited with transit traffic, but also to improve the economic ties within the country. One of the main targets of this road map was to run the freight on 9349-km-long Trans-Siberian railway in less than seven days, and in 2013 it's achieved. It must be noted that most of the improvements were not "infrastructure investments" but process improvements like decreasing the number and time for crew changes, locomotive changes and technical inspections [9]. Russian Railways also reorganized its systems for CIM (Uniform Rules Concerning the Contract of International Carriage of Goods by Rail) /SMGS (Agreement on International Goods Transport by Rail) common waybill (consignment note) to ensure seamless travel for rail freight transports between Europe, Russia and Asia all with a single freight document. CIM /SMGS consignment note combines the required CIM and SMGS contracts of carriage into one document [3] and simplifies the documentation and speeds up border crossings. All these efforts ended up with a 900 km daily speed which is faster than any other country in the region [9].

Russia's efforts on "silk road" is not limited with "Europe-China connection". Russian company Far East Land Bridge (FELB), which is running the biggest portion of container trains between China and Europe, is now getting prepared for a new container train between Suzhou (China) and Poti (Georgia). This train, if runs regularly as declared, may be the precessor of China-Turkey train, which will come very close to Turkish border and will provide truck connections to Turkey after Poti [24].

Kazakhstan

Kazakhstan is another country which succeeds in becoming an important player in transit cargo traffic between Asia and Europe. Kazakhstan Railways (Kazakhstan Temir Zholy-KTZ) has ambitious targets both to get more share from China-Europe traffic and create new traffic in north-south direction. Therefore Kazakhstan has been investing in new rail connections to change the dominance of Russian rail network [2]. Kazakh's investments include: increasing handling capacity of Dostyk (Kazakhstan-China border station) up to 25 million tonnes by the end of 2015; opening new railway border crossing at Khorgos; opening new free economic zones and terminals within the country and constructing 1500-km-long railway lines in east-west and north-south transport corridors [12].

Railroads were built to northward into Russia and it was almost impossible to travel along east-west direction of Kazakhstan without a stop in Moscow [8].

According to Kazakh's aforementioned targets several steps has been taken by KTZ. The opening of Zhezkazgan-Beyneu and Arkalyk-Shubarkol railway lines in 2014 was one of the biggest investments along Iron Silk Road. The Zhezkazgan-Beyneu connection will optimize current distance from the east to the west at least 1000 km for cargo transported from China to Caspian Sea [11].

Shubarkol – Arkalyk railway, which is located south-north direction provides a connection from central to northern Kazakhstan. That line may be an alternative route to currently used China-Russia-Europe connection via Astana [16].

According to the head of KTZ, start of the new railroads will not only give an impulse to development of the Central and Western Kazakhstan, but also will increase the transit potential of the trans Kazakhstan transport corridors passing from China in the direction of Russia and further Europe [11].Together with the rail connection to Turkmenistan which was opened early 2015, Aktau, Kazakhstan city at Caspian Sea, will be one of the most important railway hub in the region. These lines and Aktau Port now becomes the best alternative to host the China-Turkey services, if realized.

Kazakhstan's increasing capabilities and importance in Iron Silk Road fully fits the China's developing program for its western regions. Thus, Kazakhstan became the most critical partner for China in its "One Belt, One Road" program. Two countries had agreed on developing transport and logistics infrastructure, the expansion of cross-border power stations, building the supply chains with the establishment of dry ports, centers of distribution and consolidation of cargo flows [13].

Turkmenistan

Turkmenistan is trying to reduce its geographical isolation by expanding its railway network to its neighbors. The biggest railway investment in Turkmenistan in recent years was 700-km-long Gyzylgaya-Bereket-Etrek railway which connects Kazakhstan to Iran via Turkmenistan. The connection will shorten the route by 400 km, and reduce freight transport time from 45-60 days at present to 25-30 days. This new line is expected to the transport corridor for 13 million tons of grain of Kazakhstan to Persian Gulf countries [21].

Turkmenistan's another important effort is for Turkmenistan-Afghanistan-Tajikistan rail line project (TAT). Turkmenistan may benefit from connecting these "no-railway" regions to Caspian Sea, and to Black Sea and Turkey via Azerbaijan and Georgia. Thus, Turkmenistan Government is giving priority to this project [18].

Turkmenistan is willing to be the main link of Central Asia to Black Sea (and to Turkey after Baku-Tbilisi-Kars railway completed), thus constructing a huge port at Turkmenbashi which will provide huge capacity for intermodal and rail transportation [25].

Iran

Iran had declared its interest in increasing transit loads. Iran is willing to be the main link to ports for landlocked Central Asian countries. This will provide Iran to transport and handle the huge amount of exports of especially Kazakhstan. Additionally, Iran is expecting to reduce the effects of sanctions with this strategy.

The new connection to Turkmenistan and Kazakhstan, opened last year, was an important step to realize these expectations. Uzen-Bereket-Gorgan Railway may be the main connection of Kazakhstan and Turkmenistan to Persian Gulf ports.

Iran is also working on new rail connections to Azerbaijan, Armenia and Iraq. Iran is expecting to earn 285 million USD annually from rail fees of transit loads by the completion of the project. Iran also declared that country will be more active about transit loads and may review transit tariffs [25].

Turkey

Turkey has a unique strategic position for not only locating in Both Asia and Europe, but also connecting the continents via its to bridges and Marmaray under sea railway tunnel.

Turkey is also one of the countries in the region with ambitious targets about international railway traffic and investing for these targets.

Marmaray, is the biggest investment of Turkey for connecting Europe to Asia. “The continuous rail connection from United Kingdom to China is now possible” was the main motto in the opening ceremony of Marmaray, and the project was presented as the realization of Iron Silk Road. Marmaray will enable a continuous run of trains between Europe and Asia via Turkey, which otherwise have to be (and currently are being) transshipped by rail ferries running between Tekirdag and Derince. Although the frequent passenger service through Marmaray tunnel is not allowing any freight train to cross during day, Turkish State Railways (TCDD), is planning to allow freight trains run after mid-night. This will be only possible by the completion of second phase of Marmaray Project, which is expected by the end of 2016.

Although the trains are able to cross Europe to Asia (and vice versa) by Tekirdağ-Derince rail ferry and can reach to Central Asia and China via Iran, all expectations seem to be built on Marmaray and Baku-Tbilisi-Kars (BTK) railway. TCDD is expecting to boost its transit and international rail traffic –which is now very small among neighborhood- after the completion of these two projects.

Marmaray will ease, speed up and encourage the usage of terminals in Asian side and even further transport to Middle East. Today, most of the trains coming from Europe, stop at the European side terminals (Cerkezköy, Tekirdağ) and trucks are used for further transport. Usage of rail ferries means additional costs, longer transit times and uncertainty. Some of the freight trains can bear with these, but surely none of the passanger trains could. Thus, travel from Europe to Asia by train should wait Marmaray (or the ongoing 3rd Bosphorus Bridge with railway line).

The other important project of Turkey for “Iron Silk Road” is Baku-Tbilisi-Kars railway project. This line will be the first rail connection to Georgia and Azerbaijan, but be an alternative link to other CIS (Commonwealth of Independent States) countries such as Kazakhstan, Turkmenistan, Uzbekistan and China, since there is already a rail connection via Iran. This project involves modernization of 721-km-long railway line from Baku (Azerbajian) to Akhalkalaki (Georgia) and construction of 105-km-long new line from Akhalkalaki to Kars. The modernization works have already been completed and the project is now waiting for the construction of the last 105 km which is being done and funded by Turkish Government. This project is announced to be completed by the end of 2015 [23].

The BTK project is built to create an energy corridor by rail mainly supplied by Azerbaijan. In addition to that, the current traffic from Turkey to CIS countries will shift to this line. Since current traffic via Iran is facing with long delays in Van Lake and Saraks, opening of this line may cause a shift to railway. The line is expected to have an annual volume of 6,5 million tonnes at the beginning. Target is 17 million tonnes/year in long term [23].

Opening of BTK railway will surely be a better and faster way to connect to China. The alternate way via Iran means dealing with sanctions, crossing many countries, stoppage at each border [17]. Countries of Central Asia also invest for further connections and expect to have share from this route. As aforementioned before, Kazakhstan has just completed a west-east rail connection which may be a strong alternative for connection Turkey to China via Caspian Sea [16].Turkmenistan is constructing a huge port at Turkmenbashi which will support intermodal transport through Caspian Sea to Turkey. Even Afghanistan with almost no rail network has also announced interest in this project.

One the most important expected effect of the BTK is to finish Russian rail domination in Caucasus [1].

Although Turkey’s two projects have full support from the government, completion of both projects has been postponed many times due to several reasons. Marmaray’s second phase was planned to be completed by 2015 summer, but all construction works stopped for more than one year. Then a new plan with a deadline of end of 2016 was announced, but no improvement is seen since then.

BTK railway has not better performance. The construction works stopped last year, and no improvement is seen since then. The modernization of lines in Georgia and Azerbaijan had been completed and a test train already ran, so project is waiting for completion of the part under the responsibility of Turkey. Construction works were scheduled for the first half of 2015, but not realized. So the deadline for Baku-Tbilisi-Kars railway to be fully commissioned, which is end of 2015, may be postponed again.

Suggestions for Turkey

To boost Turkey’s rail share for transit cargo across Iron Silk Road some propositions are given below.

1. Turkey should start to use CIM/SMGS common consignment note, same as Russia, to connect European and Asian countries seamlessly.
2. Baku-Tbilisi-Kars project is one of the important project for not only to the Turkey, Azerbaijan and Georgia, but also all neighborhood region likewise China. Turkey should speed up the construction as soon as possible.
3. Determining transit time targets for container trains running in Turkey and following them to proof the reliability of the rail service.
4. Investing in container transshipment terminals on the transit corridor of Turkey and Georgia (Akhalkalaki, Kars, Sivas, Kayseri, Eskisehir, Köseköy) to ease the transshipment of inter-regional cargo. To assess the performance of the terminals, KPIs (Key performance Indicators) should be determined in terms of cost, service times, capacity, and professional management.
5. TCDD and Turkish government should cooperate with logistics companies who are interested in giving rail services on Iron Silk Road route via signing SLAs (service level agreements) with them.
6. Turkish government should subsidize projects/block trains on Silk Road via discounts for a period of time to support entering costs of Iron Silk Road projects.
7. To ensure connectivity to ports, government and private sector should invest in branch lines to connect ports to main line which can be integrated with Silk Road services.
8. Enabling of using of CIS wagons by changing the axles within Turkey to ensure interrupted journey between CIS countries.

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ENERGY EFFICIENCY ANAYLSIS: MERSIN FREE TRADE ZONE EXAMPLE

Mehmet Miman[194], *Köksal Hazır*[195], *Linda Küçük*[196], *Edvar Mum*[197]

Abstract − In today's competitive and global environment, it is very important to utilize energy efficiently with a limited fossil fuels such as petroleum, natural gases and coals. This importance are magnified considering that the energy is a major input for most of the economic activities, hence, contributes to the improvements of a living standards of a society, and sustainable development. In this study, energy intensities of a small and medium sized companies from a variety of sector in Mersin Free Trade Zone are analyzed using the most recent 5 years data and the trends in energy efficiencies of each sector are determined descriptively. The results highlight the need for precautions to improve energy efficiencies and productivity as the findings indicate that the energy intensities appear to have an increasing pattern after 2012.*

Keywords − energy efficiency, energy intensity, Mersin Free Zone

INTRODUCTION

As a one of the most important inputs for economic and social development, energy plays significant role for a society to have high level of living standards and a sustainable development. Todays, although the need for energy increases considerably, limited energy recourses, especially fossil ones, requires organizations, and countries to use energy efficiently. For example, Small Scall Industry (SSI)in India finds itself in a competitive environment where enhancement of its competitiveness is considered crucial for its survival and growth, [1]. Improving energy efficiency can be an important strategy for enhancing competitiveness, especially for energy-intensive SSI, [2]. One of the most widely used measures for energy efficiency is energy intensity. In general, the ratio of energy input to industrial output can be regarded as an indicator of industrial energy intensity, which are often used as a basis for policy decisions, [3]. From the perspective of a strict technical view, energy efficiency can be interpreted as a measure of useful energy output compared to energy input, [4]. Energy intensity can be Energy intensity can be measured at the individual industry or activity level, at a regional or national level, or on a global average basis, [5]. In general, energy intensity is measured as energy in TOE (ton of oil equivalent) used per revenue in 1000 USDs generated, [6]. International Energy Agency defines the ton of oil equivalent as one metric ton of crude oil having a net calorific value of 10 Gcal (=41,9 GJ), [7]. In general, the smaller the energy intensity a company has, the more efficient it operates in terms of energy.

This study investigates the energy efficiencies of small and medium sized enterprises from a variety of sectors including food, health, textile and iron and steel for the most recent 5 years (2010-2014) in Mersin Free Trade Zone through the descriptive illustrations of their energy intensities. Therefore, it is aimed to point out the trends in energy efficiencies by sectors. Free Zones are special chosen economic regions towards exports where the regulations or limitations necessary for foreign trade are partially or completely invalid. In Turkey, free zones can be established according to Free Zones Law (Law No: 3218) that was published in The Official Gazette on 15.06.1985. Mersin Free Zone was established on 3 January 1985 as the pioneer of today's free zones and have an area of 786,000 m2. In Mersin Free Zone, there are total 668 companies, 536 of which are domestic and 132 of

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which are foreign. 4252 personnel are totally employed in the free zone. Among the operating sectors of the firms in the zone, there are tobacco, textile, chemistry, petroleum, machinery, spare parts, health and so on, [8].

RESEACRH METHODOLY AND FINDINGS

To investigate the trends of energy intensities, taken as a ratio of energy usage (in TOE) to the output revenue (in thousands of dollars), over years (2010-2014) for sub-sectors of productions (food, textile, health, iron and steel) in Mersin Free Trade Zone, a sample of 11 firms are selected through the convenience sampling. Their revenues over the years and the electricity usage in KWh are obtained through the Directorate of MESBAŞ, operating company of the free zone. The revenues of companies for each year are converted to the dollar using that year's average dollar exchange rate, while the conversion of energy usage from KWh to TOE is achieved through the conversion coefficient of 0,000086. For the food sector, 5 companies' and overall energy intensities; for the health sector 3 companies' and overall energy intensities; for the textile sector, 2 companies' and overall energy intensities; for the iron and steel sector one company's energy intensity are valuated. Table 1-8 presents the data, yearly energy usage in TOE and revenues in detail, obtained to compute the energy intensities for the mentioned sectors.

Table 25. Energy Usage by Food Companies in TOE over years

	Energy Usage in TOE				
	2010	2011	2012	2013	2014
Company 1	9,06	23,50	25,58	37,05	40,38
Company 2	124,64	160,38	381,69	315,77	314,84
Company 3	0,95	25,97	20,44	20,88	9,65
Company 4	10,08	9,23	6,06	9,98	15,27
Company 5	4,52	4,27	2,98	5,71	10,12
Overall	149,25	223,35	436,75	389,39	390,26

Table 1 indicates that, for overall food sector as well as on the individual company bases, the energy consumption increases as time passes.

Table 2. Revenues generated by Food Companies in USD over years

	Revenues generated in $				
	2010	2011	2012	2013	2014
Company 1	8.936.912,29	5.899.685,85	13.461.676,17	16.751.217,82	16.804.984,21
Company 2	50.841.618,67	39.191.807,13	64.995.659,23	55.410.855,85	51.337.887,39
Company 3	1.366.011,41	4.304.591,37	3.908.661,50	4.839.727,41	3.898.702,19
Company 4	3.505.901,318	2.497.305,617	3.507.997,932	2.522.570,801	3.632.273,441
Company 5	272.069,47	292.235,97	228.914,87	234.410,35	515.294,46
Overall	64.922.513,16	52.185.625,94	86.102.909,69	79.758.782,23	76.189.141,70

Table 2 indicates that, over the years yearly generated revenues have different patterns according to companies. Though, it can said that after 2012 overall revenue generated by the food companies have a declining pattern.

Table 3. Energy Usage by Health Sector in TOE over years

	Energy Usage in TOE				
	2010	2011	2012	2013	2014
Company 1	48,72	75,22	102,89	99,01	123,86

Company 2	178,26	241,49	227,96	216,72	200,47
Company 3	332,78	349,98	364,47	425,28	655,93
Overall	559,76	666,69	695,32	741,01	980,26

Table 3 indicates that, in general for overall health sector as well as on the individual company bases, the energy consumption increases as time passes.

Table 4. Revenues generated by Health Sector in USD over years

	Revenues generated in $				
	2010	2011	2012	2013	2014
Company 1	4.839.679,94	5.663.926,51	5.623.227,27	5.532.794,96	5.387.691,46
Company 2	9.304.029,88	16.880.258,82	7.884.662,52	7.131.514,31	6.133.311,20
Company 3	8.171.136,21	10.000.070,25	7.235.694,13	8.447.784,15	8.264.515,37
Overall	22.314.846,04	32.544.255,58	20.743.583,91	21.112.093,42	19.785.518,03

Table 4 indicates that especially after 2013 revenues generated by food sector have a declining pattern.

Table 5. Energy Usage by Textile Companies in TOE over years

	Energy Usage in TOE				
	2010	2011	2012	2013	2014
Company 1	26,94	23,47	24,14	14,31	15,01
Company 2	60,76	53,11	25,17	31,08	29,23
Overall	87,70	76,57	49,30	45,39	44,24

Table 5 indicates that, for overall textile sector as well as on the individual company bases, the energy consumption have a tendency to decline after 2012.

Table 6. Revenues generated by Textile Companies in USD over years

	Revenues generated in $				
	2010	2011	2012	2013	2014
Company 1	1.436.024,74	1.283.937,06	1.100.281,41	1.264.927,62	959.541,00
Company 2	8.564.981,19	7.146.204,47	5.219.603,13	1.843.129,34	1.489.352,88
Overall	10.001.005,93	8.430.141,53	6.319.884,54	3.108.056,96	2.448.893,88

Table 6 indicates that for overall textile sector as well as on the individual company bases, revenues generated have an decreasing pattern between 2010-2014.

Table 7. Energy Usage by Iron-Steel Sector in TOE over years

	Energy Usage in TOE				
	2010	2011	2012	2013	2014
Company 1 (Overall)	86,75	209,44	206,19	201,52	268,56

Table 7 indicates that, in general for overall iron-steel sector, the energy consumption increases as time passes.

Table 8. Revenues generated by Iron-Steel Sector in USD over years

	Revenues generated in $				
	2010	2011	2012	2013	2014
Company 1 (Overall)	23.365.311,9	57.090.971,82	43.975.036,4	35.730.334,81	42.538.727,87

Table 8 indicates that revenues generated in iron-steel sector fluctuates by years.

Figure 1,2 demonstrates the overall energy usage (in TOE) and revenues generated (in USD) respectively over the years by each of the sectors that are in consideration of this study.

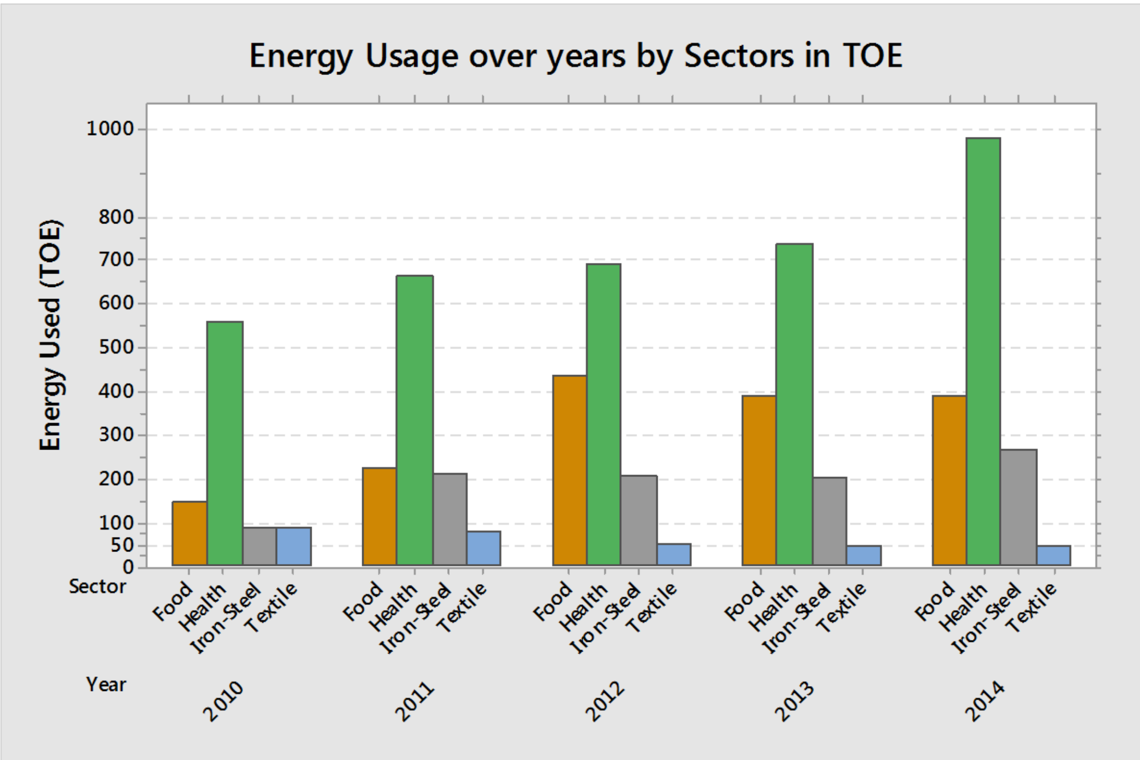

Figure 26. Overall Energy Usage by each Sector

When overall energy usages of each sector are compared, as displayed in Figure 1, the most energy-consumed sector is found to be health sector, which is an increasing pattern over the years while the least energy-consumed sector is found to be textile, which is a decreasing pattern over the years.

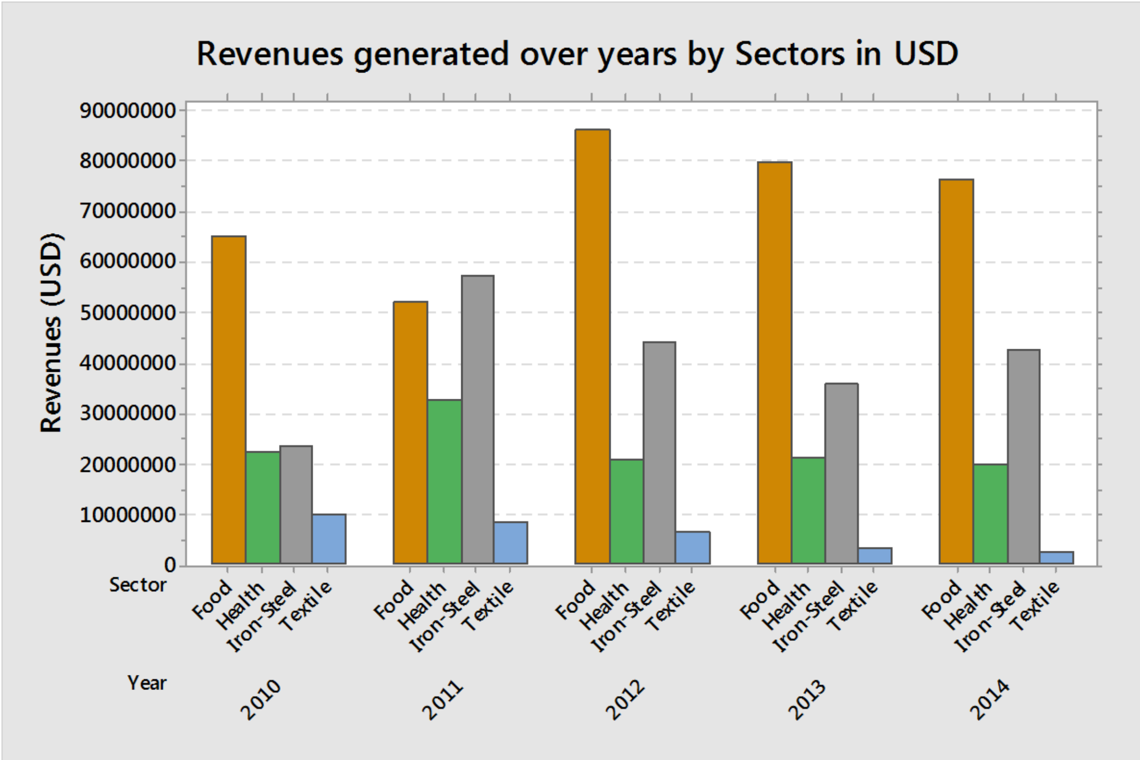

Figure 2. Revenues generated by each Sector

When overall revenues generated by each sector are compared, as displayed in Figure 2, the highest revenues are generated by food sector, while lowest revenues are generated by textile sector.

Note that the above results are limited with the limited data, which could be obtained for this study. To get better ideas of each sector, as well as more reasonable and appropriate comparisons of sectors, energy intensities are computed and tabulated as in Table 9.

Table 9. Energy Intensities of Sectors over years

Sector		Number of Employees	Energy Intensity (TOE/thousands of dollars)					
			2010	2011	2012	2013	2014	Reference in 2001*
Food	Company-1	48	0,0010	0,0040	0,0019	0,0022	0,0024	0,0050
	Company-2	36	0,0025	0,0041	0,0059	0,0057	0,0061	0,0050
	Company-3	43	0,0007	0,0060	0,0052	0,0043	0,0025	0,0050
	Company-4	18	0,0029	0,0037	0,0017	0,0040	0,0042	0,0050
	Companu-5	14	0,0166	0,0146	0,0130	0,0243	0,0196	0,0050
	Overall		0,0023	0,0043	0,0051	0,0049	0,0051	0,0050
Health	Company-1	184	0,0101	0,0133	0,0183	0,0179	0,0230	-
	Company-2	66	0,0192	0,0143	0,0289	0,0304	0,0327	-
	Company-3	229	0,0407	0,0350	0,0504	0,0503	0,0794	-
	Overall		0,0251	0,0205	0,0335	0,0351	0,0495	-
Textile	Company-1	122	0,0188	0,0183	0,0219	0,0113	0,0156	0,0290
	Company-2	256	0,0071	0,0074	0,0048	0,0169	0,0196	0,0610
	Overall		0,0033	0,0037	0,0029	0,0037	0,0034	-

Iron-Steel	Company-1 (Overall)	191	0,0037	0,0037	0,0047	0,0056	0,0063	0,0140

* The data is taken from Narin, 2006, [6].

The information presented in last column of Table 9 is based on the Narin, 2006, [6], who provides energy intensities of a variety of sectors and for a different scale (small, medium, large…) companies. This information can help this study how the sectors has changed in terms of their energy efficiencies since 2001. According to Table 9, the food sector has an increasing overall pattern for the energy intensity between 2011-2014, hence, the energy efficiencies of individual companies, as well as overall sector, apparently get worse. Though, it is still very closed to that observed in 2001. The same increasing pattern is also available for the health sector. In terms of textile sector, there are fluctuations in energy efficiencies over years. In terms of individual company that participated this study, energy intensities on the company bases are found to be improved after 2001. For the iron-steel sector in Mersin Free Zone, the energy efficiency of the sector has gotten worse after 2011, though it is still well beyond the value observed in 2001. Figure 3 demonstrates the overall energy intensity changes in each sector for the purpose of comparisons.

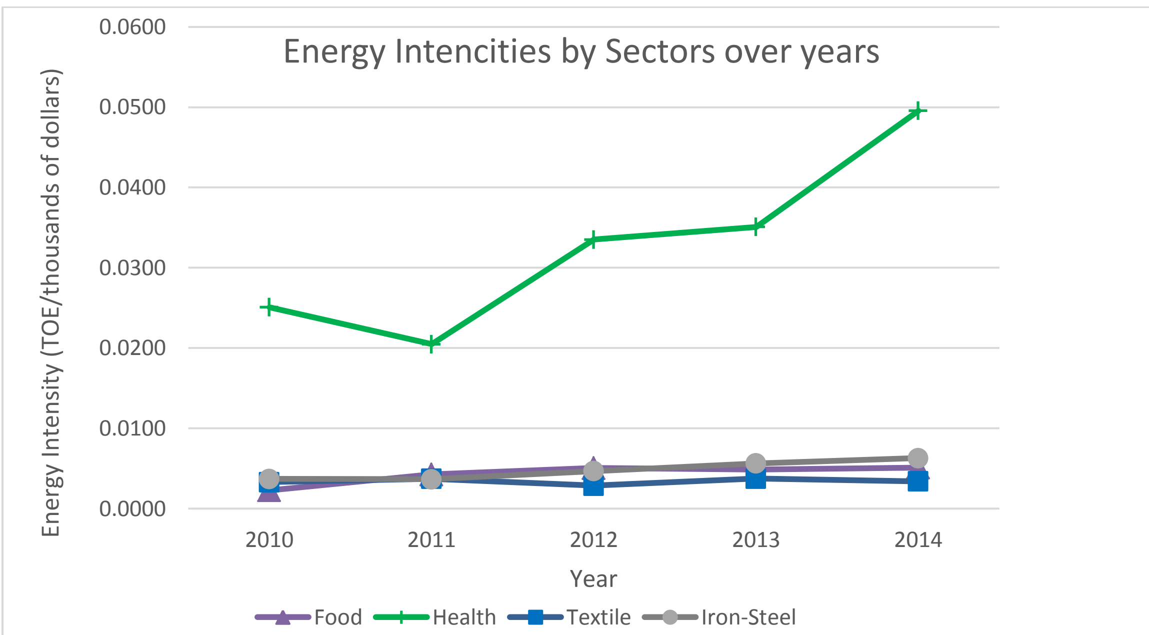

Figure 3. Energy Intensity by each Sector over years

According to Figure 3, the most efficient sector appears to be textile, while the least efficient sector appears to be health. Also, it is worthwhile to note that after 2011-2012, the energy efficiencies of all sectors have worsen.

RESULTS AND DISCUSSION

This study is an exploratory and descriptive study for the Mersin Free Trade Zone in investigation of energy efficiencies of companies from a variety of sectors and that operate in the free zone based on their energy intensities evaluated through the most recent 5-year data of their energy usage and revenues. The results indicate that the most energy-efficient sector is textile while the least energy-efficient sector is health. Also, overall it is noteworthy to emphasize that energy efficiencies has worsen after 2011-2012 for all of the sectors. Though, they are still better compares to situations in 2001, which are reported by Narin, 2006, [6]. Reflecting the most recent position of companies for a variety of sectors in the free zone as well as the trends in their energy efficiencies, the study can be regarded as a pioneer one for free zones.

However, the preliminary results presented by this study needs to be verified using a greater sample in the free zone. The similar studies based on this preliminary one can be conducted in other free zones and the results can be compared. Moreover, same methodology presented here can be applied for other sectors and other scale companies to get a better picture of production industry in terms of energy efficiency in attempts to determine the areas that require improvements. This is very important for the current competitive and global age with limited energy resources.

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THE PRESENT AND FUTURE OF AIR TRANSPORT MARKET IN THE TOURISM DESTINATIONS: THE COMPARISON OF IZMIR AND ANTALYA BASED ON TIME SERIES FORECASTING MODEL

İlhan Atik[198], *Ömer Bıyıklı*[199]

***Abstract*−** *As incomes and populations have increased and the structure of industry has changed, air transportation has grown considerably around world. A long-term forecast of the air transportation is crucial regarding the precautions that will be taken in the future. It is also an essential input for an investment planning. Strong traffic momentum since the sector deregulation in Turkey passenger numbers have risen at an approximately CAGR (Compound Annual Growth Rate) of 16% between 2003 and 2013, which means three times the real GDP (Gross Domestic Product) growth in the same period. We believe that Turkey's geographically advantageous position, increasing attractiveness as a tourism destination, and the government's supportive approach to the sector are the secular reasons for this average growth. In the field of air transportation forecasting, there are a number of empirical models, which can be classified as judgemental, causal and time series. Time series forecasting is an important area of forecasting in which past observations of the same variable are collected and analyzed to develop a model describing the underlying relationship. The model is then used to extrapolate the time series into the future. In this study, forecasting models for time series are reviewed. Aircraft and passenger statistics between 2007-2014 years in Izmir and Antalya are gathered and used to construct forecasting models for each quantity.*

***Keywords*−** *Turkish air transport market, time series, forecasting*

1.INTRODUCTION

Tourism supply is a complex phenomenon in terms of both the nature of the product and the process of delivery. It involves a number of elements that constitute tourism supply; there is a strong dependence on natural resources and historical and cultural sites; tourism activity (often) has a seasonal character; and consumers need to move towards the product. Despite its complexity, tourism is an economic activity and can be analysed using the new economic geography models. These models integrate the factor of the location of economic activities and take account of the costs of transport and the role of spatial competition [1].

The conventional view of tourism investment is that it can be a driver of economic growth and development, and has significant potential for poverty alleviation. In developing country contexts, tourism can provide a major source of new off-farm income in rural areas and help bridge inequalities between overpopulated urban areas and rural areas.

An increase in tourism demand can stimulate increased output from tourism-related sectors through direct, indirect and induced impacts where links between the tourism sector and other economic sectors exist. Where these linkages are strong, the well publicized and often misused, multiplier effects of tourism investment arise [2]. Direct impacts can include: employment generation, skill creation, higher wages, and new or improved access to basic services and infrastructure, while indirect channels include price and demand effects for land and local products including agriculture and food/beverage processing [3].

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Also, It is generally accepted that air transport demand is closely related to GDP and this is confirmed by the income elasticities that have been found from studies carried out around the world. While much of the past growth in air transport has been associated with business travel, more recently there has been a rapid expansion of tourism. This has resulted from both high income levels and more leisure time and also from lower transport costs [4].

Air transportation provides some social and economic advantages that other transport modes could. In addition, air transportation enables the accessibility to distant destinations safely and swiftly. On account of the developments in electronical communication era, including especially the Internet, worldwide trading has increased. The need for a safe and secure delivery service has expedited air transportation of cargo. Goods, equipments and staff have achieved a dynamism of accessing every destination world wide within 24 hours thanks to air transportation [5]. There is ample evidence that evolution of modern tourism has been closely related to the economic activity. A large population of tourist trips, particularly of long distance tourism, is by air transport. This is the only mode that permits long-distances tourism to be a tractable leisure option for most potential tourists.

Aviation sector provides an invaluable contribution to the development of the countries in the aspect of employing youth, increasing export of goods and service. In this context, a research conducted for IATA (International Air Transport Association) has revealed that aviation sector has provided an employment opportunity for 6.7 million people in 22 European countries and 200 billion USD of income. According to another research conducted in the USA, planning a flight to London from an American city will have a contribution of 268 million USD to the US local economy for the first year. It is also revealed that Chicago Airport has provided a job opportunity for 420 - 510 thousand people and a passenger flying to international destinations has contributed five times more (2310 USD) than a passenger flying domestically [6]. Besides, according to some research carried out in Europe, an increase of 1000 passengers for an airport provides a job opportunity for about 4 people [7].

Accurate forecasts of the air transportation is crucial regarding the precautions that will be taken in the future. The present study, which is based on domestic and international aviation statistics of 2007-2014, argues for the comparison of selected Turkish cities Izmir and Antalya for future of air transport market (2015-2019) based on time series forecasting model. It involves a comparison of the development that was made in the air transportation in the two largest cities of Turkey, namely, Izmir and Antalya as well as in Turkiye overall for a period covering the years 2007–2014. In addition, thanks to the time series forecasting model to be proposed here, some projections and predictions regarding the period of 2015–2019 will be put forth. The results obtained here will ultimately be able to give a certain guidance to the planners and the policy makers.

2. STATISTICAL MODELS FOR FORECASTING

In general, there are two groups of methods for air transport demand forecasting, one is qualitative and the other is quantitative. ***Qualitative methods,*** e.g. market surveys, Delphi method and expert meetings, etc. analyze the characteristics of the air transport market to determine empirically how the usage of an airport varies across different sectors of the population. ***Quantitative methods,*** usually establish mathematical forecasting models based on historical statistical data. Since the latter are more objective and precise, they have drawn more and more attentions. According to the difference of quantitative forecasting methods, they can be divided into three categories; time series, causal analysis and combination forecasting [8].

Time series forecasting is an important area of forecasting in which past observations of the same variable are collected and analyzed to develop a model describing the underlying relationship. The model is then used to extrapolate the time series into the future. This modeling approach is particularly useful when little knowledge is available on the underlying data generating process or when there is no satisfactory explanatory model that relates the prediction variable to other explanatory variables [9].

Time series methods, establishing a mathematical model only by historical data, include Second-Degree Polynomial [10], ARIMA/SARIMA [11], [12],[13], Logit Model [14], Gravity Model [15], Exponential Smoothing [16], Gray Theory [17], [18], which is multidisciplinary and generic theory that deals with systems characterized by poor information and/or for which information is lacking, Fuzzy System Method [19], Holt-Winters, etc. Alekseev and Seixas (2009) [20]. developed a hybrid approach based on decomposition and back-propagation neural network (BPNN) for air transport passenger analysis. Time series methods assume that all the factors that determined the development of demand in the past, will continue to operate in the same way in the future [21]. Although there are a number of studies which claim better forecasting performance than the other comparative methods, however, there is no method performing best across all scenarios. The optimal choice depends on both the time series characteristics like volatility or existence of long-term trends and the forecasting horizon.

3. MATHEMATICAL MODELING

Time series including aircraft and passenger can be decomposed of three sub functions such as trend, seasonal, and irregularity component. A trend component shows a long term movement in a time series. It is the underlying direction showing an upward or downward tendency of a time series. A seasonal component describes any regular fluctuations. It is the component of variation in a time series which is dependent on the time of year. The last component named irregular or noise component is that left over when the other components of the series have been accounted for. It includes random fluctuations in a time series.

A functional for air transportation time series can be defined as the sum of a trend (f_t), a seasonal (f_s), and an irregularity (f_{ir}) functions like the following [22]:

$$f(t) = f_t(t) + f_s(t) + f_{ir} \tag{1}$$

It is possible to use different trend functions in a functional. Exponential, polynomial, power, or even rational functions may be selected as a trend function. Among the possible trend functions, we preferred to use second-degree polynomial function [23]. Because; Polynomial function shows an increasing character. Therefore, its forecasting nature shows the existence of development in the future of industry. Based on the preferred function descriptions, a trend function such as a second degree polynomial, a periodic function like sinusoidal, and an irregular function such as logistic distribution as follows:

$$\hat{f}_I(t) = f_{I,t} + f_s + f_{ir} \tag{2}$$

where

$$f_t = \beta_1 t^2 + \beta_2 t + \beta_3 \tag{3}$$

$$f_s = \beta_4 \sin\left[\frac{2\pi}{\beta_5}t + \beta_6\right] \quad (4)$$

$$f_{ir} = \beta_7 rand('\text{Logistic}', \mu, s) \quad (5)$$

In this functional:β_1 is the coefficient of leading term, β_2 is another coefficient of the second term, and β_3 is the constant term. Similar to previous description, β_4 is amplitude, β_5 is a period, β_6 is a phase shift, and β_7 is a scale factor of irregularity. μ is the mean and s is a parameter related to standard deviation;

$$s = \frac{\sqrt{3}}{\pi}\sigma \quad (6)$$

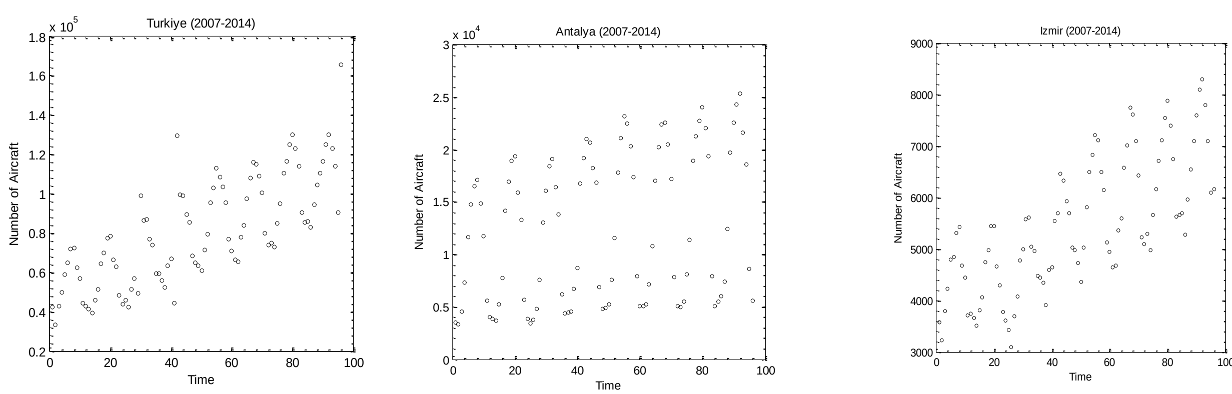
Theβ_i coefficients in each combination can be determined via a proper optimization process such as genetic algorithm. The objective function is usually a least-squares function given by

$$\sum\nolimits_{i=1}^{n} (\hat{f}_i - f_i)^2 \quad (7)$$

Where f_i is i^{th} value of a time series and$\hat{f}_i$is i^{th} value of the computed response obtained from the forecasting model.

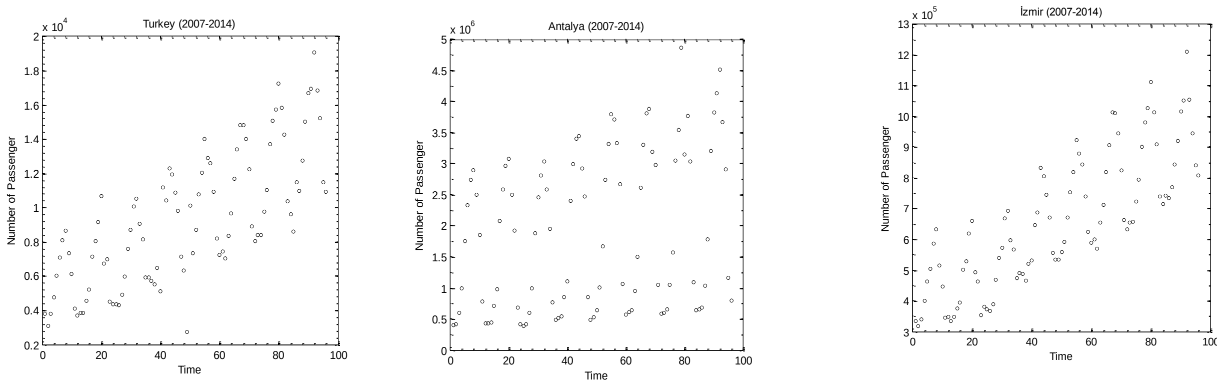
4. MODEL CONSTRUCTIONS

Two different quantities such as the number of aircraft take-off and landed and the number of passengers in domestic and international flights are taken into consideration for the future expectations. The data obtained from the official website of the General Directorate of State Airports Authority of Turkiye database(http://www.dhmi.gov.tr) is used inour experimentsand it is the total values of Turkish airports. The time series includes the monthly total numbers between January 2007 and December 2014 which means 96 observations. The following figure1 and figure 2 show the current data for each quantity.



(a) Real data and general trend for Turkiye. (b) Real data and general trend for Antalya. (c) Real data and general trend for Izmir.

Fig. 1 The number of aircraft take-off and landed.



(a) Real data and general trend for Turkiye. (b) Realdata and general trend for Antalya. (c) Real data and general trend for Izmir.

Fig. 2 The number of airline passengers.

4.1 Forecasting Model for Aircraft Quantity

The forecasting model such as $\hat{f}_I(t)$ is constructed to make estimates for the future of **aircraft quantities in Turkiye, Antalya and Izmir**. At the end of the optimization process, the functional is constructed by the following expression:

The functional for **"Turkiye"**is constructed by the following expression:

$$\hat{f}_I(t) = 2.308t^2 + 488.687t + 49{,}730.935 + 20{,}004.742 \sin\left[\frac{2\pi}{12.037}t + 35.464\right] - 2{,}320.257 rand('\text{Logistic}', 0, \sqrt{3}/\pi) \tag{8}$$

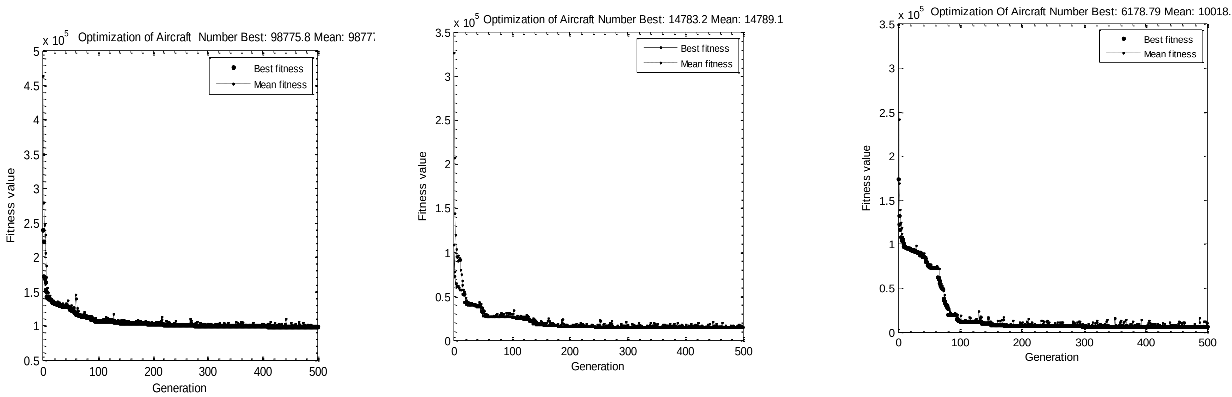
The functional for **"Antalya"** is constructed by the following expression:

$$\hat{f}_I(t) = -0.087t^2 + 70.03t + 9{,}348.88 + 9{,}066.68 \sin\left[\frac{2\pi}{11.968}t + 22.794\right] + 163.433 rand('\text{Logistic}', 0, \sqrt{3}/\pi) \tag{9}$$

The functional for **"Izmir"** is constructed by the following expression:

$$\hat{f}_I(t) = 0.852t^2 - 54.95t + 5{,}470.929 + 1{,}132.802 \sin\left[\frac{2\pi}{11.849}t + 16.253\right] - 84.006 rand('\text{Logistic}', 0, \sqrt{3}/\pi) \tag{10}$$

The period of a seasonal function is about 12 as expected. The genetic optimization process results including the best fitness values versus generations are depicted in Fig. 3.



(a) Optimization process for Turkiye. (b) Optimization process for Antalya. (c) Optimization process for Izmir.

Fig. 3 TheOptimization process for Turkiye and selected cities.

4.2 Forecasting Model for Passenger Quantity

Similar to the previous analysis, the forecasting model such as $\hat{f}_I(t)$ is constructed to make estimates for the future of **passenger quantities in Turkiye, Antalya and Izmir**. At the end of the optimization process, the functional is constructed by the following expression:

The functional for **"Turkiye"** is constructed by using the following expression:

$$\hat{f}_I(t) = 0.666t^2 + 33.791t + 5{,}618.512 + 3{,}333.593\sin\left[\frac{2\pi}{11.987}t + 22.859\right] + 49.119 rand('\text{Logistic}', 0, \sqrt{3}/\pi) \tag{11}$$

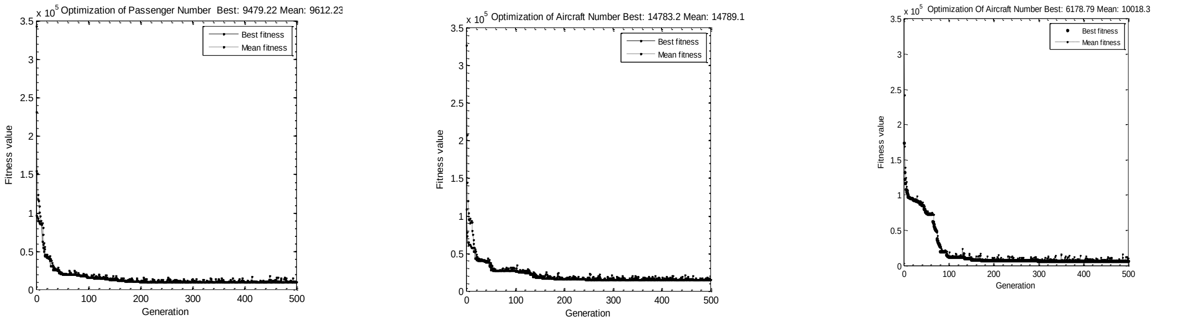
The functional for **"Antalya"** is constructed by using the following expression:

$$\hat{f}_I(t) = 40.579t^2 + 6{,}169.597t + 1{,}499{,}351.651 + 1{,}602{,}822.427\,sin\left[\frac{2\pi}{11.901}t - 128.201\right] + 385.002\,rand('Logistic', 0, \sqrt{3}/\pi) \tag{12}$$

The functional for **"Izmir"** is constructed by using the following expression:

$$\hat{f}_I(t) = -12.672t^2 + 7459.939t + 335{,}351.694 + 163{,}191.655\sin\left[\frac{2\pi}{12.119}t + 86.00\right] + 6{,}516.718 rand('\text{Logistic}', 0, \sqrt{3}/\pi) \tag{13}$$

The period of a seasonal function is about 12 as expected. The genetic optimization process results including the best fitness values versus generations are depicted in Fig. 4.



(a) Optimization process for Turkiye. (b) Optimization process for Antalya. (c) Optimization process for Izmir.

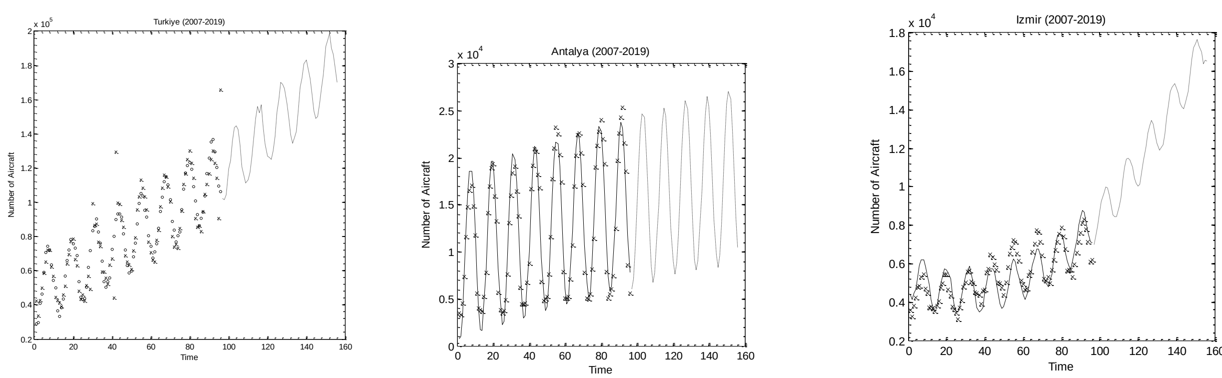
Fig. 4 The Optimization process for Turkiye and selected cities.

Similar to the previous conclusion, the figures and best fitness values show that the polynomial fits. The number of passengers carried by Turkish airline industry is in rising trend. The future does not show a stagnation process.

5.THE FUTURE OF TURKISH AIR TRANSPORT MARKET: 2015-2019

5.1 The Forecast for The Number of Aircraft

Optimization results shows that a forecasting model based on a second degree polynomial, a periodic function, and an irregular function fits better and can be taken into consideration for future expectations. It is possible to use Eq. (8,9,10) to make **the forecast for the number of aircraft** in Turkiye and selected cities. Similarly, Eq. (11,12,13) can be utilized to make **the forecast for the number of passengers.** For that purpose, we need to establish a time horizon. A five-year term including 2015-2019 years and 60 months in total is selected as the long-term time horizon.



(a) Real data and the future expectations for the number of aircraft in Turkey. (b) Real data and the future expectations for the number of aircraft in Antalya. (c) Real data and the future expectations for number of the number of aircraft in Izmir

Fig. 5 The future expectations for the number of aircraft in Turkeyand selected cities.

The estimated numbers of aircraft amount versus months forecasted by Eq. (8,9,10) are shown in Fig. 5. Additionally; the minimum, the maximum, an average, and the total number of aircraft in each year are tabulated in Table I,II and III. On Fig. 5, the real data belong to the past and the forecasted data are depicted together.

According to the forecasting model of **Turkiye**, it is expected to increase % 9.06 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 2,106,900. This increase means %41.47 development in total.

Table I Future data for the number of aircraft in Turkiye

Year	Min.	Max.	Average	Total
2015	101,410	144,720	124,110	1,489,300
2016	111,310	157,080	135,470	1,625,700
2017	125,170	170,150	148,670	1,784,000
2018	134,510	183,230	161,460	1,937,500
2019	148,950	198,890	175,580	2,106,900

According to the forecasting model of **Antalya,** it is expected to increase % 3.49 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 214,780. This increase means % 14.72 development in total.

Table II Future data for the number of aircraft in Antalya

Year	Min.	Max.	Average	Total
2015	6,004.4	24,646	15,601	187,210
2016	6,789.8	2,524.5	1,614.8	193,770
2017	7,646.8	26,091	16,833	201,990
2018	8,045.4	26,494	17,297	207,570
2019	8,380.4	27,086	17,898	214,780

According to the forecasting model of **Izmir,** it is expected to increase % 17.06 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 197,790. This increase means %87.80 development in total.

Table III Future data for the number of aircraft in Izmir

Year	Min.	Max.	Average	Total
2015	6,985.2	9,954.6	8,776.7	105,320
2016	8431.3	11,491	10,338	124,060
2017	10,104	13,416	12,148	145,780
2018	12,171	15,363	14,229	170,740
2019	14,367	17,671	16,482	197,790

When we take a look at the table IV, which compares the projections concerning Turkiye and the two developed cities in the aviation, we can see that there is a match between the growth rate of Turkiye and the growth rates of

Izmir for the period of 2015-2019. On the other hand, the growth rates of Antalya is quite low when compared with Turkiye at large as well as with Izmir.

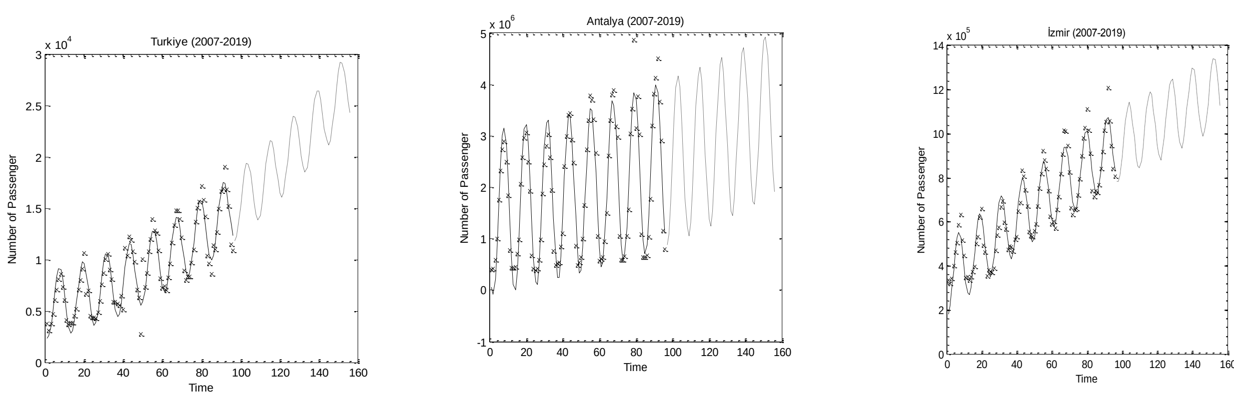
Table IV Comparison (%)

Year	Turkiye	Antalya	Izmir
2015*	10.79	5.24	28.83
2016	9.16	3.50	17.79
2017	9.74	4.24	17.50
2018	8.60	2.76	17.12
2019	8.74	3.47	15.84
2015-2019 Average*	9.40	3.84	19.41

*(By using real data of 2014)

5.2 The Forecast for The Number of Passenger

The estimated numbers of passengers carried by airlines versus months forecasted by Eq. (11,12,13) are shown in Fig. 6. In addition to this figure, the minimum number of passengers, the maximum number of passengers, an average number of passengers, and the total number of passengers in each year are tabulated in Table V,VI and VII.



(a) Real data and the future expectations for the number of passenger in Turkiye.

(b)Real data and the future expectations for the number passenger in Antalya.

(c) Real data and the future expectations for the number of passenger in Izmir.

Fig. 6 The future expectations for the number of passenger in Turkey and selected cities.

According to the forecasting model of **Turkiye,** it is expected to increase % 12.52 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 309.49 million. This increase means % 60.3 development in total.

Table V Future data for the number of passengers in Turkiye (x 1000)

Year	Min.	Max.	Average	Total
2015	11,871	19,442	16,088	193,060
2016	13,937	21,595	18,235	218,820
2017	16,124	23,971	20,573	246,880
2018	18,543	26,485	23,078	276,940
2019	21,164	29,275	25,791	309,490

According to the forecasting model of **Antalya,** it is expected to increase % 6.972 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 40.0 million. This increase means % 30.96 development in total.

Table VI Future data for the number of passengers in Antalya (x 1000)

Year	Min.	Max.	Average	Total
2015	876.67	4,167.6	2,545.6	30,547
2016	1,051.6	4,345.7	2,725.1	32,701
2017	1,242.8	4,530.4	2,916.3	34,996
2018	1,449.6	4,722.4	3,119.4	37,433
2019	1,672.8	4,921.5	3,334	40,007

According to the forecasting model of **Izmir,** it is expected to increase % 4.90 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 14.04 million. This increase means % 21.12 development in total.

Table VII Future data for the number of passengers in Izmir (x 1000)

Year	Min.	Max.	Average	Total
2015	781.28	1,144.3	966.4	11,597
2016	843.74	1,188.4	1,022.3	12,268
2017	878.24	1,248.2	1,074.8	12,898
2018	933.49	1,298.7	1,125.3	13,503
2019	988.82	1,338.7	1,170.5	14,047

When we take a look at the table VIII, which compares the projections about the number of passangers concerning Turkiye and the two developed cities in the aviation, the growth rates of Antalya and Izmir are quite low then Turkiye.

Table VIII Comparison (%)

Year	Turkiye	Antalya	Izmir
2015*	16.32	7.78	6.03

2016	13.34	7.05	5.78
2017	12.82	7.02	5.13
2018	12.17	6.96	4.69
2019	11.75	6.87	4.03
2015-2019 Average*	13.28	7.13	5.13

*(By using real data of 2014)

6. CONCLUSIONS

The purpose of this paper was to construct mathematical models to forecast the Turkish air transport market in long-term period. For this purpose we first presented the short review of the main classical forecasting methods and also gave a brief introduction into a mathematical modeling. For our empirical study, we chose a combination of three basic functions such as a trend function, a seasonal function, and an irregularity function. A genetic algorithm process was used to determine the coefficients of each function. We tested a second degree polynomial as a trend function, a periodic function like sinusoidal, and an irregular function such as logistic distribution fits better. The results also confirmed that the Turkish air transport market is an emerging market.

According to the forecasting based on the constructed mathematical models, we project a 41.47 % increase in Turkish aircraft traffic and a 60.3 % increase in Turkish air passenger traffic between 2015-2019 years. On.the other hand, the results about The Turkiye's most favorite tourism destinations Antalya and Izmir have different path from Türkiye's results.

According to the forecasting mathematical models, we project a 14,72 % increase in the number of aircraft landing in Antalya and a 87,80% increase in Izmir. This means that there is a match between the growth rate of Turkiye and the growth rate of Izmir for the period of 2015-2019. On the other hand, the growth rate of Antalya is quite low when compared with Turkiye.

Also,we project a 30,96 % increase in the number of passenger in Antalya and a 21,12% increase in Izmir. This means that the growth rate of Antalya and Izmir are quite low when compared with Turkiye for the period of 2015-2019.

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NEW SERVICE DEVELOPMENT PROCESS IN INTERMODAL TRANSPORT: THE CASE OF TURKEY

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Abstract_*Intermodal transportation, which combines the advantages of each transport mode and increases the overall efficiency of transport, has been promoted worldwide as well as in Turkey since it is considered as economic, social and environmental friendly transportation service. Increasing interest on intermodal transport both by the shippers and carriers has led logistics service providers and transport operators to develop new intermodal transport services. When the service literature is analyzed, it is founded that there are a few studies on the new service development of specific service industries. However, it is observed that there is a gap on new intermodal service development. That's why this study aims to focus on and explore the stages in the new service development process of intermodal transport and to determine the common stages of NSD for developing new intermodal transport services. In order to reach this aim, intermodal transport operators and service providers offering intermodal transport services in Turkey are investigated by in depth interview method in this study. This study is the preliminary step for NSD processes in intermodal transport for the current literature. According to the findings, the topics of the human resources have not been paid enough attention during the NSD process. Additionally, it is concluded that intermodal transport requires more detailed and industry-specific NSD models compared with the other service industries.*

Keywords_*Intermodal transport, new service development, service industry, Turkey.*

INTRODUCTION

Businesses have shifted the paradigm from production orientation to service orientation starting from 1980s [41] as a reflection of rapidly increasing contribution to economy [52] and in such a competitive environment creating new services is vital factor for service industry [49] in order to create and increase value for existing customers and attracting new customers [44]. In other words, superior performance and competitive advantage is suggested by new services [31]. These factors with the continuous innovation forces decision makers in service firms to develop new services [20]. Although developing new services is essential for success of the service, it has not received due attention in the literature [44]. Much of the research on new service development is about the process of NSD [38; 5; 39; 4]. However, there are no researches specifically on intermodal transport. New service development process has the industry specific nature [24] which also needs to be considered by the intermodal transport industry.

The transportation industry and international trade have undergone great changes since 1950s. Three major factors are responsible for and characterize the changes: demand for transportation, transport technology and organization of the transportation system [29]. Intermodal transport has grown considerably with the developments taking

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place in the shipping and transport industry triggered by containerization and increasing global trade such as the improvements in the infrastructure, vehicles and specific equipments.

The growth of intermodal freight transportation will be driven and challenged by four main factors [23]: (i) understanding the changing customer requirements and hyper-competition of supply chains in a global marketplace; (ii) responding to changing customer requirements with seamless and integrated coordination of freight through various modes; (iii) knowledge of current and future intermodal operational options and alternatives, as well as the potential for improved ICT and (iv) constraints on and coordination of infrastructure capacity as well as better management of existing infrastructure and broader considerations on future investment in new infrastructure.

Intermodalism is the idea of process pointed out by [38] and the process consists of technical, legal, commercial and management framework indicated by D'Este (1996) [22]. These views confirm that the intermodal transport is a "service" rather than a technology. Therefore, the concept of intermodalism emphasizes "soft" features of service delivery that facilitate the technology of multi-modal transport [22].

Intermodal transport is an efficient and sustainable solution to deal with increasing transport volumes. With intermodal transport, different modes of transport such as trucks, trains and ships are optimally combined to handle transport as environmentally-friendly and cost-efficiently as possible [36]. Appearance of the door to door transport [34] rising tax levels and fuel prices, increasing problems with congestion and increasing environmental consciousness among shippers has drawn attention to intermodal transport [47]. Hence new intermodal transport services have been promoting for several years (e.g.,PROMIT, Twinning Project, Marco Polo Programme, and The Cream Project ect.). Intermodal transportation provides many remarkable opportunities to the related parties for saving money [48], saving of time, simplification of trade documentation, reliability, safety needs [34], expanding markets, increasing value added services related to distribution [33] and increase efficiency and also provides competitive advantage [14]. These benefits of intermodal transport suggest that more attention for new service development in intermodal transport is required [51].

The objective of the paper is twofold. First objective is to explore the stages in the new service development process of intermodal transport. Second objective is to determine the common stages of NSD and explore whether these stages are always necessary or not as addressed by Menor et al., (2002) [37]. To reach these objectives first an interview questionnaire form derived from the literature were applied to decision makers from intermodal service providers in Turkey. Turkey as a developing economy has great potential on intermodal transportation due to its geographical position. The opportunities have been recognized by many major transportation companies, which have located in the region or abroad due to increasing need for the intermodal transport services. This situation provides an opportunity to observe the NSD process in intermodal transport industry.

This paper has structured in five sections. The next section reviews the literature on the new service development process and intermodal transport. Section three describes the methodological context, including data collection and sampling and the results of the empirical analysis are given thereafter. The conclusions and discussion are provided in the last section.

LITERATURE REVIEW

Developing new services are important, complex and risky for service firms [19]. Because of the high competition in the industry, the shift toward the innovativeness has recognized for the survival of the companies [35]. In order to bypass the failure of the new service in such environment, strategic focus on NSD and development competencies are applied. Although there have been several studies referring that there has been limited use of formal NSD process [7], it is increasingly important to explore and understand the NSD and its processes [32]. There has been considerable amount of research carried on the NSD that provides a structure to the activities and concepts related to NSD process [26].

The literature proves that the services and products have different features because of the intangibility, inseperability, perishability and heterogeneous characteristics of the services [1]. Although the applicability of processes of new product development into the service industry is under discussion [46], literature related NSD process was based on the NPD process of Booz, Allen and Hamilton (1982) [10] [49]. Obviously, there is various ways to describe the NSD process [24] as shown in Table 1. Most NSD processes are the waterfall models [12] that have adopted sequential structure [26]. First, Bowers (1985) [11] suggested a normative market driven process of NSD for hospitals. This research revealed that developing new services differs from the BAH model. Likewise, Bitran and Petrosa (1998) [8] specified the differences between product and service development by reviewing the related literature and developed generic model.

Some other NSD process researches have employed nonlinear structure. Edvarson and Olsson (1996) [24] created a nonlinear model within the focus of customer and quality. The research also indicates the variability of the process due to time and dependency relations. An exploratory comparative longitudinal research on two individual industry projects were conducted by Steven and Dimitriadis (2005) [49] in order to present a NSD model that consist organizational learning component. Gottfridson (2011) [27] investigated NSD process with 11 small Swedish companies and concluded that there is no clear formal NSD process in studied companies. Digitalization of business environment created the need of more shorter NSD process and Alam (2014) [6] proposed phase wise, informal and shorter NSD process model based on the 158 new service projects that located USA, Australia and India.

Alam and Perry (2002) [7] proposed a simplified model based on the case studies of Australian financial service firms. This study has stressed both sequential and parallel process in NSD and indicated the need for the new ways of conceptualizing NSD process. The research of Frohle and Roth (2007) [26] presented both resource and process centric perspectives within a single framework. Burger et al., (2011) [13] investigated the level of maturity of NSD process by revealing a proposal model. This model helps assessing the NSD practices of the companies. Cocca and Ganz (2015) [18] introduced the developing green services with the literature and tried to find out its influence on the NSD process. All these models have their own merits, and offer theoretical background and managerial thinking [26] and answer the question of how the NSD process can best be organized for an innovation [21].

Table 1. Summary of the Key NSD Models

Bowers (1987)	Edvardsson and Olsson (1996)	Bitran and Petrosa (1998)	Alam and Perry (2002)	Tatikonda and Zeithaml (2002)	Steven and Dimitriadis (2005)	Alam (2014)
Linear	**Non Linear**	**Linear**	**Linear/Non Linear**	**Linear**	**Non Linear**	**Non Linear**
Develop a business strategy	Service Concept Development	Strategic Assessment	Strategic Planning	Strategic Positioning	Interpretation Stage	Initiation Phase
Develop a new services strategy	Service System Development	Concept Development	Idea Generation	Idea Generation	Development Stage	Comprehension Phase
Idea Generation	Service Process	System Design	Idea Screening	Concept Development	Implementation Stage	Corroboration Phase
Concept Development and		Component Design	Business Analysis	Concept Implementation		Execution Phase
Business Analysis		Implementation	Form a cross functional team	Full Prototype Tests		
Service Development and Evaluation		Feedback and Learning	Service design and Process system design	Market Rollout		
Market Testing			Personnel training	Performance Evaluation		
Commercialization			Service testing and pilot run			
			Test marketing			
			Commercialization			

Source: Authors

In line with the above models and approaches, the structure of NSD process is substantially affected by the industry that the company operates in. In addition to this models, various models are suggested by various researchers (e.g. Reidenbach and Moak, (1986); Scheuning and Johnsson, (1989); Voss et al., (1992) [26]. However, as indicated by Fitzsimmons and Fitzsimmons (2000) [25] there are still not enough studies on NSD process to meet the industry specific needs. Thus, lack of empirical evidence on new intermodal transport service development in the literature create research opportunity for the authors and leads this study to focus on the process of new intermodal transport service development.

Intermodal transport has expanding its market share through markets for flows over short distances, for perishable and high-value commodities, for small consignments, and for flows that demand speed, reliability and flexibility. In that case the industry achieves significant breakthrough innovations [9]. In Turkey currently changing trend occurs through the shifting intermodal services. Turkey is involved in different transport networks and corridors related with intermodal transport. In the context of connections between Pan-European Transport Corridors and

Central Asia, Turkey has an important role as one of the most important countries in the Black Sea and Mediterranean basin in terms of both east-west and North-south connections [43].

In order to overcome the vulnerability of transport industry and become more sustainable, Turkey needs to develop intermodal transport solutions that can rapidly yield results without losing the advantages of its competitive road transport system. Turkey has significant potential, and several projects are underway to develop intermodal transport [40].

Transportation industry has evolved with economic and technological developments and changes in customer requirements which lead to service providers to follow customer-oriented strategies [45]. Therefore passing through user friendly processes in NSD has increased the importance in such an innovative and competitive environment [24].

As asserted previously, this reveals the importance of NSD process studies specific to the intermodal transport. When the NSD process literature reviewed, only a few studies have found in terms of transport industry. Nijssen et al., (2006) [39] tried to reveal differences between NSD and NPD, and they have taken into account the companies operate in different industries including transport industry as a sampling. Zhou and Wang (2012) [53] also referred the logistics enterprises in NSD process. Chen et al., (2015) [17] proposed to apply Kensei engineering based approach in new service development with analyzing the home delivery service which is one of the crucial part of the logistics industry. Apart from these studies, it has not been faced with any other studies which focused on intermodal transport with the point of NSD process literature.

RESEARCH METHODOLOGY

Qualitative research is conducted in line with the below mentioned research questions in this study. The research gap in intermodal transport literature has been tried to be fulfilled by testing the convenience of Alam and Perry's (2002) [7] NSD model in intermodal transport. This research used the case study as a research method. Case study research provides a close investigation of topics, issues and people and seeks to answer focused questions by producing in-depth descriptions and interpretations over a relatively short period of time [28].

In this study, the research questions are considered as follows:

(i). What are the differences in the NSD process encountered by the intermodal service provider companies?

(ii). What are the differences in the activities of NSD process practiced by the intermodal service provider companies?

Data Collection

Judgmental sampling which includes experienced people with the central phenomenon was used in the study [31]. After reviewing the relevant logistics and transportation journals and websites on intermodal transportation, the intermodal service providers were compiled and listed. Within this list, the websites of each intermodal transport company were analyzed and the information on their intermodal services was explored. As a result of this analysis, 10 companies which meet the research questions were selected. The profiles of respondents from these companies included in the case study were summarized in the Table 2.

Table 2. Profiles of the Respondents

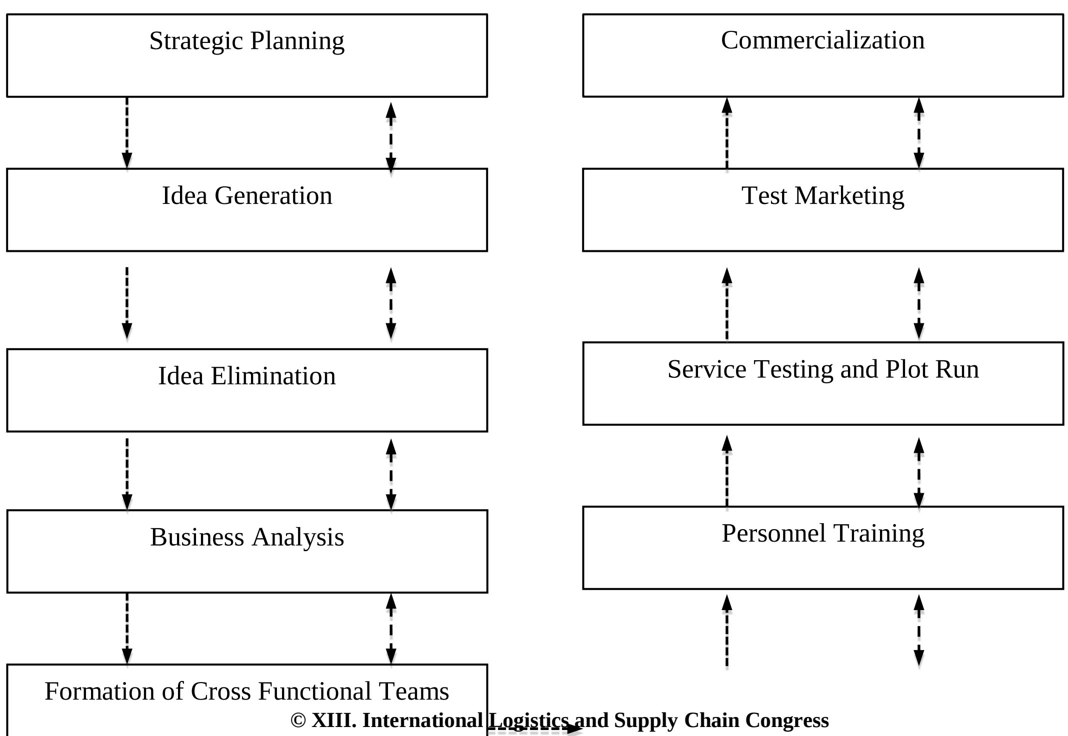
Interview	Positions	Experiences (years in the company)
A	Regional Director	1-5 years
B	General Manager	6-10 years
C	President of Strategic Investments Group	11-15 years
D	Management Executive	1-5 years
E	Intermodal Manager	1-5 years
F	Operations Manager	6-10 years
G	General Manager	1-5 years

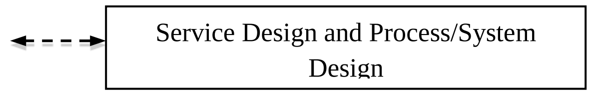
The interview form was distributed to the intermodal services providers operating in Turkey by web based interface, on July 2015, followed up by a telephone call. Respondents were asked to reply the stages and the relevant activities that they have been taken into consideration during the new intermodal service development process. Out of 10 companies, seven responses have been received from the respondents.

Research Model

The relevant literature related on NSD models were reviewed as a first step of the research design. From this review an extensive list of NSD models was founded and an interview form was developed based on Alam and Perry's (2002) [7] model. The model used in this study is depicted in the Figure 1. The stages in the model are both sequential and parallel. This model was also used by [3; 46; 30; 2] to reveal industry specific empirical evidences. Since this model fit to the notion of customer oriented transport perception in the modern world leads us to apply this model in the study.

Figure 1. Conceptual Model of the Study





Source. Adopted from Alam and Perry, 2002 [7]

Empirical Analysis and Results

The analysis was conducted with the help of a matrix which groups the relevant data into simple categories and provides a multidimensional summary [16]. Due to the small number of responses and the open nature of questions, statistical data processing was not appropriate.

Table 3. Stages and the Activities Followed by the Sampling Companies

NEW SERVICE DEVELOPMENT PROCESS	A	B	C	D	E	F	G	Total
Strategic planning	✓	✓	✓	✓	✓	✓	✓	7
Identify strategic roles	✓	✓	-	✓	✓	✓	✓	6
Review of historical performance	✓	✓	✓	✓	✓	✓	✓	7
Agreement on a common NSD strategy	✓	✓	-	✓	✓	-	✓	5
Specification of the research categories to approach	✓	✓	✓	✓	✓	-	✓	6
Assignment of individual roles and responsibilities	-	-	-	-	-	✓	✓	2
Idea generation	✓	✓	✓	✓	✓	✓	✓	7
State needs, problems and their solutions	✓	✓	✓	✓	✓	-	✓	6
Critize existing service	✓	✓	-	✓	✓	✓	✓	6
Identify gaps in the market	✓	✓	✓	✓	✓	✓	✓	7
Provide a wish list	✓	✓	-	✓	✓	-	✓	5
State new service adoption criteria	-	-	-	✓	✓	✓	✓	4
Idea elimination	✓	✓	✓	✓	✓	✓	✓	7
Customer screen	✓	-	-	✓	✓	-	-	3
Operational screen	✓	✓	✓	✓	✓	✓	✓	7
Strategic screen	✓	✓	✓	✓	✓	✓	✓	7
Financial screen	✓	✓	✓	✓	-	-	✓	5
Technological screen	✓	✓	✓	✓	-	✓	✓	6
Business analysis	✓	✓	✓	✓	✓	✓	✓	7
Limited feedback on financial data, including profitability of the concepts, competitors' data.	-	✓	-	-	✓	-	-	2
Market opportunity forecasting	✓	✓	✓	✓	✓	✓	✓	7
Sales forecasting	✓	✓	✓	✓	✓	-	✓	6
Financial forecasting	✓	✓	-	✓	✓	✓	✓	6
Formation of Cross-Functional Teams	✓	✓	✓	✓	✓	✓	✓	7
Search and identify appropriate personnel from various departments	✓	✓	-	-	✓	✓	✓	5
Assess their expertise and compatibility with the project	✓	✓	-	✓	-	-	✓	4
Joining the top management in selecting team members	-	-	✓	✓	-	✓	-	3
Service Design and Process/System Design	✓	✓	✓	✓	✓	✓	✓	7
Review and jointly develop blueprints	✓	✓	✓	✓	✓	✓	✓	7
Suggest improvements by identifying fail points	✓	✓	✓	✓	✓	-	✓	6
Observe the service delivery trial by the firm personnel	-	-	-	✓	✓	-	✓	3
Personnel Training	✓	✓	✓	✓	✓	✓	✓	7

Observe and participate in mock service delivery process	✓	✓	✓	-	✓	✓	-	5
Suggest improvements	✓	✓	✓	✓	-	-	✓	5
Service Testing	✓	✓	✓	✓	✓	✓	✓	7
Participate in a simulated service delivery processes	✓	✓	✓	✓	✓	✓	✓	7
Suggest final improvements and design change	-	✓	-	✓	✓	-	✓	4
Test Marketing	✓	✓	✓	✓	✓	✓	✓	7
Comments on the marketing plan	-	✓	-	✓	✓	-	✓	4
Detailed comments about their satisfaction of marketing mixes	✓	-	✓	✓	✓	✓	✓	6
Suggest desired improvements	✓	-	-	✓	✓	-	✓	4
Commercialization	✓	✓	✓	✓	✓	✓	✓	7
Adapt the service as a trial	-	✓	✓	✓	✓	-	✓	5
Feedback about the overall performance of the service along with the desired improvements	✓	✓	-	✓	✓	✓	✓	6
Word of mouth communications to other potential customers	✓	✓	-	✓	-	-	✓	4

Source: Alam and Perry (2002) [7]; Papastatthopoulou et al., (2001) [42]; Alam (2010) [4]

The results of the case study have substantiated the proposed model of Alam and Perry (2002) [7] and this study helped to validate the model for intermodal transport. Obviously it has been observed that all stages in the model are also conducted by the intermodal service provider companies. Table 3 illustrates the results of the study. New intermodal transport service development process follows the stages of strategic planning, idea generation, idea elimination, business analysis, formation of cross functional teams, service design and process/system design, personnel training, service testing, test marketing and commercialization.

The total numbers of stages followed by the respondents are illustrated in the last column of the Table 3. In this table, “review of historical performance” as a “strategic planning”, “identify gaps in the market” as a “idea generation”, “operational and strategic screens” as an “idea elimination”, “market opportunity forecasting” as a “business analysis”, “review and jointly develop blue prints” as a “service design and process/system design” and “participate in a simulated service delivery processes” as a “service testing activities” have been conducted by all the intermodal transport companies during their NSD process.

Apart from these findings, there are additional activities that are not listed in the form but have been considered by the respondents includes “sustainability of the project”, “environmental screen”, “political and legal screen”, “comparing with the other transport modes”, “applying intra-company and outsourced personnel training”. Of these, “compare with the other transport modes” seems industry-specific NSD activity.

DISCUSSION AND CONCLUSION

The importance of intermodal transport has increased worldwide including Turkey due to its environmentally friendly nature and contribution to the cost reduction during the logistics processes. This situation has provided much more attention to the new intermodal service projects. However, the service industry in which the intermodal transport involves has differences in terms of the NSD processes. The intermodal transport has some specific characteristics such as; being international, necessity of integration between software and hardware of different transport modes, having medium level of customer contact etc. Due to these characteristics of intermodal transport, each stage of NSD process should be carefully conducted because of the low fault tolerance. Additionally, financial stability of the companies operating in this industry should be steady as the services are conducted without considering the demand.

The models on NSD have been examined in the literature, and a model of Alam and Perry (2002) [7] has been tested by an empirical research, and the model was strongly supported by the results. Although the model is not new, previous studies generally focus on different regions and different service industries. Nevertheless, this study focused on Turkey which is a natural bridge between the East and the West, serving as a junction between the continents of Asia and Europe in terms of intermodal transport perspective. This in itself is a conceptual contribution to the NSD literature. This study provides specific perspectives into the stages and activities for intermodal transport providers. Similarly, this model can be seen as a reference for the NSD processes of the actors involved in this transportation service industry.

While the activity of “limited feedback on financial data” in the “business analysis” stage is regarded as the most important stage in the Alam’s (2011) [5] study, only two respondents applied these activities during their NSD processes. Apart from preserving the current market share, customer orientation, which is one of the needs to enter the new markets and to hold the competitive advantage accordingly, has not been paid much attention in the NSD process of intermodal transport companies. This can be regarded as a remarkable finding of the study.

The most significant implication of this study is that the issues related to human resources have not been considered the intermodal transport companies. In this respect, it is found that the “formation of cross-functional teams” and “personel training” stages have rarely been applied rather than the other stages. “Assignment of individual roles and responsibilities”, “joining the top management in selecting team members” and “observe the service delivery trial by the firm’s personnel” are determined as the least applied activities. However, as indicated by Cadwallader et al., (2010) [15], employee participation is vital for successful implementation of new service development.

Furthermore, Alam (2014) [6] claimed that previous models have unnecessary details to meet the needs of NSD, thus provided shorter model thanks to the digitalization, especially with the help of social media. However, this study has revealed that detailed models are much more appropriate for the intermodal transport due to its capital intensive and complex nature. From this aspect, it is realized that NSD processes have industry-specific nature and should be structured in terms of the dynamics and needs of the industry.

This study is the first step on NSD in intermodal literature. However, as with any study, there are some limitations for this study as well. First, the sampling of the study is restricted to only one country. Second, the model of Alam and Perry (2002) [7] has been taken into consideration in this study. However, a new model with the stages and activities that are generated based on the focus group consists of the practitioners, policy makers, scholars can be formed. Afterward, this new model can be tested with a wider geographical area which can be regarded as a future research direction. Additionally, the studies on determining the failure and success factors for the new intermodal services can be conducted as well. Last but not least, the reason of why the topics of the human resources have not been paid enough attention during the NSD process can be investigated in the future studies.

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THE COMPETITIVENESS OF SERVICES OFFERED BY LINER SHIPPING COMPANIES BASED ON THEIR LOGISTICAL RESOURCES

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Abstract : *Nowadays, the competition between ship owners is fierce and year after year, it can be heard about the withdrawal of one of them from the business field to be absorbed by another. Each shipping company must seek to increase its competitiveness and develop its competitive advantages to survive and to be competitive in the business field. On one hand it needs to keep their eyes open to competitors, on the other hand ensuring the satisfaction of customers, without forgetting the internal development of the society by its logistical resources. This study essentially treats the competitiveness, the development of shipping companies and their logistical resources (informational and equipment), which consists a cross-study to combine between the vision of the company 'the offer' and customer's vision 'demand' to analyse the need that exists and try to improve the offer on the market in order to achieve a higher customer satisfaction. This study focus on both informational (ERP, CRM,...) and equipment resources (containers, container terminals…) of liner shipping companies.*

Keywords : *Competitiveness, Information resources, Liner shipping , Logistical resources, Material resources.*

The aim of the study: This study deals with the following research question:

RQ: How liner shipping companies can increase their competitiveness and develop their competitive advantages to survive,exceed their competitors in the first place and to retain its customers in the second place?

Method: primary data for this research has been mainly collected through interviews.

Conclusion: This study will evaluate the operations and logistics services provided in liner shipping companies (CMA-CGM).

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INTRODUCTION

Maritime transportation is the major conduit of international trade, About 90% of world trade, in terms of volume, is transported on ocean going ships, which makes up 70% of world trade in terms of value (see Hoff- mann 2008, p. 14). Maritime industry plays an important role in international freight. It can provide a cheap and high carrying capacity conveyance for consumers. Therefore, it has a vital position in the transportation of particular goods, such as crude oil and grains. Its disadvantage is that it needs longer transport time and its schedule is strongly affected by the weather factors. To save costs and enhance competitiveness, current maritime logistics firms tend to use largescaled ships and cooperative operation techniques. Moreover, current maritime customers care about service quality more than the delivery price. Thus, it is necessary to build new logistics concepts in order to increase service satisfaction.. The operation of maritime transport industry can be divided into three main types: (1) Liner Shipping: The business is based on the same ships, routes, price, and regular voyages. (2) Tramp Shipping: The characters of this kind of shipping are irregular transport price, unsteady transport routes, and schedule. It usually delivers particular goods, such as Dry Bulk Cargo and crude oil. (3) Industry Shipping which can ensure the supply of raw materials. This sometimes needs specialized containers, such as the high-pressure containers for natural gas.

Liner vs. Tramp shipping:

Prior to addressing the matter concerning competition in liner shipping, we have preliminarily to understand what is meant by liner shipping, which is one of the two modalities for the carriage of goods by sea, the other being non-liner shipping, better known as “tramp” seaborne transportation of goods. Liner differs from tramp shipping in several instances: in the first place, in liner services vessels are scheduled according to a given frequency of calls at predeter mined specified ports along a given route, while in tramp shipping the service is not scheduled and the entire vessel is normally chartered for a given voyage or for a period of time. Secondly, vessels used for liner shipping also have quite different characteristics from other kinds of vessels: in particular, since containerization has taken place, and has virtually replaced all other forms of transportation of goods in cargo units, ships used in liner services are cellular container vessels, having different sizes and tonnages, and are capable of carrying from a few hundred boxes up to several thousands. Hence, liner vessels are capable of carrying a large variety of goods in small parcels whereas tramp vessels usually transport one and the same good in large quantities, be it solid or liquid, as it happens with, respectively, bulkers and tankers. The capacity of liner vessels to transport a large and variable number of goods in parcels or cargo units displays a third peculiarity of liner services compared to tramp ones: as we have just pointed out, tramp vessels carry dry or bulk liquid cargo (oil, ore); in contrast, goods moved in liner services are high-value ones, i.e. either manufactured or semi-manufactured goods. Finally, substantially different are also the contractual terms accompanying liner transport vis-à-vis tramp shipping: in the former mode of transportation, the relationship between shippers and carriers is regulated by standard printed forms of contracts (e.g. bills of lading or similar documents) whose terms and conditions are directly prepared by carriers without any negotiation with their contractual counterparts, except as regards tariffs. In tramp shipping, the trader normally charters and pays a negotiated rate for the whole ship, either for a voyage or for a period of time. [1] Competition in Liner Shipping Francesco Munari.

What is Competitiveness?

For the company, competitiveness is the ability to provide products and services as or more effectively and efficiently than the relevant competitors, it means the company's ability to match or beat the world's best firms in cost and quality of goods or services.

At the industry level, competitiveness is the ability of the nation's firms to achieve sustained success against (or compared to) foreign competitors, again without protection or subsidies. . Competitiveness at the industry level is often a better indicator of the economic health of the nation than competitiveness at the firm level. The success of a single firm from the nation might be due to company-specific factors that are difficult or impossible to reproduce. The success of several firms from the nation in an industry, on the other hand, is often evidence of nation-specific factors that might be extended and improved.

For the nation, competitiveness means the ability of the nation's citizens to achieve a high and rising standard of living. Competitiveness at the national level is measured by the level and growth of the nation's standard of living, the level and growth of aggregate productivity, and the ability of the nation's firms to increase their penetration of world markets through exports or foreign direct investment**.** [2] what is competitiveness? by Franziska Blunck .publishing date: 26.06.2006)

THE COMPETITIVE ENVIRONMENT OF CMA-CGM:

A competitive environment is the number and types of companies against which a given business competes in its industry .Also it refers to the dynamic external system in which a business competes and functions. The more sellers of a similar product or service, the more competitive the environment in which you compete**.**

CMA- CGM group :

CMA CGM is the world's third largest container shipping company. Today operating a fleet of more than 428 vessels, the Group serves over 400 ports around the world. With a presence on all continents and in 150 countries through its network of 650 agencies, CMA CGM employs 18,000 people.

The Group offers a complete range of activities including transport by sea, river and rail, handling facilities in port as well as logistics on land. Our main objective: offer our customers all over the world a proactive and innovative service combining quality and high performance with protection of the environment. [3] **CMA CGM YOUR SHIPPING EXPERT IN XXL CARGOES.**

Logistical resources of CMA-CGM :

To provide their services worldwide and to cover the all 5 continents the group CMA-CGM is based on both material and information resources . In parallel , there are the maritime networks of the CMA -CGM which organize the global fleet to reach all world ports .

I – <u>Information resources:</u>

- ERP(Enterprise Resources Planning)
- CRM(Customer Relationship Management)
- SCMS(Supply Chain Management System)
- PDM(Product Data Management)
- EDI(Electronic Data Interchange)

The different types of information resources of CMA-CGM :

category	**System**	**Utility**
ERP	LARA Line and Agent Real time Application	Système d'exploitation Cotation Booking Liaison entre siège et agents
CRM	DIVA	Creating marketing reports and transmission of customer 's information
Financial system	OCEAN	Application Accounting finance
Online system	E-service	Online Client Services for E-commerce
Website	www.cma-cgm.com	Portal of CMA-CGM
Online business	INTRA	E-Business and online business relationships.
EDI	➢ MIRA ➢ BADR ➢ PORTNET	➢ Communication between agents ➢ EDI for customs ➢ The link between shipping agents and customs .

Figure 1.The different types of information resources of CMA-CGM

[4] Compétitivité de l'offre de services des compagnies du transport maritime, et développement des avantages concurrentiels basés sur les ressources logistiques.

Information resources can facilitate communication between shipping agents and customers, and also between CMA-CGM subsidiaries worldwide.

II-Material resources:

- Containers
- Container terminal
- Stock
- Average handling time
- Vehicle fleet

Material resources are considered as the core service of CMA-CGM , and without it CMA-CGM cannot offer any of its services to customers.

category	Function and utility	number
Container ships	Movement of containers in all the 5 continents	428 ships (world fleet)
Containers	Potting of goods to facilitate movement	1 486 962 containers (global circulation)
Stock	Satisfy the need of containers	Fluctuating depending on demand
Terminals	Ensure the loading and unloading of container ships at docks	
Presence	Office or agency	605 agencies in 150 country

Figure2. Material resources of CMA-CGM

INTERVIEW WITH MR. ADNANE ESSEKARI :LOGISTICS COORDINATOR IN CMA-CGM – MOROCCO:

1-What is the most difficult or challenging thing about running a shipping company as CMA-CGM?

As third international company operating in shipping, all efforts are concentrated to strengthening actual clients and giving them a well satisfaction by offering them additional services more than maritime transportation, which is insuring road transport service from their manufactory to the commercial port.

Then on the other hand CMA CGM has a second objective, prospecting potential targets and wining their confidence in what concerns importations and exportations.

2-What difference have you noticed between shipping in 1990 and How it is today in 2015?

We must recognize that this sector which occupied 90% of international trade and has developped in different axes, like infrastructures those can be seen in a new ports built recently, Also a lot of expansions in the ports had been done to support the big quantities of goods transported each week.

The difference can be seen also in the ships and crafts used to transport goods in its different kinds.

3-Where do you see CMA-CGM in 10 years?

We can say that this shipping actor, classified third at international level, can obtain a very important place between the competitors, and can bring to the customers more services and satisfaction. Besides to that, CMA CGM is a company which has a lot of relations with different actors, like the transit company, Taxation of public administration, National agency of ports…So CMA CGM is not only thinking about the costumers, but also its environment, and it looks to develop the administrative relations with all actors operating in the port, thing which can help in developing the containers deadline treatment.

4-What do you suggest for small shipping companies which are starting their own work?

Try to determine the quantities that their customers want to send before communicating these to public authorities, this action help to not wasting time by doing modifications at the last minutes, thing which is not accepted by the port actors who need to know exactly the quantity that will be transported.

In addition to that in a first step, these companies don't need to buy own ships, it can only rent them and after having a certain autonomy, they can invest in such commercial operation.

CONCLUSION:

Shipping companies are companies that offer services, and provide satisfaction to their customers. This remains difficult and complex because customer's choices are based on a subjective criteria to choose a shipping company. More so in a highly competitive market, there is a need for shipping companies to study and analyze the needs of customers. In addition to this there is need to monitor all its competitors.

Concerning CMA-CGM ,it has the necessary logistical resources to be as competitive as the first ranking shipping companies (WAN HAI ,MAERSK ,..) since it can satisfy all customer's needs thanks to the services it can offer in the market . The most important thing is to combine between all available resources and use them in the right time, the right place and look for opportunities to exploit in an optimal way .

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A CONTENT ANALYSIS ON THE LOGISTICS AREA IN THE GRADUATE THESES WRITTEN IN TURKEY: 1996-2014 PERIOD

Tekin Erdoğan [206], *Ömür Yaşar Saatçioğlu*[207]

Abstract – *Scientific research is an important indicator which reflects on countries' specific areas of expertise and their development. The Turkish logistic sector is a dynamic industry that constantly improves the quality of its international services due to its diverse and specialized services and the economic development and technological advances. Researches on logistics conducted in the country are an important indicator of the importance given to logistics in a country. The goal of our research is to analyze multiple graduate theses written on "logistics" in Turkey. This paper analyzes Turkish post-graduate social science theses from the years of 1996-2014 which were defined with "logistics" as keyword and sent to the Council of Higher Education National Thesis Centre. 199 accessible post-graduate theses have met these criteria and have been utilized for this study. Content analysis techniques in form of frequencies and percentages have been applied for the analysis of the theses. The results obtained in the study should be considered as help for researchers during their selection of new research topics in the field of logistics. The goal of this research is to analyze which topics in regard of logistics have already been discussed in existing theses and which topics have not been given professional attention. The findings will form classifications on studies of logistics and will offer recommendations in regard to activities which might be open for discussion in future writings.*

Keywords: Logistics, postgraduate theses, business, content analyses

INTRODUCTION

Industrial production and trade that started after Industrial Revolution, have accelerated since 20th century and today base on technology developing within world economic system, require concomitantly transmitting of feed stock distributed unevenly in world toward manufacturing facility and also of final goods toward customers.

If it is considered that there are 193 countries connected to United Nations and totally 206 countries in the world and these countries have variety climate conditions, underground and aboveground treasures, different technological development, production culture, labor and capital structure, many products can be made with different price equilibriums.

In this perspective, requirement of transmitting of products and services causes the circumstance that countries need to increase commercial, cultural and social relationships of goods and services by way of imports and exports, by overtaking their closed economies in global system. At the present time, primary aim of every country in world is to have powerful economy with sustainable growth. Therefore, globalization processes in economics determine the necessity to ascertain and effectively to take competitive advantages of logistics networks on national and international levels in case to ensure the long-term stable growth of economy and with the goal to reach long-term competitiveness of the country [4]. These logistics networks are veins of the economics of the country, so they cause economic development and prosperity as well as their power and length. Especially raw

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materials, industry, agriculture, energy and consumption goods requirements of countries has been increasing day by day, and countries should develop these logistical networks in order to adopt sustainable competing.

In this context, Turkey has had the feature of route used in east and west for years. Turkey in middle of three continent due to geopolitical position, has a marketing in approximate worth 200 million even if only its near abroad is considered. It is important reason to be logistic base for Turkey.

AIM OF THE RESEARCH

This paper aims which analyzes Turkish post-graduate social science theses from the years of 1996-2014 which were defined with "logistics" as keyword and sent to the Council of Higher Education National Thesis Centre. These mainly selected related with business administration and related field whereas some theses excluded reason for related with such as history art, archaeology and art. 199 accessible post-graduate theses have met these criteria and have been utilized for this study. Content analysis techniques in form of frequencies and percentages have been applied for the analysis of the theses. The results obtained in the study should be considered as help for researchers during their selection of new research topics in the field of logistics. The goal of this research is to analyze which topics in regard of logistics have already been discussed in existing theses and which topics have not been given professional attention.

If it requires to summarize briefly of this research aim, it analyzes of master and Ph.D. theses which written about logistics. In accordance with this general aim, the research analyzes theses in these headings;

a) Distribution of theses according to program level.
b) Distribution of theses according to universities.
c) Distribution of theses according to advisors.
d) Distribution of theses according to methods.
e) Distribution of theses according to years.
f) Distribution of theses according to application level.
g) Distribution of theses according to sectional level.
h) Distribution of theses according to language.
i) Distribution of theses according to sector and field
j) Distribution of theses according to subjects.

POST-GRADUATED THESES WRITTEN ON LOGISTICS IN TURKEY

If you were to Google for a definition of logistics, the responses would be numerous and varied. These explanations range from basic and optional to extensive and detailed. Here are a few examples:

Table 1. Different Definitions of Logistics

Perspective	Definition
Inventory	Management of materials in motion and at rest
Customer	Getting the right product, to the right customer, in the right quantity, in the right condition, at the right place, at the right time, and at the right cost (called the "seven R s of logistics)
Dictionary	The branch of military science having to do with procuring, maintaining, and transporting material, personnel, and facilities
International Society of Logistics	The art and science of management, engineering, and technical activities concerned with requirements, design, and supplying and maintaining resources to support objectives, plans, and operations
Utility/Value	Providing time and place utility / value of materials and products in support of organization objectives
Council of Logistics Management	That part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services
Component support	Supply management for the plant (inbound logistics) and distribution management for the firm's customers (outbound logistics)
Functional management	Materials requirements determination, purchasing, transportation, inventory management, warehousing, materials handling, industrial packaging, facility location analysis, distribution, return goods handling, information management, customer service, and all other activities concerned with supporting the internal customer with materials and the external customer with stories.
Common culture	Handling the details of an activity

Source: Adapted from Coyle, J. John, Bardi, J. Edward, Langley, C. John. 2003. The Management of Business Logistics.9th edition, South-Western, Thomson Learning, p.39

The term logistics has become much more widely recognized by the public in the last 20 years. Television, radio, and print advertising have lauded the importance of logistics. Another factor contributing to the recognition of logistics has been increased customer sensitivity to not only product quality but also to the associated service quality [3]

Term of logistics mixed with some terms and these are using behalf of it. For example, "Logistics management", "Supply chain management", "Business logistics management", "Integrated logistics management", "Materials management", "Physical distribution management", "Marketing logistics", "Industrial logistics", "Distribution" consider as term of logistics.

The logistics concept began to appear in the business-related literature in the 1960s under the label of physical distribution, which had a focus on the outbound side of the logistics system [6]. During the 1960s, military logistics began to focus on engineering dimensions of logistics—reliability, maintainability, configuration management, life cycle management, and so on—with increased emphasis on modeling and quantitative analysis [3].

Logistics Performance Index (LPI) covering 150 countries measures performance in such areas as customs procedures, logistics costs, infrastructure quality, ability to track and trace shipments, transit times, and domestic logistics competence.

Connecting to Compete: Trade Logistics in the Global Economy reports that logistics may be the key that will open the door to prosperity for developing nations, Logistics is the backbone of international trade and commerce.

Their logistics encompasses freight transportation, warehousing, border clearance, payment systems, and increasingly many other functions outsourced by producers and merchants to dedicated service providers [2]. The importance of good logistics performance for economic growth, diversification, and poverty declining is now firmly established. Connecting to Compete: Trade Logistics in the Global Economy reports that connections between supply chain participants are gaining in importance as predictability and reliability become a higher priority than costs for many companies [5].

Academic research may cause emerging to innovation and economic prosperity. Logistics is one of the important and international economic industries that cause to enrich the world power. Academic research on innovation helps to comprehend innovation in the logistics sector. Additionally, academic researchers are scientific and one of commercial advancement source. Also they provide to be understood temporary or current situation. Academic researches discuss many issues about developing of countries, companies, institution, products and services, and also assist to be produced, to be criticized and to be reformed innovation.

Therefore, it is not wrong inference to state that number of postgraduate thesis made about logistic is directly proportional with logistic activities made in any country. In this context, there is any study examining postgraduate thesis about logistic. So, our study will be the first study about this issue. With this study, it is tried to reveal the situation of postgraduate thesis made in field of logistic and contents of study in general terms.

METHOD

Research Method

A qualitative research method document examining is using in this research. Qualitative researches help to work on a subject, appearance and situation deeply. These researches with document examining technical define as bibliometrics that is a statistical analysis of books, articles, or other publications. Bibliometrics analysis use data on numbers and authors of scientific publications and on articles and the citations therein (and in patents) to measure the “output” of individuals/research teams, institutions, and countries, to identify national and international networks, and to map the development of new fields of science and technology. Bibliometrics research disciplines have their own areas of release levels; number of publications, the nature of the publication, the publication such as the selection of the platform are made belongs in the light of the criteria defined in the index evaluating for the future can help the creation of science policy [1]. This research is a descriptive bibliometrics research with using descriptive methods. This method is used while logistics undergraduate theses research and data evaluate with frequencies and percentages.

Unit of Analysis / Sample

In this study, total 199 postgraduate theses that were published in Thesis Centre belongs to Council of Higher Education and are open for access, were reached with “logistic” keywords. 165 of these theses is postgraduate thesis and 34 of them is PhD thesis. Theses consist of theses prepared in 2001-2014 years (14 years) by paying attention the periods when were prepared intensively.

Table 2. Level of Examined Theses and Distribution According to Preparation Years

Level of Theses	Number of Theses	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Master	165	-	-	-	6	7	10	29	13	18	21	17	15	18	11
Ph.D.	34	1	-	-	-	1	-	6	4	5	4	8	2	3	-
Total	199	1	-	-	6	8	10	35	17	23	25	25	17	21	11

In the beginning of data collection period, it is decided to examine postgraduate thesis studies made in field of logistic without year limitation. However, theses before 2001 and in 2015 were not included this study because National Thesis Centre has less theses belonged previous 2000 years and current theses were closed for access, similarly there were less current theses belonged 2015 years and their Access was restricted by authors in order to write an article. Examined theses were gained from Thesis Centre belongs to Council of Higher Education between 08.05.2001-31.12.2014 dates. Distribution of these gained theses is demonstrated in Table 2.

Restriction

There are 329 theses opened for postgraduate access without any criterion, 170 theses closed for access and totally 499 theses that prepared in field of logistic between 2001-20014 years. These numbers contain theses written in physical sciences and other fields.

This study, however, was restricted with postgraduate theses that were scanned with "logistic" keyword registered in Council of Higher Education Thesis Documentation Centre until 2001-2014 years and were made under institute of social sciences where was thought to be related to logistic issue. "Logistic regression" method of analysis that is way used for limitation of individuals by dividing into different groups was excluded in study. Number of theses reached with this limitation was determined as 199.

Collecting of Data

Data of research were collected with technique of document examination. Postgraduate theses written between 2001-2014 years were tried to access by using www.yok.gov.tr web address, postgraduate theses in condition of permission were put in order and theses related to department of business administration were discussed as a research subject. In this context, in table 3 is the most important criterion providing the classification of theses.

Table 3: Distribution of Theses According to Institute, Department and Field of Science

Institute, Department and Field of Science	Frequency	Percent
Maritime Business Administration	9	5%
Institute of Education Sciences	2	1%
Department of Econometrics	2	1%
Department of Economics	10	5%
Department of Business	86	43%
Department of Business Management	11	6%
Department of Accounting and Finance	5	3%
Institute of Defense Studies	10	5%
Department of Quantitative Methods	8	4%

Institute of Social Sciences	14	7%
Department of Total Quality Management	3	2%
Department of International Business	7	4%
Department of International Trade	5	3%
Department of Production Management and Marketing	13	7%
Department of Management and Organization	5	3%
Others	9	5%
	199	**100%**

As it is seen in Table 3, department of business administration is department that the most logistic studies are done with 86 theses. Generally, it seems that institute of social sciences is in number two with 14 theses. It is clear that studies are done in field of department of business administration and similar sciences.

FINDINGS AND INTERPRETATION

Distribution of Theses According to Educational Level

Distribution of theses in level of postgraduate and PhD was demonstrated in Table 4. Majority of theses (% 83) written about logistic has level of postgraduate. Number of theses written in level of PhD is 34 (%17). According these data, when number of theses written in field of business administration and opened for access is considered, it is apparent that they are not sufficient in terms of quantity.

Table 4: Distribution of Theses According to Postgraduate Education Level

Application Level	Frekans	Yüzde
Master	165	83%
Ph.D.	34	17%
	199	**100%**

Distribution of Theses According to Universities

Distribution of Theses According to Universities was demonstrated in Table 5. Theses were written mostly and respectively in Dokuz Eylul University (38), Marmara University (25), Istanbul University (13) and Turkish Military Academy (11) in field of “Logistic”. There are studies in other 31 universities in this field. Since, number of these studies, however, is two or less than two, they were classified in this way.

When it was made a search with logistic keyword without institute and university name, 499 theses were found. Any studied was not found with these keywords in field of medical and there were 56 studies made with this keyword in field of physical sciences. If logistic word was not used in any postgraduate theses, this would not mean that this thesis is not logistic study. However, theses written in field of social sciences were determined as 199 due to search criteria and number of university that studies were done, is only 50.

Table 5: Distribution of Theses According to Universities

University	Frequency	Percent

Dokuz Eylül University	38	19%
Marmara University	25	13%
İstanbul University	13	7%
Military Academy	11	6%
Dumlupınar University	9	5%
İzmir Ekonomi University	7	4%
Anadolu University	6	3%
Gazi University	5	3%
Selçuk University	5	3%
Gebze Yüksek Teknoloji Enstitüsü	5	3%
Beykent University	4	2%
Gaziantep University	4	2%
Süleyman Demirel University	4	2%
Afyon Kocatepe University	3	2%
Maltepe University	3	2%
Niğde University	3	2%
Trakya University	3	2%
Uludağ University	3	2%
Yıldız Teknik University	3	2%
Others (Under 2 theses)	45	23%
	199	**100%**

Distribution According to Consultant

The distribution related to career of academicians who do thesis study in field of "Logistic", is demonstrated in Table 6.

Table 5: Distribution of Theses According to Consultant

Consultant Title	Frequency	Percent
Asst. Associate Prof.	68	34%
Assoc. Prof.	79	40%
Prof.Dr.	52	26%
	199	**100%**

When examined Table 5, 26 % of person managing thesis in field of "logistic" is professor, 40 % of them is associate professor, and 35 % of them is assistant professor doctor.

Distribution of Theses According to Method

Research methods of theses could give clue about type and quality of studies in field of logistic. Distribution of methods used in theses was demonstrated in Table 6.

Table 7. Distribution of Theses According to Method

Method		Frequency	Percent
Master	Quantitative	149	75%
	Qualitative	16	8%
Ph.D.	Quantitative	32	16%
	Qualitative	2	1%
		199	**100%**

When examined methods being an example for theses researches, it is seems that quantitative research methods are more important (% 91). In quantitative methods, survey methods are preferred as data collection tool. In quantitative methods, data could be collected through observation, interview and survey. Interview and survey, however, were used as data collection tool in only very small part of analyzed theses. In some theses, it was tried to describe the subject under-researched without mentioning what method was. These kinds of studies have the characteristics of compilation in general and were done in the way of literature search.

Distribution of Theses According to Years

Distribution of theses according to years was demonstrated in Table 8.

Table 8: Distribution of Theses According to Years

Years	Frequency	Percent
2001	1	1%
2002	-	-
2003	-	-
2004	6	3%
2005	8	4%
2006	10	5%
2007	35	18%
2008	17	9%
2009	23	12%
2010	25	13%
2011	25	13%
2012	17	9%
2013	21	11%
2014	11	6%
	199	**100%**

According to postgraduate theses made in field of logistic between 2000-2014 years, it was seen that 2007 years was period when the most studies were done, with 35 studies. It is seen that number of studies in field of logistic has increased after 2007 years.

When considered that thesis writing process consist of at least two years for postgraduate thesis and four years for PhD thesis in general, it is clear that interest oriented logistical theses has increased since 2000 years.

Additionally, it is seemed there has been increasing tendency in number of thesis since 2004 years. On the contrary 2011 years, the number has been decreasing because there are many theses closed for Access between 2012-2014 years. When searched the Council of Higher Education data base, this number closed for access was 30 between 2012-2014 years. However, even if theses closed for access are added, it could be not mentioned about important increment or upside acceleration

Distribution of Theses According to Application Level

Distribution of theses according to application level was demonstrated in Table 9.

Table 9: Distributions of Theses According to Application Level

Application Level		Frequency	Percent
Master	Field Study	149	75%
	Literature Research	16	8%
Ph.D.	Field Study	34	17%
	Literature Research		
		199	**100%**

As it is seen from Table 9, almost whole theses were discussed as field study. A part of postgraduate thesis (%7) was discussed only as literature research.

Distribution of Theses According to Data Section Level

Data section studies could be classified in the form of two ways as cross sectional and longitudinal. Cross sectional studies are studies that are performed collecting data only once in random samples presenting population subgroup. On the contrary in cross sectional, longitudinal studies are not performed upon only data collected in certain short time, they are studies that are performed by collecting different data for every part in long period of time. Distributions of theses according to data section level were demonstrated in Table 10.

Table 10: Distributions of Theses According to Data Section Level.

Data Section Level		Frequency	Percent
Master	Cross sectional	150	75%
	Longitudinal	15	8%
Ph.D.	Cross sectional	30	15%
	Longitudinal	4	2%
		199	**100%**

The basic point is to gain data for whole factors in every using period. 90% of post graduate theses of our search subject is latitudinal cross sectional studies gained with one-off data. Latitudinal studies that need to more data set and data are more difficultly but however more significantly gained, constitute only 14% part of theses.

Distribution of Theses According to Writing Language

You can see theses writing language in Table 11. Logistic is one of the main sectors integrated with world and other countries especially when it is made with seaway and airlines. In this context, it will be the great deficiency that writing academic studies hold in Turkish and outputs are not understood by other countries and researches. In this context, it is great deficiency in order to express condition of logistic sector in our country that number of writing theses is %15.

Table 11: Distributions of Theses According to Writing Language

Language		**Frequency**	**Percent**
Master	Turkish	152	75%
	English	13	8%
Ph.D.	Turkish	32	15%
	English	2	2%
		199	**100%**

Distributions of Theses According to Sectors and Subjects Researches Were Done

Distributions of theses according to sectors and subjects researches were demonstrated in Table 12. As it is seen in Table 10, logistic companies are the most examined facilities with 34% in studies. When these theses were analyzed in general, logistic companies were examined as normal facilities while some theses were being examined and any view point observing the logistic bases was not dealt. Then, number of thesis researching logistical businesses of SME consists of 20% part. Logistical businesses of food and livestock sectors take part within food sector and studies examining the subjects such like the information sector or logistic information systems take part under technology. As it is seen in Table 12, number of researching general total thesis is not 199, it is 188. Cause of this is that some literature searches or companies stating general logistic concept were excluded.

Table 12: Distributions of Theses According to Sectors and Subjects Researches Were Done

Research Area and Sector	**Frequency**	**Percent**
Logistics Sector Companies	64	34%
KOBI	38	20%
3PL Services	12	6%
Food	12	6%
Retailer & Supplier	10	5%
Technology	10	5%
Ports	8	4%
Service Sector	6	3%
ISO 500	6	3%
Maritime Sector	4	2%
Textile	4	2%
Customs	4	2%
Medical	4	2%
Automotive	4	2%
Warehouse	2	1%

	188	**100%**

Distributions of Theses According to Research Subjects

Distributions of theses according to research subjects were demonstrated in Table 12. Theses examining management and strategies are majority with 27%. In these theses, in general, logistic processes of any logistic company and other company were dealt and it was observed to examine the logistic processes management or strategies. In 13% part of theses, logistic operation managements of companies were examined. Total 199 theses are dealt according to their subjects, this number is 154. Cause of this is that some literature subjects mention about de facto comprehensive issues and some subjects are not demonstrated in table because they are less than 2 numerically

Table 13: Distributions of Theses According to Research Subjects.

Research Subjects	Frequency	Percent
Management and Strategy	42	27%
Operation Management	20	13%
Finance and Capital	18	12%
Performance	14	9%
CRM	12	8%
Service Quality	12	8%
Distribution Channels	8	5%
Marketing	8	5%
Outsourcing	6	4%
Competition	6	4%
Human Resource Management	4	3%
Security	2	1%
Risk Management	2	1%
	154	**100%**

CONSEQUENCE: DISCUSSION AND SUGGESTIONS

Number of university in every part of Turkey is 181 according to CHE (Council of Higher Education). It is indicator of our backwardness about logistic studies that there are 499 theses totally and 199 theses in field of social sciences among these universities. It was observed that there were not theses based on logistic and that only applications were performed upon logistic companies.

In new world order, logistic is building block that individuals, companies and countries aggregate in centre of it. It is clear to destroy the companies and countries that do not innovate. In this context, academic study that is among of sustainable growth sources, is one of important sources will help to innovation in logistic sector. With developing world, logistical achievements and powers of the great companies are started to occur. In this context, achievements and attempts of both countries and important companies about logistic investments has been continuing in our country. However, if these are transformed theses, article and publication in level of post graduate by examining, this condition will cause that the required examinations become barren and prevent to become building block in future studies. Because there are 15 sectors and subjects are discussed upon them, there are many sectors whose logistic works must be examined.

Important current issues for Turkey such as public sector, service sector, livestock, air logistic, e-logistic and reverse logistic must be researched peculiarly. If thesis areas are chosen by researches who will write logistic thesis, will be beneficial in terms of originality of studies intended to do about logistic.

Logistic over time became a function raising their importance for economy and companies. Even though reflection of this is expected in post graduate theses, it was observed that there is not any high increment trend on the basis of yeas. These conditions did not change even though number of theses closed for access was added.

Examining of logistic application especially in service and information sector is important areas, which important studies could be done for service sector that is one of the post powerful sectors of Turkey and information sectors technological applications increase day by day. However, it is clear these subjects do not have sufficient majority among these examining theses.

A great majority of post graduate theses about logistic used cross sectional data and quantitative methods, and survey method was preferred to collect data from among these quantitative methods. It is clear that other tools were not used sufficiently as data collection tool.

It is suggested that such like study could be done by Turkish academicians by scanning of it in any magazine indexed publications about logistic and consequences from this study are examined. In this context, also, it will be beneficial to compare the postgraduate articles and theses about logistic with logistic index of countries.

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A QUALITATIVE STUDY ON EXPLORING THE DETERMINANTS OF MARITIME LOGISTICS VALUE: A RELATIONSHIP MARKETING VIEW

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Abstract *– Globalization brings out considerable development and enables serious improvement of transportation and logistics with new concepts such as maritime logistics. International trade requires the main actors in maritime logistics industry to work together in a value network. This study aims to explore the main components of maritime logistics value from the view point of relationship marketing and value network. The study also investigates the main variables involved in the relationships between the main actors in maritime logistics by revealing the degree of awareness of these actors in working together. Semi-structured interviews are conducted with maritime logistics service providers located in Izmir. Main findings of the literature review are compared with the findings of the semi-structured interviews and a conceptual model based on the maritime logistics value is presented. The originality of the study lies in highlighting the relationship between related actors in maritime logistics value from the view point of relationship marketing and value network.*

Keywords– Maritime Logistics, Maritime Logistics Value, Relationship Marketing, Value Network

INTRODUCTION

The globalization of business and the evolving recognition of the importance of customer retention and market economies and of customer relationship economics, among other trends, reinforce the change for the global players of the system [8]. Lower transport costs, global networks, the improvement of logistical services, along with high performance information systems, all meet the needs of shippers which require an efficient logistical chain, in order to develop their production or distribution activities at international level [6]. The growing flows of freight have been a fundamental component of contemporary changes in economic systems at the global, regional and local scales. Logistics is about the wide set of activities dedicated to the transformation and circulation of goods as well as the related information flows and creating time and space utilities for both suppliers and customers [15]. Developing and maintaining competitive advantage is becoming increasingly difficult for maritime operators in today's hyper-competitive, increasingly complex global environment. As customer demand for more customized product and service offerings increases, individual firms and supply chains as a whole are looking for new and innovative ways to achieve competitive advantage. One way to achieve competitive advantage is through logistics and value networks [44].

In business-to-business (B2B) markets, there is a significant trend over the last few decades towards holding fewer and closer relationships and colloborative approaches [40]. By understanding the dynamics and gaps of networks sustaining long term relationships could be established in which these relationships can help supplier and customer to create higher value mutually [7]. Intensifying global competition demands corporate excellence that is no longer rooted in individual performance but in seamless interorganizational collaboration one of which could be establised through networks [18].

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LITERATURE REVIEW

Relationship Marketing

One of the very first definitions of relationship marketing (RM) was initially proposed by Berry in 1983 as: "*attracting, maintaining and - in multi-service organizations - enhancing customer relationships*" [11][22][28]. Relationship marketing implies the development of long-term relationships between the customers and the suppliers, in order to generate advantages for all those involved and to allow the co-creation of value rather than its unilateral distribution. The focus is on attracting new customers and generating as many transactions as possible. Relationship marketing aims not only at attracting but also at retaining customers and knowing them better and cretaing long lasting relatinships with them [22].

According to Gummesson (2002); relationship marketing is marketing based on interaction within networks of relationships. Rather than letting a large number of suppliers fight for contracts at lowest price, companies increasingly choose to develop intimate relationships with a limited number of suppliers. Information technology (IT) can facilitate the creation of close customer– supplier networks. The core values of RM are found in its emphasis on collaboration and the creation of mutual value. It includes viewing suppliers, customers and others as partners rather than opposite parties. RM should be more of win–win than win–lose, more of a plus sum game than a zero sum game [14]. Closer customer relationships involve proactively acquiring information from downstream customers about their needs and becoming responsive in serving them [37]. Understanding the customer's goals should enable the value offering to the customer to be better tailored to their needs [32] as well as creating mutual value.

The concept relationship marketing has emerged within the fields of service marketing and industrial marketing. In relationship marketing, one of the most important constituents of the approach is the promise concept. A firm that is preoccupied with giving promises may attract new customers and initially build relationships. Fulfilling promises that have been given is equally important as means of achieving customer satisfaction, retention of the customer base, and long-term profitability. Another important constituent of the relationship marketing concept is trust, which enables the establishment of long term relationships between parties. In relationship marketing the customer interface is broader, and the firm has opportunities to provide its customers with added value of various types such as technological, information, knowledge, social, etc. [8]. If inter-organisational interactions become closer and more frequent, all parties of the maritime logicistics could accumulate mutual trust. Such trust could make them more open. As a result, maritime operators with strong ties are more likely to share valuable and fine-grained knowledge with one another [20].

Maritime Logistics

Effective management of a logistics network has been increasingly recognized as a key factor in differentiating product and service offerings and gaining competitive advantage for firms. And in this hyper competitve world of transportation, operators could use logistics capabilities and networks as a weapon of differentiation. Maritime logistics entails the integration of logistics concepts in maritime transportation [31]. Maritime logistics concept has defined by [21] as "*...the process of planning, implementing and managing the movement of goods and information which is involved in ocean carriage".* Maritime transportation in containerised cargoes, as an integrated component within international logistics, is now regarded as a maritime logistics system which offers not only sea transport service but also additional logistics services such as warehousing, material handling, inventory, and packaging [30]. The parties of the maritime logistics system are composed of major maritime transport operators such as shipping lines (SLs), port-terminal operators and freight forwarders (FFs), which are pressured to improve their logistics value which is called as maritime logistics value; due to globalization and the success of networks by providing their services in a more efficient and effective manner. Maritime logistics involves not only the activities relating to maritime transportation, like contracting, shipping, loading/ unloading, but also other logistics services such as stripping/stuffing, storage, warehousing, packaging, repacking, repairing, inland connection and re-use and so on [20]. Maritime logistics value can be improved when the operators offer quicker, more responsive, flexible and reliable services, with a lower price. The most important constituents of maritime logistics is the identification of optimal transportation routes, the development of networks and the facilitation of door-to-door services. Developments in liner shipping services enabled ocean carriers to serve global destinations though complex maritime networks and hub and spoke systems [31]. Due to the market pressures, shipping lines have had to expand the range of their services. Liner shipping networks have been developed to fulfill customer requirements in terms of frequency, accessibility and transit times. While conducting all these operations, matitime operators also have to balance their costs and given services quality. Maritime operators expanded their service offering by becoming involved in inland transportation and logistics services [31]. Maritime operators try to improve their entire logistics performance which enables maximization of maritime logistics value and refining operators' sustainable competitiveness [36]. By adopting maritime logistics strategies, maritime operators could increase their financial and operational performances [31]. The process of maritime logistics which enables maritime logistics value was conceptualized by [21] as shown in Figure 1.

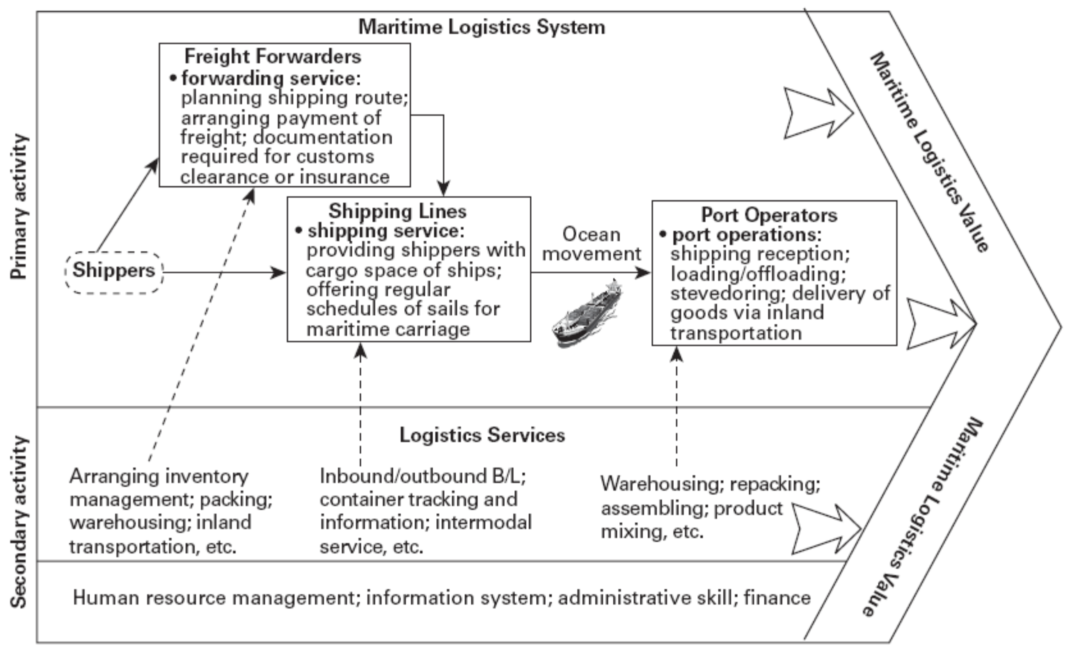

Figure 1. Maritime Logistics Process
Source: [21]

Establishing networks is a mean of creating sustainable relationship among parties of maritime logistics. These networks could be established by being vertically and horizontally interconnected to each other. The business networks of maritime logistics operators have recently become bigger and more complex and the structures and practices of the network have greatly changed. One of the most important example of mentioned integration is that shipping lines have begun to enter port terminal operations and they have then become the new competitors of the port terminal operators. Alliances and integrations among large shipping lines have facilitated the hub-and-spoke system among ports. The global expansion of shipping lines may also influence the behaviour of freight forwarders and their business relationships. Port terminal operators produce the worldwide network by globally extending their business scope and scale. So all mentioned parties have been affected by each other through these new relations of the globalization [20].

Integration of Maritime Logistics Concept with Relationship Marketing Approach

Logistics, itself is a network of relations and by using these relations, operators and parties could create sustainable competitive advantage which will be named as maritime logistics value. Creating a sustainable competitive advantage was based on the coordination of the all parties involved. Joint initiatives for acquiring, sharing and interpreting information and knowledge, and the role of the internet as a facilitator of both learning and the generation of superior customer value, are therefore of interest to corporate strategies which are the key factors of relationship approach. Efficient management of the distribution process is also data driven as information on alternative shipping routes, schedules, costs, documentation, and insurance needs to be gathered and evaluated prior to decision making. Relevant, real time data are therefore needed on financing, shipping, logistical and other activities in multiple locations around the world of the network [42].

Establishing networks, creating shared values and sustaining long-term relations enable maritime operators to be connected with such strong ties. Innovations such as containerization and IT developments have integrated all components of the chain. An integrated freight transport system requires a high level of coordination. According to the increasing degree of logistics integration, many firms and locations are bound together in material flows and value chains. In order to operate their businesses efficiently and competitively, these firms establish complex relationships that are performed by contracting (vertically or horizontally), by competition (horizontally), or, in rare cases, by co-operation [15]. By applying relationship approach in their businesses; maritime operators could create competitive advantages by establishing long-term relationships where both parties over time learn how to best interact with each other. This certainly leads to decreasing relationship costs for the customer as well as for the supplier or service provider. A mutually satisfactory relationship makes it possible for customers to avoid significant transaction costs involved in shifting supplier or service provider and for suppliers to avoid suffering unnecessary quality costs [8]. The focus is shifting from the activity of attracting customers to activities which concern having customers and taking care of them. By applying relationship marketing approach to maritime logistics, firms could create customer loyalty so that a stable, mutually profitable and long-term relationship is enhanced [33].

According to relationship marketing approach; retaining important customers is crucial to business success. Maritime operators who develop strong relationships with their customers over the long-term, where customers desire to remain with those maritime operators even when they have the opportunity to go elsewhere, possess a unique advantage over their competition [5]. Successful interorganizational relationships are critical to firms' financial performance because most firms must leverage other organizations' capabilities and resources to compete effectively. The strong ties of relationship enables related parties to acsess new markets, to gain financial support from their partner, to focus their core business and so on [26]. Maritime operators who establish sustainable relationship with their customers and partners could be also successful to enter new markets, gather financial support from their long term partner and other commercial benefits from mentioned relational ties.

As stated there is a growing recognition that collaborative relationships in business markets offer significant opportunities for maritime operators to create competitive advantages [39]. In on-going business relationships a multitude of more or less interactive contacts between maritime operator and a customer takes place. The success of a maritime operator is not only dependent on how well it manages to provide maritime logistics service to a customer but also dependent on how well time tables are kept, the timing of deliveries, how well a solution for the customer is made and maintained, etc. In addition, the maritime operator's invoicing systems, ways of handling quality problems and service failures and how other customer-influencing process are handled also have an impact on the precived value of customer. Value for a business customer does not emerge from one resource only, but from the whole spectrum of maritime–customer interactions that support a successful use of this core resource [10].

Creating Value in Maritime Logistics

In order to create unique competitive advantage, there is a need for maritime operators to figure out that their long-term competitiveness is conditioned by customer retention. In order to achieve this, there's a need to change the way the customer is perceived by implementing bilateral communication with him, by winning the customer's trust, by treating him as a partner that can contribute to value creation [22]. One of the definition of value according to [9] is: "*...a function of what a customer gets, the solution provided by an offering, and the sacrifice of the customer to get a solution*". To be able to manage the value creation in a relational context, the firm has to focus on the resources — personnel, technologies, knowledge and information, customer's time and the customer itself — as well as on the competencies of the firm to acquire and manage these resources. [20] defined value as; *"...the perceived worth in terms of the economic, technical, service and social benefits received by a customer firm in exchange for the price paid for a product offering"*.

Value is considered to be an important constituent of relationship marketing and the ability of a company to provide superior value to its customers. By using this customized value, maritime operators could sustain their customer relationship which enables them to gain a competitive advantage. By adding more value to the core product (the product quality is improved, supporting services are included into the offering, etc.) companies try to increase customer satisfaction so that the bonds are strengthened and customer loyalty is achieved [33]. Maritime operators aim to understand how customer value is identified, created and delivered so as to use these information as the next source of competitive advantage [32] . The usual approach of value-adding strategies is that the supplier adds technical product features or supporting services to the core solution so that the total value of the offering is increased. Value cannot be derived only from the core product plus supporting services but must also include the effects of maintaining a relationship [33]. In a relational context, value for the customer is not embedded in a transactional exchange of a product for money. Instead customer perceived value is created and delivered over time as the relationship develops [9] [32].

The creation of mutual value becomes the core focus of both customers and suppliers and other stakeholders in the relationship so that value is jointly created between all the parties involved in a relationship [14] [32]. As mentioned, value is a benefit of an offer or a sacrifice of a solution in which by both ways maritime operators could create mutual value for their customers in relational manner. These facts constitute an opportunity for the company to improve the customer-perceived value and thereby establish and maintain a long-term relationship. If the company can provide value in terms of reducing the customer's perceived sacrifice, so that the relationship costs are minimized and customer performance is improved. However, to be able to provide this kind of value, the company must understand the elements of customer-perceived value and how the company's activities influence (positively or negatively) customer performance [33] [43]. Sacrifices of a choice could be defined by cost of the incident. The perceived sacrifice includes all the costs the buyer faces when making a purchase: purchase price, acquisition costs, transportation, installation, order handling, repairs and maintenance, risk of failure or poor performance. The perceived benefits are some combination of physical attributes, service attributes and technical support available in relation to the particular use of the product, as well as the purchase price and other indicators of perceived quality [33].

Maritime operators have to understand the goals of their customers in order to assess the needs they require so as to offer tailored services in long term relationship setting [32]. The value created by the maritime logistics system can be defined as a maritime logistics value. Maritime logistics value is related to the extent of how well the maritime logistics system responds to the customer demands through the successful management of the flow of goods, services and information over the maritime logistics. The higher maritime logistics value would lead to the greater customer satisfaction as well as the higher performance of both individual operators and the entire logistics system [20]. By offering customized quality, maritime operators enable an other important constituent of relational approach, the customer satisfaction. The value of the maritime logistics system can be created when the customers of maritime operators become a long term partner of the operator via sustainable relationship. The more the customers are satisfied with the service, the higher the maritime logistics value is achieved [36]. Maritime operators could enable to differentiate their offerings for customers by creating mutual value. Basicly logistics value has been defined through time and space utility that it creates ability to deliver the right product in the right amount at the right place at the right time for the right customer in the right condition at the right price [44]. According to literature review, logistics creates customer value via two common indicators which are operational efficiency and service effectiveness [44] [20]. Efficiency refers to an organization's ability to provide the desired product/service mix at a level of cost that is acceptable to the customer. Effectiveness refers to an organization's ability to meet customer requirements in certain critical performance areas of logistics [44]. Relationship management strategy can be helpful for maritime logistics operators in maximising their logistics value, since the relationship-based benefits enable higher operational efficiency and service effectiveness [20]. As stated before, value could be created by either providing benefits to the customer or lowering a customer's costs [40]. Maritime logistics could create customer value via enhancing operational efficiency and service effectiveness [44] [20] or should minimize the sacrifices of customers. In the light of the literature review, maritime logistics value and its main determinants are listed in Table 1 [17, 19, 28, 36, 40].

Table 1. Maritime Logistics Value

	Maritime Logistics Value	
Operational Efficiency Reducing lead time Efficient Loading/discharging Efficient transhipment of cargoes Efficient/ Customized operations Proper equipment usage, etc. **Reducing Business Cost** Reducing logistics costs Reducing administrative costs Reducing cost associated with crew/ facilities/equipment etc.	**Service Effectiveness** Flexibility Perfect order fulfilment Proper communication Customized servcie offering Lean and agile service, etc. **Responsiveness** Give prompt services/solutions Willigness to help Timely response, etc. **Reliability** Fulfil promises Solve problems Keep records Provide services at the right time Trustworthiness, etc.	**Minimizing Sacrifices** Minimize wrong/ delayed delivery Minimize accidents/breakdowns Minimize inaccurate information Minimize incorrect service assignment, etc.

Source: adapted from [17, 19, 28, 36, 40]

Maritime operators have started to realize the needs and requirements of the diverse and varied customers and logistics function has the potential to turn services into value-added solutions for those customers [44]. Maritime logistics could create customer value via enhancing operational efficiency and service effectiveness so that the system can satisfy the demands of the customers. The extent to which the maritime logistics system meets those requirements is referred to as maritime logistics value, and enhancing the maritime logistics value has recently become a significant strategic consideration that maritime logistics operators should take on board in their daily operations and management. This is because a higher maritime logistics value would lead to greater customer satisfaction; as a result, the higher maritime logistics value may facilitate the higher performance of both individual maritime operators and the entire logistics system [20].

METHODOLOGY

Maritime logistics value could be created by benefits via increasing operational efficiency and service effectiveness of the offer or by minimizing the potential sacrifices of the offer. This study aims to understand the current perceptions of the container shipping lines and the freight forwarders, namely the maritime operators through an exploratory research. Semi-structured interviews are employed in order to explore the maritime logistics value determinants by focusion of the views and perceptions of two critical parties in maritime logistics operations, namely freight forwarders and container shipping lines. Semi-structured interviews are categorised between the structured and unstructured types of interviews. They are widely accepted and preferred which may be due to *“the expectation that the interviewed subjects’ viewpoints are more likely to be expressed in a relatively openly designed interview situation than in standardised interview or questionnaire”* [4]. In semi-structured interviews, the researcher has a list of themes and questions to be covered, although these may vary from interview to interview. The reasons for using this type of interview are that they provide flexibility in that the content and number of the questions may be changed from one party to another if required. The main reason behind using semi-structured interviews in this study is for collecting data (excavation) and for exploratory reasons since the main area of the study, maritime logistics value, is specific and unexplored. The authors prepared an interview guide in advance in order to guide the interviewee during the interviews. A sample of the questionnaire is given in Appendix 1. Since the sequence of questions plays an important role in the success of the interview, the authors preferred the use of broader issues such mutual value, relationship value, maritime logistics value, value-added services etc. According to the feedback from the interviewee, the authors arranged the flow of questions during the interviews.

Content of the semi-structured interviews is prepared in accordance with the main literature on maritime logistics, relationship value and relationship marketing. In addition, the main variables shown in Table 1 are cosnidered in the preparation of the interview guide. The main components incorporated in the study are basically extracted from the relationship and value-related marketing literature. Moreover, the characteristics and the dynamics of both the freight forwarders and container shipping lines were considered in accordance with the maritime logistics value concept. Table 2 shows the main components of each question in the semi-structured interview guide. From the literature review enhancing sustainable relationship depends on how good a maritime operator could serve its customers as a trading partner. In order to be successful, operators could adopt relationship marketing approach for increasing preceived service value of its customers. Table 2 shows the main determinats employed in the semi-structured interviews.

Table 2. Contents of Semi-Structured Interview Form

Question Numbers	Components in the Interview Guide
Question 1	Mutual Value
Question 2	Customer Value
Question 3	Relationship Value
Question 4	Relationship Approach
Question 5	Maritime Logistics Value
Question 6	Maritime Logistics Value – Operational Efficiency
Question 7	Maritime Logistics Value – Service Effectiveness
Question 8	Maritime Logistics Value – Minimizing Sacrifices of the Customers
Question 9	Value Added Services
Question 10	Relationship Communication
Question 11	Value Network

Exploratory research framed by semi-structured interviews included 16 maritime operators located in Izmir. While 9 of the interviewed companies were freight forwarders, 7 of the interviewed companies were container shipping lines. Semi-structured inteview was used in this research for reaching major beliefs, opinions and experiences of maritime operators in managing their relations with customers while creating maritime logistics value. Face-to-face interviews were executed in Izmir in which maritime operators were choosen via convenience sampling and snowball sampling. Convenience sampling involves selecting haphazardly the cases that are easiest for the researcher to obtain for the sample. Since it was agreed by the authors that the study has exploratory characteristics in terms of understanding and indentifying the maritime logistics value, the use of non-probability sampling was considered adequate. Convenience sampling was used in accordance with the contacts of the authors and the authors accessed some companies which were conveniently available. Also snowball sampling was used in which the contacted respondents suggested other potential respondents who could contribute to the study. This was not thought to affect anonymity negatively because only few participants suggested other respondents and responses of all the participants were kept confidential. Selected companies were contacted and the aim of the interview was briefly explained by phone before conducting the interviews. Duration of the interviews was between 15 to 60 minutes. In terms of anonymity, the names of the individuals interviewed were kept secret due to confidentiality issues. Voice recording was permitted only in two interviews so that mostly the notes taken during the interviews were critical. While 14 participants are recruited in marketing and sales departments of the companies who are directly engaged with customers, 2 participants are branch managers of global operators' Izmir offices.

FINDINGS

Maritime logistics which is the process of planning, implementing and managing the movement of goods and information involved in the ocean carriage, is concerned with the development of close relationships between related parties involved in maritime transport and logistics management. [21]. In the light of the literature review, the study aims to figure out maritime logistics value from the view of the relationship marketing. Value is an important constituent of relationship marketing. Maritime operators could create sustainable logistics value through good relational ties. In order to establish good relationship with customers, operators have to understand the needs and desires of their customers. Without understanding the customer, maritime operators could not create tailored solutions for their customers. In the question regarding how the parties create mutual value, similar approaches from shipping lines and freight forwarders are observed that creating common goals with customers, good relationship establishment and also good service quality for customers are dictated as the most important determinants for obtaining mutual value. The next question is about establishing customer value different than the competitors. It was observed that while shipping lines create customer value through tailored services and customer segmentation, creation of customer value depends on worldwide offices and available equipments from the view point of freight forwarders. Creating a relationship value with customers and sustaining long term relationships with them are seen as common target for both shipping lines and freight forwarders. In order to gain and sustain mentioned relations, maritime operators indicate such main factors as; transparent service for customers, regular and reliable ship programs, corporate reputation, tracking and tracing of cargo, friendly and problem solving approaches for customers and accessible operator and mutual profit approach.

In terms of understanding the view of interviewed parties regarding the maritime logistics value, a question on maritime logistics value is added to the interview form. It is seen that maritime logistics value is perceived quite different by shipping lines and freight forwarders. Moreover, nearly all the respondents do not have a common understanding of "maritime logistics" and "maritime logistics value". This may be due to the fact that "maritime logistics" is a new term used in the shipping industry. Shipping lines have strong global network and partnerships which enables service differentiation for their customers. By serving different alternatives, shipping lines create their own logistics value. Freight forwarders usually use suppliers' services and equipments to serve their customers which sometimes cause problems in their service offerings. But these problems strengthen their problem solving abilities and creating fast solutions for their customers. In terms of operational efficiency, participants mostly mentioned similar cost reduction and efficient operational approaches through, fast return to customer desires, using charted ships/equipments/trucks instead of owning them, new IT systems, internal harmony of departments and good information flows etc.

Service effectiveness is mentioned and defined according to these service characteristics: reliable ship arrival/departure/schedule, transit waiting times, timely/correct documentation, special service equipment for special cargoes, special training for customers and direct-nonstop service offers. Both parties concentrated on the importance of these factors in increasing service effectiveness. Another question regarding the maritime logistics value is about minimizing the sacrifices. The common points that operators insist on are; offering alternative/fast solutions, consulting customers for shipping routes/services/international regulations, reducing equipment availability problems, accurate invoicing, reliable booking, on-time and accurate documentation amendments. Shipping lines grant guarantees to their customers to compansate suppliers fault and grant an extension for due time more than freight forwarders could.

Value added services for customers in the next question also shows similar solutions and offering such as: offering all kind of logistics services and tailored services for special cargoes etc. Since communication is the key component in relationship marketing and it is also considered as an important determinant for the creation of maritime logistics value, a question regarding the ways of communication with the customers is asked to the participants. Both shipping lines and freight forwarders care to be an accessible operator for their customers. They all invest high IT technologies to create frindly web sites/ cargo tracking systems/ telecommunication systems for their customers. Their sales and marketing departments coordinate customer visits periodically for better serving and problem solving.

Value network is discussed as the final question in semi-structured interviews. Shipping lines are very interested in creating mutual value networks with their competitors via alliances, partnership agreements, mutual service offerings and slot charters. With working together; they access new markets, enables diversification of their services and reducing their operational costs. However, freight forwarders mostly do not provide any mutual service offerings, partnership agreements or even mutual equipment usage. According to freight forwarders working with their competitors is not ethical. Freight forwarders could only be customers or suppliers for one another, which enables data protection.

Shipping lines and freight forwarders also point out that available equipment, tailored services, new information technologies which enable accurate information flow between parties are the most strong weapons of the operators. With regular customer visits and via special care and interest; operators create sustainable and strong relationships with their customers. The operators all insist on that offered service to the customers from shipping lines or forwarders are not quite different from each other. The differentiation lies under the problem solving ability and relationship management techniques. Maritime logistics customer needs global network, timely and faultless transhipment for their cargoes. In case of any problem through any part of the shipment; offering proper solution, consulting appropriate alternatives can shape operators relational ties.Maritime operators also point out that the cost of maritime logistics services is not a strong selection criterion for most of the customers. Today's informed customers need special care, accessible system, timely and accurate information flow about their cargoes and operations, service quality, effective consultancy for special cargoes and for changable charges and sincere problem solving on behalf of them. The results obtained through the interviews in addition to the discussed findings, could be highlighted as follows:

- The responses obtained are quite similar with the relevant literature in general. Maritime operators in Izmir are very sensitive about establishing long term relationship with their customers. They all try to retain their customers with special offers and loyal, reliable, transparent relationship establishment.
- Relationship management is seen as creating differantiation in today's transportation and logistics activities. Customer retention through strong relational ties is targeted results from the operators point of view.
- Creating and sustaining strong relational ties needs strong and skillful sales departments, update and friendly information technologies, new equipments, granting financial convenience, proper transit waiting time, global service networks that enables shipping lines and forwarders to reconstruct their systems. According to the findings of the interview answers mentioned table of the maritime logistics value can be restructured as shown Table 3.

Table 3. Restructured Maritime Logistics

	Maritime Logistics Value	
Operational Efficiency Reducing lead time Efficient Loading/discharging Efficient transhipment of cargoes Efficient/ Customized operations Crew/personel training Proper equipment usage, etc. **Reducing Business Cost** Reducing logistics costs Reducing administrative costs Customer segmentation Customer orientation e- service offering Mutual services with competitors Reducing cost associated with crew/ facilities/equipment etc.	**Service Effectiveness** Flexibility Perfect order fulfilment Proper communication Customized service offering Accessible sales representative Know how of the operator Friendly IT systems Inter and intra harmony between departments Consultancy for cargoes Global service network Lean and agile service, etc. **Responsiveness** Give prompt services/solutions Willigness to help Proper alternative offerings Timely response, etc. **Reliability** Fulfil promises/Solve problems Provide services at the right time Risk sharing Create mutual goals Corporate reputation After sales services Service range of the operator Transperent and sincere relations Trustworthiness, etc.	**Minimizing Sacrifices** Minimize wrong/ delayed delivery Minimize accidents/breakdowns Minimize inaccurate information Minimize incorrect service assignment Minimize incorrect invoice/documentation Minimize improper communication Minimize expire certificates Minimize crew/personel faults Compensate suppliers fault Timely amendments Minimizing wrong labeling/barcoding,etc

Source: adapted from [40] [28] [17] [36] [19]

Limitations and Future Research Directions

The research has some limitations and further research into this area should be extended. Since it is observed that "maritime logistics" is a very new concept both in practice and the literature, this study is designed as an exploratory research in order to provide an insight to the field and understand the main views and perceptions of related parties. As the first limitation of the study, it can be mentioned that all the respondents in the study did not have a common understanding of "maritime logistics" and "maritime logistics value". Although the authors made related explanations regarding maritime logistics concept during the interviews, it was observed that the participants did not have a clear perception and understanding of the concept and this may limit their contribution to the study. Although the relationships between the port operators, shipping lines and the freight forwarders are mainly discussed within the concept of maritime logistics value, this study only focused on freight forwarders and shipping lines. Due to time limitation, port managers are not included into the sample of the study. Many employees especially from the marketing and sales departments of related companies are contacted, however 16 participants are interviewed. This may be due to summer season, work overload of the participants etc. This may be considered as another limitation of the study.

Since this study is an exploratory research, there is room for many research methods to be applied for the further studies. Empirical studies investigating the relationship between the main variables discussed in the study can be suggested. Survey studies applied only for the freight forwarders, shipping lines or ports through the investigation of the main variables employed in relationship marketing and maritime logistics value concepts can also be suggested. Since "maritime logistics" is a new concept and needs to be explored in detail, focus group studies incorporating various participants from maritime logistics environment such as ports, freight forwarders, shipping lines, shipping agencies, logistics service providers etc. can be employed. The relational ties between port managers, shipping lines and forwarders can be the subject for further research.

Appendix 1 – Questions of the Research

1- How 'mutual value' is created with your customers? What are the most important constituents of mutual value ?
2- How could you establish 'customer value' different than your competitors ?
3- What does 'customer relationship value' means for your company ?
4- What are the main aprroaches that your company use for creating long term relationship with your customers ?
5- What does 'maritime logistics value' mean for your company ?
6- What does 'operational efficiency' mean for your company ? Does it enable value creation for your customers ?
7- What does 'service effectiveness' mean for your company ? Does it enable value creation for your customers ?
8- Does minimizing sacrifices enable value creation for your customers ?
9- What are value added services that your company offers ?
10- What are your communication ways with your customers ? Are these ways enough to sustain long term relationship with your customers ?
11- Has your company established a 'value network' with the competitors ?

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THE THIRD PARTY LOGISTICS FIRM SELECTION USING OF AHP-PROMETHEE METHODS

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Abstract – The third party logistics involves the use of external companies to perform the firm's logistics activities in part or the whole. The third party logistics has become a widespread practice among firms. It is therefore very important to choose the most appropriate the third party logistics firms with a model which is effective and implementable. However, choosing a proper the third party logistics firm is a kind of Multicriteria Decision Making problem, which requires considering a large number of complex factors. In this study focused on the selection issue of third-party logistics firm. The decision making criteria are determined through utilising the preliminary interviews with firms in the sector and the literature review on supplier selection. To find in the solution of the problem analytic hierarchy process method and PROMETHEE sorting methods were used. Criteria were weighted by the analytic hierarchy process. In the last stage for firm candidates PROMETHEE sorting method has been used and the most suitable candidate has been selected.

Keywords – The Third Party Logistics, Firm selection, Multicriteria Decision Making, AHP, PROMETHEE

1. INTRODUTION

In globalling market conditions, costs and competition of the companies has become an important factor for the logistic transations. Selection of the Third Part Logistics (3PL) providers is vital for the firms. Apart from the traditional works of the companies, making some or all logistic issues with the help of outsourcing can be explained as the 3PL [1]. Logistic services offered by third party providers of logistics services, is widely used today. Total cost is an issue often discussed in the logistics outsourcing in recent years to minimize and maximize the efficiency of resource use [2]. 3PL company selection should be made taking into account several criteria. Therefore, the selection of multicriteria decision-making firms (MCDM) methods are widely used. The most widely used multicriteria decision-making methods; Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), TOPSIS, ELECTRE, VIKOR and PROMETHEE [3]. In this study, selection of 3PL firms in the retail sector is made with using AHP and PROMETHEE methods. AHP is applied with weighted selection criteria which are affecting the company. PROMETHEE method is evaluating to decide the appropriate order from the alternatives. This paper is organized as follows; 3PL firm selection has been told in second chapter. In the third section, AHP and PROMETHEE Methods are explained which MCDM procedure briefly. In fourth section, studies are investigated about selection of the 3PL firms. Case study is told in fifth section. Finally, case study and forthcoming studies is explained in sixth section.

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2 - SELECTION OF THE THE THIRD PARTY LOGISTICS FIRM

3PL concept is developed as a consequence of requirements of transportation for the customers widely. Basicly, 3PL can be explained as transportation and logistics activities of the sender of goods or merchandise delivery area instead of the company described as the outsourcing to foreign companies [4]. Third-party logistics companies sustain many logistics activities. These activities can perform limited or completely combined with more complicated. Performed major outsourcing activities can be listed as follows [5]: transportation, warehousing, cargo consolidation and distribution, product marking, labeling and packaging, inventory management, traffic management and fleet operations, freight payment and auditing cross-shipment (cross docking) harvesting 18, order management, packaging, carrier selection and so on. Supplier selection process is formed like several steps; evaluation of the aim, criteria selection, preevalution of the criteria and final assesment.

3. MULTICRITERIA DECISION MAKING METHODS

Focusing on conclusion with only single goal on decision problems, is very effective for reaching the result easily. However, problems related with study about facing with not only single goal but also multiple goals. Numerous methods in the time to reach the optimal solution value for multiple purposes have been developed. These methods are commonly referred to as multicriteria decision-making methods name.

3.1. AHP Method

AHP method is a MCDM technique which is developed in 1977 by Thomas L. Analytic hierarchy process can be understood by managers because of the hierarchical visualization on complex, multi-person, multicriteria problems. Selection process is used for qualitative and quantitative criteria to determine the relative importance of each decision criterion of the transmitter and then choosing between alternatives based on the decision based on any criteria. The steps of the Analytic Hierarchy Process Many applications which form is given below [6]:

Step 1: Create Hierarchical Structures
Step 2: Identification of Priority
Step 3: Bilateral Comparison Matrix and Solution
Step 4: Normalization and Relative Importance Weights
Step 5: Calculation of Consistency Rate
Step 6: Determination of the Final Order

3.2. PROMETHEE Method

PROMETHEE is decision making method developed in 1982 by Brans. Method determines the main stage to the decision point of order, Promethean I (partial order) and Promethean II (full sequence). According to the decision point Prometheee method of assessment is based on binary comparison factor. But the main difference from other multiple decision-making process, as well as indicating the level of importance of the relationship between the weights of each evaluation factor is the evaluation of each factor to consider its own internal affair [7]. PROMETHEE method is a simple method, compared to other multi-criteria decision-making methods in terms of scope of application, can be adapted to a number of criteria that can be expressed with the actual values. PROMETHEE method consists of seven steps [8]:

Step 1: Creating a Data Matrix: w = (w1, w2, ..., wk) k with weights by c = (f1, f2, ..., fk) as assessed by alternative = (a, b, c, ...) for data matrix is created as in Table 1.

Table 4. Data Matrix

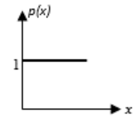
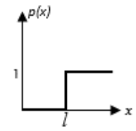
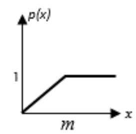
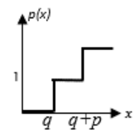
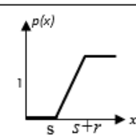
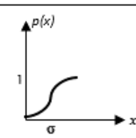
		Evaluation Factors				
		f_1	f_2	f_3	…	f_k
Decision Points	A	f_1(A)	f_2(A)	f_3(A)	…	f_k(A)
	B	f_1(B)	f_2(B)	f_3(B)	…	f_k(B)
	C	f_1(C)	f_2(C)	f_3(C)	…	f_k(C)
	…	…	…	…	…	…
Weights	w_i	w_1	w_2	w_3	…	w_k

Step 2: Identifying the Preferred Functions for Criteria: 6 different preference function are shown in Table 2 which is used to calculate in the practice.

Preference Function and Threshold Type (p, q and s) selection can be depend on by the nature of criteria and buyer firms' species. Some rules for the selection of the correct choice of the function determined by the nature of the criteria is as follows: [9]

- V-type (type 3) and Linear (Type 5) preference functions is the most appropriate for quantitative criteria (price, cost, power, etc.). V-type is a special case of the linear things selection indifference threshold depends on the use.
- Ordinary (Type 1) and Level (Type 4) preference function is suitable for the qualitative criteria. In the case of a low number of criteria scale level (eg yes / no to the criteria or five-point scale) and different levels are quite different from each other, the usual preference function will be a good choice. If the smaller ones, are desired to distinguish deviations from large, level of preference functions would be more efficient. -Type (Type 2) is to miss a state preference with the function level and rarely used.
- Gaussian (Type 4) function is not used very often preferred for complex parameters (s threshold; q is somewhere between indifference threshold and choosing p threshold).

Table 5. Preference Functions

Type	Parameters	Function	Graph, $p(x)$
Type-I (usual)	-	$p(x)=\begin{cases}0, & \forall x \leq 0\\ 1, & \forall x \geq 0\end{cases}$	
Type-II (U-type)	l	$p(x)=\begin{cases}0, & x \leq l\\ 1, & x \geq l\end{cases}$	
Type-III (V-type)	m	$p(x)=\begin{cases}x/m, & x \leq m\\ 1, & x \geq m\end{cases}$	
Type-IV (level)	q,p	$p(x)=\begin{cases}0, & x \leq q\\ \frac{1}{2}, & q < x \leq q+p\\ 1, & x > s+r\end{cases}$	
Type-V (Linear)	s,r	$p(x)=\begin{cases}0, & x \leq s\\ (x-s)/r, & s < x \leq s+r\\ 1, & x > s+r\end{cases}$	
Type-VI (Gaussian)	σ	$p(x)=\begin{cases}0, & x \leq 0\\ 1-e^{-x^2/2\sigma^2}, & x \geq 0\end{cases}$	

Step 3: Determination of Common Preference Function: Schematic representation of the common function set for the preferred alternative are given in Figure 1, For alternative A and B common preference function is determined by Equation (1).

$$P(a,b) = \begin{cases}0 & , f(a) \leq f(b)\\ p[f(a)-f(b)] & , f(a) > f(b)\end{cases} \quad (1)$$

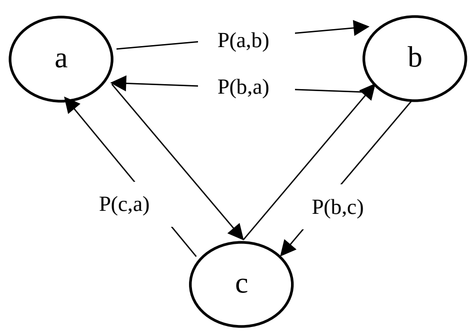


Figure 1. **Schematic Diagram of Common Preference Function**

Step 4: Determining the Preferred Index: Common preference functions can be determined choice index for each pair of alternatives. W (i = 1,2, ... k) evaluated by the criteria having the weight k, a and b alternatives are calculated by preferred index with Equation (2).

- $\pi(\mathrm{a,b}) = \frac{\sum_{i=1}^{k} w_i * P_i(a,b)}{\sum_{i=1}^{k} w_i}$ (2)

Step 5: Verification of Superiorities Positive ($\boldsymbol{\Phi^+}$) and Negative ($\boldsymbol{\Phi^-}$) for Alternatives: A rule for alternating positive and negative dominance are shown schematically in Figure 2, Positive dominance is calculated by Equation (3), and negative dominance is calculated by of Equation (4).

- $\Phi^+(a) = \frac{1}{n-1}\sum \pi(a,b)$ (3)
- $\Phi^-(a) = \frac{1}{n-1}\sum \pi(b,a)$ (4)

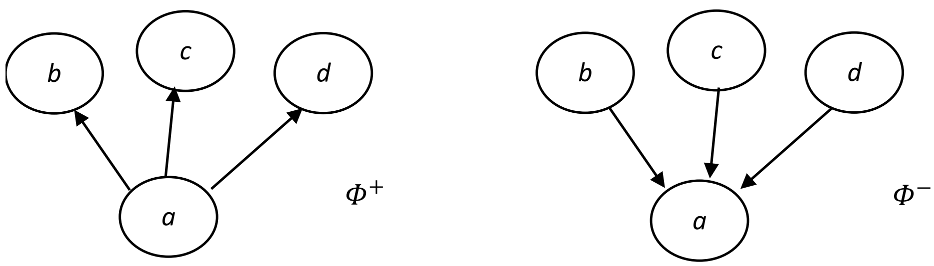


Figure 2. Calculated Positive and Negative Rule for the Alternative A

Step 6: Determination of Partial Priority for Alternatives with PROMETHEE I: Partial priorities, according to another alternative preferred status as identical and the alternative which allows the identification of alternatives which can not be compared with each other. The determination of two alternatives for priorities such as a and b, the situations are mentioned below.

I. Situation: If either of the following circumstances is providing, a alternative is prefered to the b alternative.

- Φ^+(a) > Φ^+(b) ve Φ^-(a) < Φ^-(b) (5)
- Φ^+(a) > Φ^+(b) ve Φ^-(a) = Φ^-(b) (6)
- Φ^+(a) = Φ^+(b) ve Φ^-(a) < Φ^-(b) (7)

II. Situation: If the condition is provided below, a alternative and b alternative have no difference.

- Φ^+(a) = Φ^+(b) ve Φ^-(a) = Φ^-(b) (8)

III Situation: If any one of the following conditions is provided, a alternative cannot be compared with b alternative.

- Φ^+(a) > Φ^+(b) ve Φ^-(a) > Φ^-(b) (9)
- Φ^+(a) < Φ^+(b) ve Φ^-(a) < Φ^-(b) (10)

Step 7: Determination of the Strict Priority for a Alternative with PROMETHEE II: The following equation is calculated with the help of exactly the priorities for each alternative. Calculated values of all alternatives with full priority ranking is determined by assessing precisely the same plane.

- Φ(a) =Φ^+ (a) - Φ^-(a) (11)

Depending on the exact priority value calculated for a and b are two alternative decisions are given below.

- Φ(a) > Φ(b) in case, a alternative is more superior,
- Φ(a) = Φ(b) in case, a and b alternatives are identical.

4. LITERATURE REVIEW

Aguezzoul et al. [10] are proposed a structure using the ELECTRE method to evaluate the most appropriate 3PL companies can apply and practice managers to select, used and applied fairly easy. Bottani ve Rizzi [11] have proposed a decision support system based on the fuzzy TOPSIS method for selection of 3PL firms. Zhang et. al. [12], Karagül and Albayrakoğlu [13], Göl and Çatay [14], Fu et al. [15], have used the AHP to select the most appropriate service provider. Qureshi et al. [16] have developed a model that uses both the AHP and TOPSIS method to evaluate the performance of the logistics service provider. Işıklar et. al. [17] have introduced a real-time approach to effective decision-making 3PL evaluation and selection in a fuzzy environment. Huo and Wei [18] have used in their study; AHP, Entropy method and Gray system method, for use with their choice of 3PL companies. Chen et al. [19] in order to fulfill the ideal 3PL operating model have suggested that the ANP. Efendigil et al. [20] in their study, aimed at helping decision-makers based on artificial neural networks and fuzzy logic using a two-phase model with efficient "best fit" in the election logistics provider. Çakır et. al. [21], have used the BET method to select the best 3PL companies. Bhatti et al. [22], configured fuzzy analytic hierarchy process for selecting the most appropriate 3PL service provider (BET) proposed method. Vijayvargiya and Dey [23] have used logistics capability addressing the company's reputation and service quality as the main criteria, they proposed a model based on AHP decision making structural basis in their study. Guoyi and Xiaouhua [24] logistics service providers evaluated in the study and provided the most appropriate choice of 3PL companies. Aktepe and Ersöz [25] have used the fuzzy analytic hierarchy process in choosing logistics provider. Ye and Liu [26], choose the most appropriate 3PL companies, presented a model with using balanced scorecard system and Goal Programming (GP). Ravi [27] has chosen 3PL firms from using the most ideal method with AHP and TOPSIS. The choice of logistic suppliers, Özbek and Eren [28], [29] have used the AHP and ANP. in the study; quality, long-term relationship, identifying the criteria and operational performance of the company image. Cooper [30] have been organized at work; in terms of taking measures for the 3PL supply chain performance and post-production and ongoing events starting with the delivery of the goods to customer distribution centers. He verified the weight used in the performance evaluation are determined by AHP. Hsu and Liou [31] has proposed a hybrid multi-criteria decision model for the outsourcing provider of choice.

5 - CASE STUDY OF SELECTION OF THE 3PL COMPANY

In this study, selection of the 3PL companies is made by operating in the retail sector. The application's steps are indicated in Figure 3. Problem is solved as shown in Figure 3. in the third stage.

Stage 1: In this study, a company's outsourcing preference is discussed which is operating in the retail sector. Alternative firms is defined as Firm A, Firm B, Firm C and Firm D. By taking into account the company's request and studies in the literature; cost, delivery performance, information technology, quality and has been identified as a long-term relationship.

Cost (C): The cost of services is an important criteria in the selection of third-party logistics. In this ultra-competitive environment, carriers; short delivery time, delivery service, monitoring and follow-up and so on. While demand for value-added services at the same time as they search for less cost. Thus the cost of the services has become a major concern.

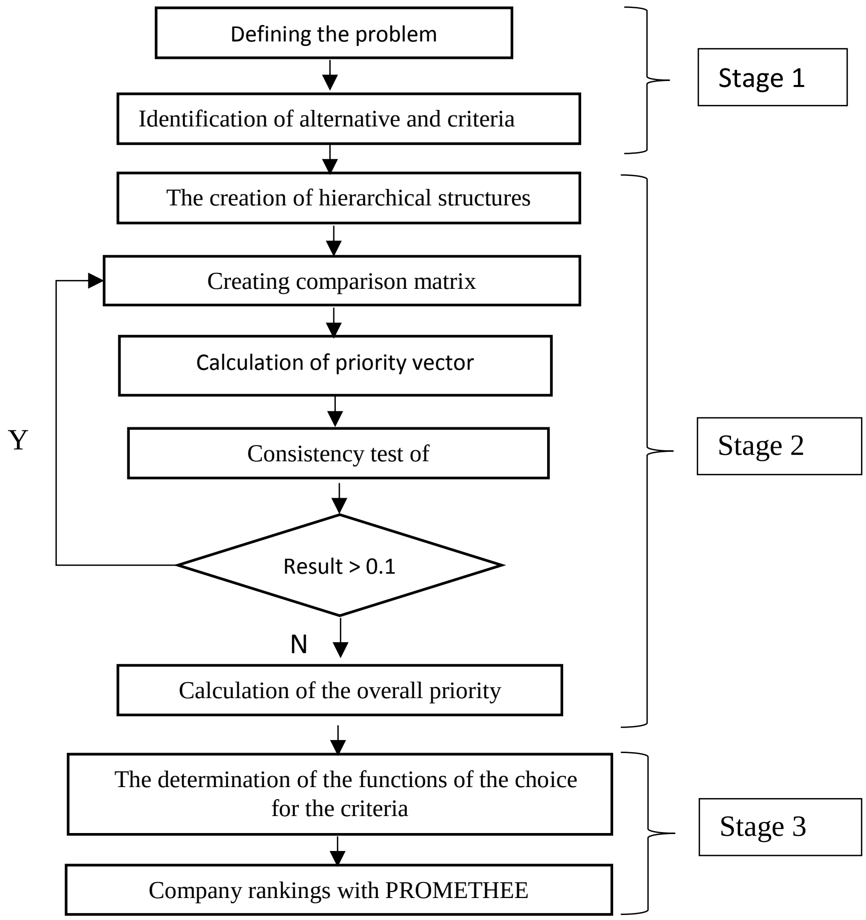


Figure 3. Flowchart

Delivery Performance (DP): Delivery on Time and Quality Service plays an important role in the strength of the supply chain. Supply performance of third-party logistics companies to increase their market share of the company and the rule of competition as they allow the removal of the harsh conditions in this level. This performance is proportional to the market share it can be said. And flexibility in the delivery operation, the supply of third-party logistics companies to improve their performance. These factors are important for the company in terms of seeing what level they can respond to changing market conditions. Delivery Performance is an important attribute to be considered in the selection of third-party logistics provider.

Information Technology (IT): This criterion occupies an important place in the selection of third-party logistics provider. The ability of information technology can increase some of the company through special programs (withdrawal via Resource Planning, Electronic Data Transfer, Simulation Software, Vehicle Routing Systems, Conveyor Installation Optimization Tools, etc.). Some hardwares like; Servers, network, and Internet / intranet connections, radio frequency identification devices (RFID), barcode printers and scanners, global positioning system (GPS) satellite tracking devices and so on, simplify procedures and can be used to increase productivity [13]. Improved IT capacity can also result in a reduction of service costs in the long term [5].
Quality (Q): Quality plays an important role in value-addition in products [8]. These factors led to a significant widening of third-party logistics alliance and have contributed to the development of metering systems.
Long Term Relationship (LTR): In today's market conditions, firms act with caution when selecting suppliers to work together. The company is working with the appropriate profile for the performance of suppliers is growing

in a positive direction. If the supplier work with poor and weak, this situation affects and impairs company also processes [33]. Companies working together for achieving harmonization process is long structure has been adapted to each other. This situation brings success.

Stage 2: Calculation with AHP

The second stage is determined by the AHP weights of the criteria. Steps of the procedure are shown below.

Step 1: Creating a Hierarchical Structure: The criteria involved in the study was determined based on studies in the literature as shown in Figure 4.

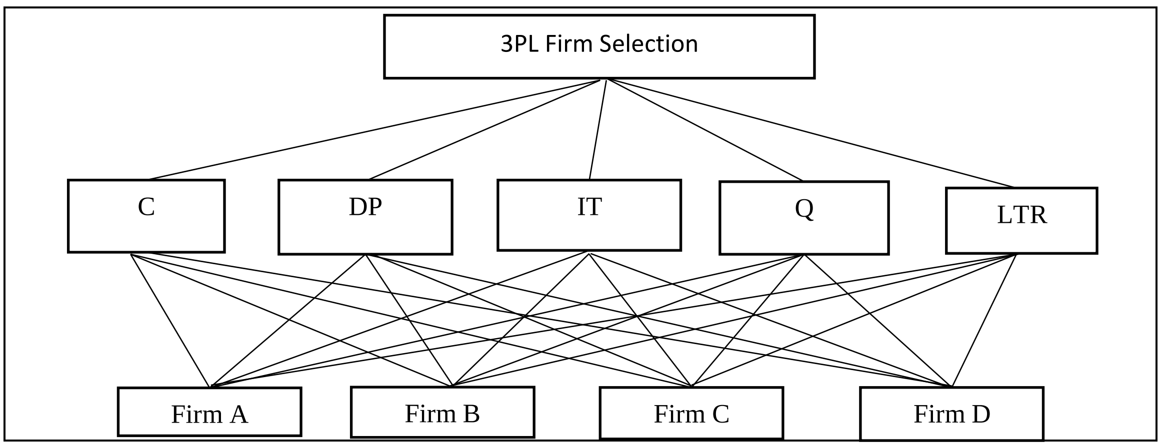


Figure 4. Hierarchical Structure

Step 2: Determination of Priorities: After the problem is expressed as a hierarchical model are compared with each other elements that make up the existing hierarchy and the weight is determined. In practice, "1-9 scale" is used developed by Saaty to make comparisons, which is shown in Table 3 [32].

Table 6. Saaty's "1-9 Scale"

Intensity of Importance	Definition	Explanation
1	Equal Importance	Equal Importance Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Step 3: Bilateral Comparison Matrix and Solution: Pairwise comparison matrix are shown in Table 4.

Table 7. Comparison Matrix of Criteria

Criteria	C	DP	IT	Q	LTR
C	1,000	3,000	4,000	2,000	3,000
DP	0,333	1,000	3,000	1,000	2,000
IT	0,250	0,333	1,000	0,143	3,000
Q	0,500	1,000	4,000	1,000	5,000
LTR	0,333	0,500	0,333	0,200	1,000

Step 4: Normalization and Relative Importance Weights: The generated binary comparison matrices are normalized in to this step. Normalized operation is obtained by dividing the column values where each element. The resulting normalized matrix is shown in Table 5.

Table 8. Normalized Matrix

Criteria	C	DP	IT	QS	CP
C	0,414	0,514	0,324	0,461	0,214
DP	0,138	0,171	0,243	0,230	0,143
IT	0,103	0,057	0,081	0,033	0,214
Q	0,207	0,171	0,324	0,230	0,357
LTR	0,138	0,086	0,027	0,046	0,071

Once this is done, line weights in Table 6 is determined by taking the average. Weights are obtained by multiplying the corresponding priority vector comparison matrix.

Table 9. Weighted Matrix of Criteria

Criteria	Weights
C	0,385
DP	0,185
IT	0,098
Q	0,258
LTR	0,074

Step 5: Calculation of Consistency Rate: This step is calculated by the consistency of the results. Consistency rate used in calculating the randomness index is determined using randomness index in Table 7.
CI= Consistency Index =$(\lambda_{max} - n/(n-1))$, RI= Randomness index

Table 10. Number of Randomness Index

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Randomness Index	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57

$$CR = consistency\ rate = \frac{CI}{RI} = \frac{(\lambda_{max} - n/(n-1))}{RI}$$

Comparing the consistency of the criteria; CI=$\frac{5{,}328-5}{5-1}$=0,082 RI=1,12 (because of n=5)

CR=$\frac{0{,}082}{1{,}12} = 0{,}073$<0,10 Our conclusion is consistent.

Table 11. Data Matrix

	Alternatives						
	Firm A	Firm B	Firm C	Firm D	w_i	Max/Min	Preference function
C	5$	3$	4$	6$	0,385	Min	Lineer
DP	Bad	Average	Good	Good	0,185	max	Level
IT	Average	Good	Average	Very Good	0,098	Max	Level
Q	Good	Very Bad	Good	Good	0,258	Max	Level
LTR	Average	Very Good	Very Good	Good	0,074	Max	Level

Stage 3: Calculation with PROMETHEE

Ranking of companies with the PROMETHEE method is performed in the third stage.

The data obtained by the Visual PROMETHEE program is as shown in Table 9.

Table 12. Positive and Negative Superiority of Alternatives

	Firm A	Firm B	Firm C	Firm D
Φ^{+}	0,0428	0,0378	0,0866	0,1068
Φ^{-}	0,1038	0,1284	0,0163	0,0255

Partial sequence, which is made with PROMETHEE I, is shown in Figure 5. According to PROMETHEE I results, Firm C and Firm D are superior to Firm A and Firm B. Firm A is superior to Firm B. there is no advantage between Firm C and Firm D.

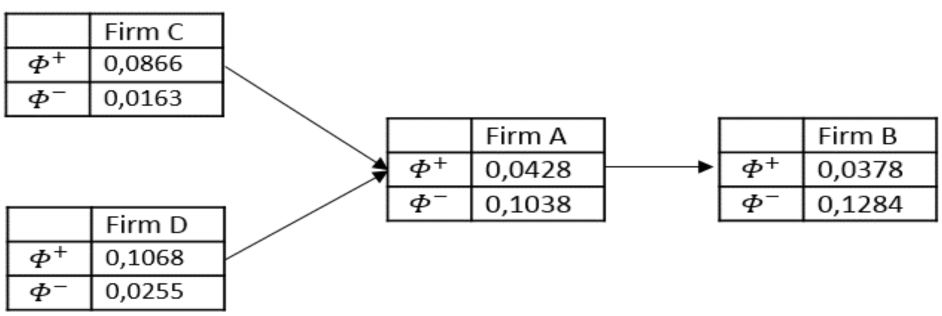


Figure 5. Ranking with Promethee I

PROMETHEE II complete ranking by Figure 6 is shown. According to the results PROMETHEE II, Company D has been identified as the most suitable provider.

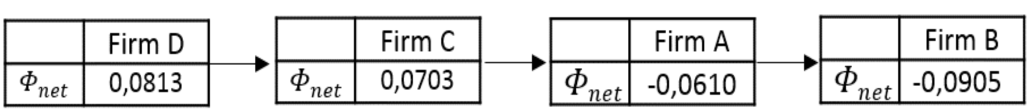


Figure 6. Ranking with Promethee II

6. CONCLUSION

Make the right decision for the future of the outsourcing company is very important. The aim of the present conditions in the company in a highly competitive environment is to use all resources efficiently. Companies want to use these resources efficiently, and they want to meet customer requirements fully and completely [34]. The prospects of companies in the studies aimed to select an appropriate service provider consideration. First, the criteria are determined by the requested of company. Then alternatives are weighted with AHP. Alternatively, the four companies listed with PROMETHEE method considering the weights determined by AHP. In the future, different multi criteria decision making methods can be examined.

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RISK CLASSIFICATION IN SUPPLY CHAIN MANAGEMENT

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Abstract − *In recent years, supply chains became highly vulnerable against any disruption. In literature, several reasons are submitted to explain the reasons behind. In our research, we determined the drivers of supply chain risks studied in the academic world. Then they are classified in the context of importance. Following this, risk categories in the literature is analyzed and a new classification is proposed. In order to understand the importance level given to these risk categories by Turkish Supply Chain Professionals, a survey is conducted among a sample group and their given importance level is measured. Mitigating actions against the top five important risks are compiled and suggested as coping strategies.*

Keywords − *Supply chain risk management, risk categories, risk drivers, mitigating strategies*

INTRODUCTION

Supply chains become increasingly vulnerable against any disruption. Though location of the disruption is far away from the focal company, with the help of evolving information technologies, it became easier for any company to conduct trade throughout the globe. In addition to this, several trends on cost reduction, increased competitiveness affected the companies' vulnerability negatively. Importance of supply chain risk management increased significantly after several incidents which seriously affect the companies' financial statements. With this paper, we examined the drivers and categories of risk and their corresponding mitigating action.

Companies became intolerant and vulnerable to any kind of disruption in their supply chain. In the literature, several authors paid attention to risk drivers ([10], [16], [7], [8], and [18]). In this section, drivers which led companies in such degree of vulnerability will be examined in detail. In order to make classification easier, Figure 1 is proposed by the authors.

Main risk drivers are cost, competitiveness and legislation & public concerns. Sub drivers are generated as an outcome of one or more of main drivers.

Due to several reasons, like outsourcing, shorter product life cycle, increasing customer demand, globalization, etc., level of competition increased significantly. This led companies to re-evaluate their strength and weakness points against the competitors and various initiatives are generated in the aim of winning the competition.

Main initiatives are focused on quick wins, thus, on cost especially. Though some of these initiatives are successful in financial and marketing wise, it made companies so vulnerable against any disruptions that may happen throughout their long and many ownership included supply chain.

In addition to this, customers' awareness and concerns about environment, human rights, worker rights and fair trade, drove the demand on behalf of companies who invest on these points. Governments could not remain indifferent to this public initiative and new regulations on environment, health and safety and products are being raised periodically to ensure safe environment and working conditions.

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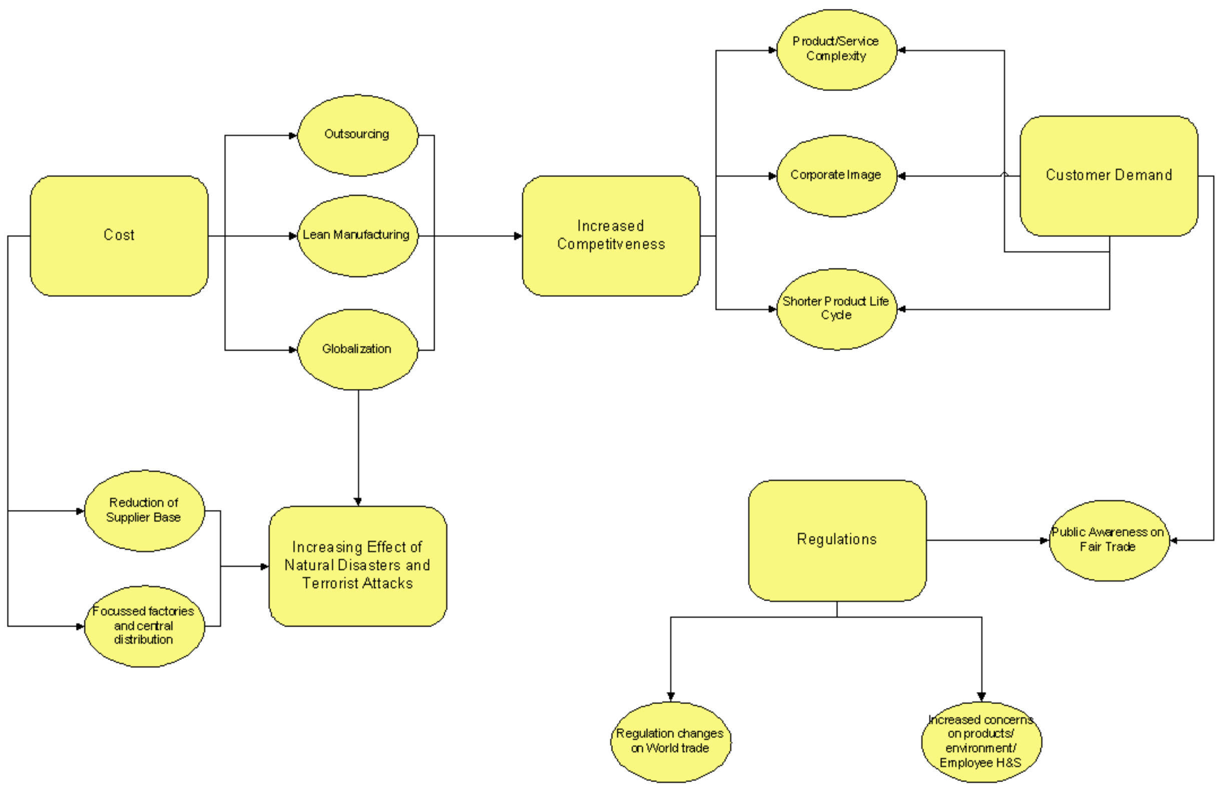

Figure 27. Main & Sub Risk Drivers

Some sub drivers generated from these main drivers are explained as below:

GLOBALIZATION OF SUPPLY CHAINS

As a result of technological developments at IT and communication, it is quicker and easier to get in touch with any supplier around the world. This enhanced important strategic advantage for the suppliers who are close to the raw material sources since they become able to sell their products to the globe. As the demand increases, these companies favored from economies of scale and thus, cost reduction.

In addition to this, material movement around the globe became more secure with the efforts of intergovernmental organizations like WTO, IMF, World Bank and with standardizations, like using standard tariffs, etc. Some undeveloped or developing countries with or without raw material sources choose to use cheap labor tool as leverage for development. This led price-sensitive products’ production to move to these countries.

With above factors, companies source their requirements throughout the world which causes higher replenishment time and more complex supply chains. Also, global supply chains have potentially more delay points, greater uncertainties and hence the need visibility and coordination [10], than their domestic counterparts and this complexity comes at a cost of more severe disruption risks. Craighead found that supply chain complexity along with density and cone critically are factors that influence how severe an impact a disruption will be on a supply chain. So these cost reduction measures increases the likelihood of a supply chain being disrupted and also the impacts of these disruptions to become more severe ([25], [8]).

OUTSOURCING

As companies aim to reduce cost, non-core competencies are often outsourced to other companies. Outsourcing company's aim is to focus on core business and increase its strengths. In the meantime, they favor the access to the capacity when required which will never be available to them when they use their own resources.

Technological developments take place nearly in all fields as IT and internet based technologies become easier and cheaper to reach. Since companies prefer to dedicate their limited sources to reinforce their core competencies, non-competency areas are under the risk of being dated.

Also by outsourcing, companies are able to convert their fixed costs into variable costs.

With all these advantages, loss of expertise may become a serious issue when focal company decides to insource them. In addition, outsourcing increases vulnerability by increasing the number of ownerships. Similar to globalization, the more delay points, the more increased risk and visibility requirement.

LEAN MANAGEMENT /A FOCUS ON EFFICIENCY

According to lean supply chain strategy, a focal firm must take cost reduction as its first priority. In order to achieve this target, long-term relationships based on trust with its suppliers must be built. Resources from supply chain partners must be developed and accessed. So this will enable the focal firm to realize the benefits of a lean strategy ([15]).

The focal company can reduce costs by effectively managing inventory in the supply chain and by employing continuous improvement techniques across the chain. By eliminating excess inventory and improving the quality of parts, the supply chain has the ability to reduce set-up time, adjust capacity and respond quickly to the customer ([17]).

The lean philosophy has enabled countless organizations to reduce cost by removing waste from their systems. However, the savings has a cost. However, lean supply chains are inherently vulnerable to disruption risks (A40/10). This means as supply chains become leaner by reducing buffer and redundancy, they become highly efficient in stable conditions but highly vulnerable in volatile conditions since they lose the ability to absorb unusual system disturbances ([8], [13]).

FOCUSED FACTORIES AND CENTRALIZED DISTRIBUTION

Risk pooling suggests that demand variability is reduced if one aggregates demand across location. This reduction in variability allows a decrease in safety stock and therefore reduces average inventory (designing and managing supply chain).

In order to achieve higher efficiency, factories try to minimize the set-up time by producing the same or similar kind of products. In case of multi-product/multi-factory, focused factories are designed for high efficiency.

Geographical concentration of both factories and distribution centers leads the supply chains to be vulnerable to geographic specific risks. If this type of risk realization happens, alternative sourcing/production will not be possible in short period.

REDUCTION OF SUPPLIER BASE

In order to build stronger, long term relationships with their suppliers, companies uses tools as consolidation and reduction of supplier base. Addition to that some companies use these tool to reduce complexity and uncertainty in their supply bases.

According to Cousins' ([5]) survey, 79 percent of the respondents mentioned that their main air is to save money by reducing the price of product of services or by reducing transaction costs associated with managing suppliers.

Though above advantages are present, risk of disruption in supply chain requires this approach to be revisited. In order to achieve these goals, a company must develop deep relationships and work very closely with their suppliers. Developing such relationship is expensive and requires continuous caution state. Otherwise doing would put the company at great risk.

INCREASING CUSTOMER DEMAND

The more market becomes competitive, the more customer demand increases. In the beginning of industry revolution, production was the most important goal. As globalization and advances in information technology are spread around the global, competition became intense and companies tried to become outshined by showing their efforts in increasing customer satisfaction. Increased product features, omni-channel sales, guarantee policies are just some examples of tools used to achieve higher satisfaction rates.

PRODUCT IMPROVEMENT/PRODUCT LIFE CYCLE

In order to keep customer attention on their brand, companies tend to bring out new products in the market. Along with the competition and with the help of advances in technology and production techniques, time interval between product launches decreased in time. Thus, the product life cycles became shorter. As this happens, toleration to any wrong-goings during the sales period is not present any more since there is no buffer time for any adjustment or improvement. Any supply disruption, without the reason behind, can cause the loss of sales generation

PRODUCT/SERVICE COMPLEXITY

As a part of differentiation, companies add additional features to their product or services. These additional features can be developed by company itself or other suppliers. In both cases, additional suppliers are added to the supply chain. This increases risk of potential failures

CORPORATE IMAGE

Customers do not just buy products, they buy product of companies as well. They require not only the products with high quality but also they ask the companies to be respectful to environment, to make sustainable production and increase their employees' motivation. Companies spend considerable amount of money for PR activities. Corporate social responsibility became an important tool for companies in order to benefit society, to have brand differentiation, to increase customer and employee engagement. As information sharing is in lightning speed, any supply disruption has enormous negative effect on the all efforts made for company image

FAIR TRADE

Customers are aware of their buying power. As the consciousness rise with social media, PR campaigns, companies who obey legal and ethical business rules differentiate themselves positively and the other companies are affected from these. As business gets global, misconduct behavior risk increases, unless proper monitoring tools are not implemented

REGULATIONS ON PRODUCTS/ENVIRONMENT/EMPLOYEE H&S AND WORLD TRADE

Legislation bodies work intensely in orienting the business industry to serve safer products, to offer livable and working safe work environments for workers, to minimize the unfavorable effects of production. Though in some cases, limited time allowances are given, these regulations might change the structure of whole supply chain which can cause some companies to be significantly affected.

As the material flow gets easier and quicker, competition is felt all around the world intensely. Sometimes countries use their influence power, if not enough, organizations/unions power as well. This has the ability to change rules of trade which might have important effect on the companies.

INCREASING EFFECT OF NATURAL DISASTERS

Natural disasters have always been a threat for humans and their property. Before 1990's, disasters had important also but geographically limited affect. In the last 100 years, reported disasters has increased over 40-fold. Their financial effect also increased considerably. This is partly to widespread geographic human presence and advancement in information technology but this increasing trend is alarming since it shows the economic and human losses that can be caused by natural disasters ([13]).

With globalization, cultural and political factors, around the world effects supply chains as well. Civil unrest, shifts in government and terrorist attacks may have widespread effect on the availability of the goods and services throughout a global supply chain ([32])

RISK TYPES

Supply chain involves many risks. In the literature, its classification is one of the intensely researched area. Some examples of these classifications are as below:

Table 26. Risk types in SCRM literature

M.Christopher, 2004, [4]	I.Manuj, 2008 - [14]	D.Olson, 2010 - [16]	S.Wagner, 2008 - [22]	P.Trkman, 2009 - [23]
· Internal to the firm o Process o Control · External to the firm but internal to the supply chain network o Demand o Supply · External to the network o Environmental	Supply risks Operational risks Demand risks Security risks Macro risks Policy risks Competitive Risks Resource risks	* External o Nature o Political system o Competitor and market * Internal o Available capacity o Internal operation o Information system	· Supply risks · Process risks · Demand risks · Intellectual property risks · Behavioral risks · Political/social risks	* Endogenous uncertainty o Market turbulence o Technological turbulence * Exogenous uncertainty

Tummala, R., Schoenherr, T., 2011 -	C.Harlanda, 2003 - [7]	N.Wildgoose, 2012 - [28]	S.Chopra, 2004 - [10]	C.Tang and B.Tomlin, 2009 - [30]
Demand risks Delay risks Disruption risks Inventory risks Manufacturing breakdown risks Physical plant risks Supply risks System Risks Sovereign risks Transportation risks	Strategic risk Operations risk Supply risk Customer risk Asset impairment risk Competitive risk Reputation risk Financial risk Fiscal risk Regulatory risk Legal risk	• Industry-specific exposures: • Supplier-specific exposures: • Management controls o Supplier management o Supply chain management o Infrastructure. • Management controls o Risk management • Suppliers' supply chain management:	Disruptions Delays Systems risk Forecast risk Intellectual property risk Procurement risk Receivables risk Inventory risk Capacity risk Environment Local permits	Supply risks Supply cost risk Supply commitment risk Supply continuity risk Process risk Demand risks Rare-but-severe disruption risks Other risks Intellectual property risks Behavioral risks Political risks Social risks

S.Wagner, C.Bode, 2009 - [30]	Zeng, 2005 - [29]	S.Wagner, 2006 - [26]	Ritchie and Brindley, 2007 - [18]	U.Jüttner, 2005 - [9]
Demand side supply side regulatory, legal and bureaucratic infrastucture catastrophic	Capacity limitation Technology incompatibility Supply disruptions Currency fluctuations Disasters	Demand-side risk Supply-side risk Catastrophic risk	Strategic Tactical Operational	Supply risks Process & Control ampliar or absorber Demand risks Environmental risks

Tang 2006 - [21]	J.Cavinato, 2004 - [1]
Operational risks Disruption risks	Physical Financial Informational Relational Innovational

After reviewing the risk types, authors of this paper suggests the below classification:

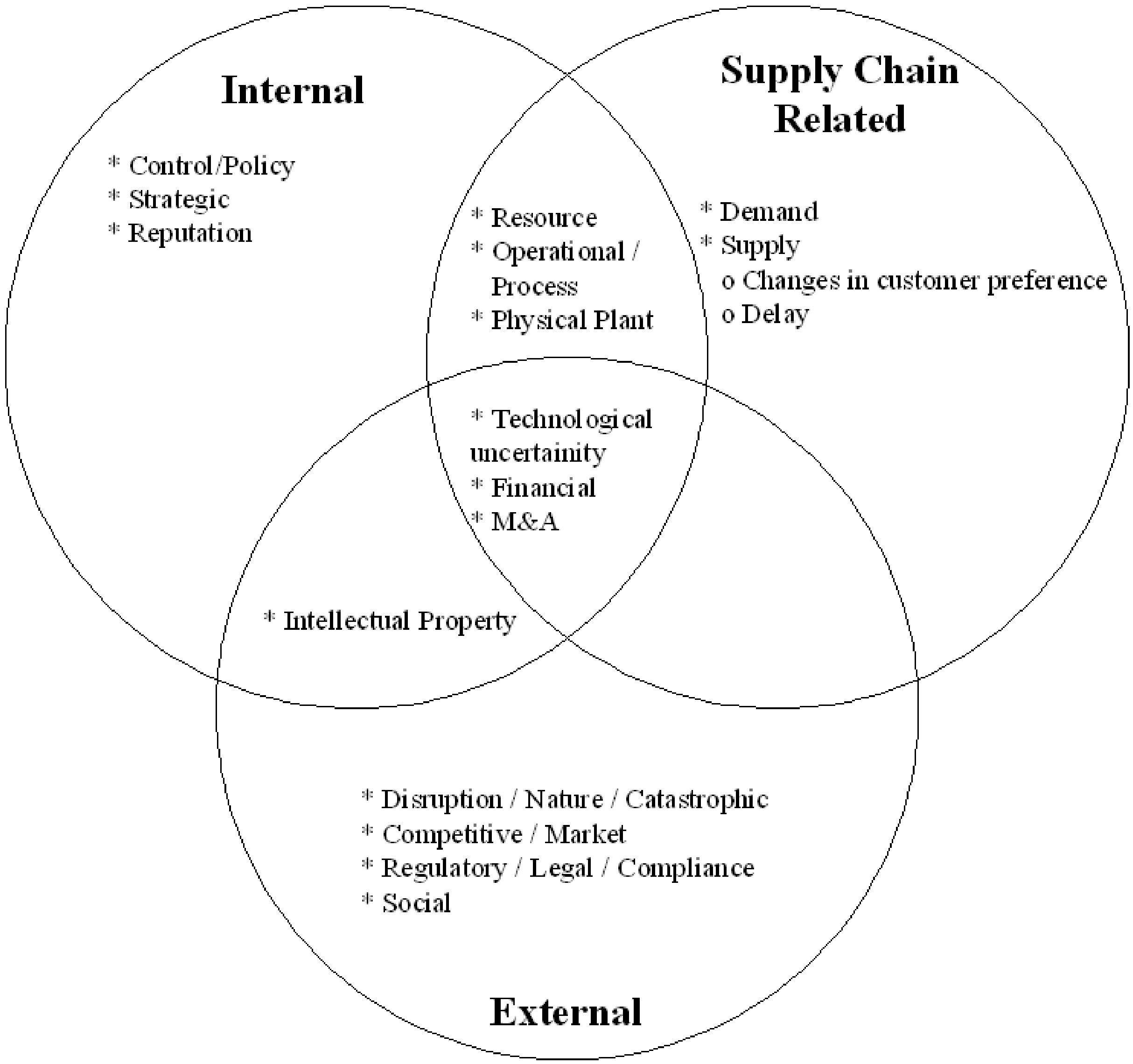

Figure 2. Proposed Risk Types Classification

Supply chain risk types can be classified, mainly, in three categories.

INTERNAL RISKS

This risk type comprises the risks which are relevant to the focal company. This type of risks' controllability is higher than the other risk types since their risk drivers are mainly originated from the focal company. Risks and consequences can be determined in higher precision and required mitigating strategies could easily engaged in the company's policies.

SUPPLY CHAIN RELATED RISKS

With recent developments in 20th and 21st centuries, competition started to take place not between the companies but between the supply chains. The risks that effect focal firm are multiplied with number of companies in its supply chain. Controllability of the risks decreases when compared with internal risks since the level of authority decreases and number of owners increase. This requires the risks relevant to supply chains must be classified and examined in detail.

EXTERNAL RISKS

External risks are not controlled by the focal company and companies are exposed to this type of risk by the environment that they are in. These risks do not realize often but when they are actualized, most of the time, they happen rapidly and without warning. In general, their effect is very serious and it might not be limited to the company but also supply chain and all external bodies might be affected seriously. Risk avoidance is possible for very limited cases, like avoiding investment in an earthquake zone might be an prevention but financial crisis in operating country might not be avoided.

SELECTION OF RISK TYPES

In order to understand the perception of Turkish supply chain professionals, a survey study is performed. With this study, SC professionals were asked to prioritize the above mentioned risk categories.

Demographic data of the survey participants are as below:

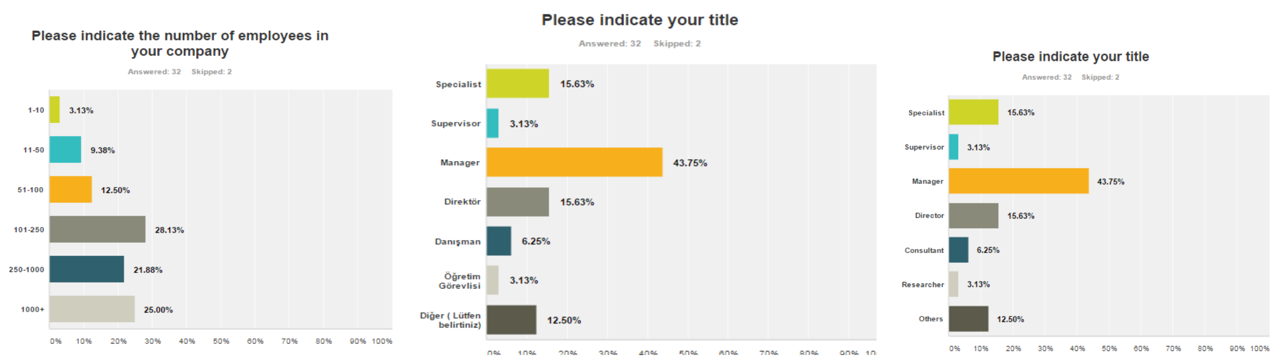

Figure 3. Demographic information about the participants

Top 5 important risks are determined as below:

Table 2. Survey results

	Very Important	Fairly Important	Important	Slightly Important	Not at all Important	Weighted Average–
Operational Risks	55.88%	29.41%	14.71%	0.00%	0.00%	1,59
Supply Risks	32.35%	50.00%	14.71%	2.94%	0.00%	1,88
Strategic Risks	50.00%	23.53%	14.71%	11.76%	0.00%	1,88
Resource Risks	44.12%	26.47%	20.59%	8.82%	0.00%	1,94
Financial Risks	35.29%	23.53%	32.35%	8.82%	0.00%	2,15
Intellectual Property Risks	38.24%	23.53%	20.59%	17.65%	0.00%	2,18
Reputation Risks	20.59%	50.00%	20.59%	5.88%	2.94%	2,21
Control Risks	23.53%	35.29%	35.29%	5.88%	0.00%	2,24
Regulatory/Legal/Compliance Risks	26.47%	38.24%	20.59%	14.71%	0.00%	2,24
Technological Uncertainity Risks	17.65%	38.24%	29.41%	14.71%	0.00%	2,41
Physical Plant Risks	14.71%	35.29%	44.12%	5.88%	0.00%	2,41
Competition/Market Risks	23.53%	32.35%	23.53%	17.65%	2.94%	2,44
Demand Risks	11.76%	44.12%	32.35%	8.82%	2.94%	2,47
Merger & Acquisitions Risks	20.59%	26.47%	26.47%	26.47%	0.00%	2,59
Social Risks	17.65%	23.53%	32.35%	23.53%	2.94%	2,71
Disruption/Nature/Catastropic Risks	11.76%	32.35%	23.53%	23.53%	8.82%	2,85

In the scope of this paper, authors will examine the mitigating actions for the top-5 risk categories in the following section.

MITIGATING ACTIONS

Many mitigating actions are determined in the supply chain risk management literature. Within the scope of this paper, authors selected the proposed actions in the literature and related them with the top 5 prioritized risk categories. Below table shows the action & risk category relation.

Table 3. Mitigating Strategy & Affecting Risk Types

Quoted from	Classification	Mitigating Strategy	Operational Risks	Supply Risks	Resource Risks	Strategic Risks	Financial Risks
	Managed System	**Adjust the structure of the supply chain**	X	X	X		
		Reduce the length of the supply chain	X	X			
		Change the location of facilities	X	X	X		
		Use Product management					
		*Avoid risky products	X	X	X		
		*Rationalize the product range	X	X	X		
		*Plan component/material substitution	X	X	X		
		Increase product differentiation, particularly in fast-moving markets, offers customers a wider choice and reduces the risk of building high inventories of obsolescent products			X		
		Buffering in capacity and inventory					
[11]		Better inventory management	X	X	X		
		Increase number of equipment, vehicles or workers	X	X	X		
		Increase capacity of equipment, vehicles or space	X	X	X		
		Make strategic (safety) stocks	X	X	X		
[6]		Build some safety stock at certain strategic locations (warehouses, logistics hubs, distribution centers) to be shared by multiple supply chain partners (retailers, repair centers, etc.)		X	X		X
		Make well stocked supply pipeline	X	X			
		Increase the flexibility of the supply chain					
		Use multiple modes of transportation		X		X	
		Use multiple purpose resources (e.g., standardized equipment, vehicles, cross-trained employees)	X	X	X		
		Use flexible automation	X	X	X		
		Use temporary workers			X		
[10]		**Increase vertical Integration**					
[6]	Supplier Based	Develop multiple supply sources for the same component	X	X			
[6]		Develop input material in a manner that will cost effectively enhance flexibility	X	X	X		
[6] - [10]		Create a local supply base		X	X		
[6]		Create multiple supply sources with the appropriate manufacturing capacities to build the component when needed	X	X	X		
[6]		Use a supplier with more than one manufacturing site to supply materials	X	X			
[11]		Increase loyalty to existing suppliers	X	X	X	X	
[31]		Establish supplier development system	X	X	X	X	
[31]		Develop supplier performance measurement system	X	X	X	X	
		Supplier quality / auditing / certification programmes	X	X	X	X	
[11]		Use approved list of suppliers		X			
[11]		Visit supplier operations and establish good relationship with suppliers	X	X	X	X	
[11]		Proactive supply management	X	X	X	X	
[16]		Add redundant suppliers in the supply chain		X	X		
[3]		Increased "local for local" production	X	X			
		Use of technical solutions to deal with disturbances (alarms, fire distinguishers, etc)	X				
[13]		**Choose robust suppliers and transportation media**	X	X			
[21]	Managing system	**Invest to avoid or reduce exposure to vulnerability sources**	X	X	X		
		Regular replenishment of equipment, vehicles	X			X	
		Economic supply incentives to cultivate additional suppliers		X			
		Increase capacity	X		X	X	
		Innovations (eg. To packaging, information systems, etc)	X		X	X	
		Control variability					
		Careful supplier selection process using vendor rating techniques; supplier audits and quality certification programs	X	X			
		Use (virtual) pooling; centralization of decisions				X	
		Increase price stability			X	X	X
		Sell products to various markets					
		Use standardized work (procedures)	X				
		Use procedures and techniques to improve quality control as well as industry standards	X				

Table 3. Mitigating Strategy & Affecting Risk Types (cont.)

Quoted from	Classification	Mitigating Strategy	Operational Risks	Supply Risks	Resource Risks	Strategic Risks	Financial Risks
[13]	Managing system	Standardize various processes	X				
		Develop proactive maintenance	X	X			
		Use demand postponement strategy			X		
		Use revenue management stratejies					X
		Use dynamic pricing (vonvenient for perishable products)					X
[12]		Use price and promotion planning					X
		Decrease lead time	X	X	X	X	
		Use short term forecasts or aggregate forecasts				X	X
[22] - [8]		**Increase agility for reducing the impact of short term changes in demand or supply**	X	X	X	X	
[11]		**Focus on Core competence**	X		X		
		Hedging					
		Produce certain products in-house and outsource other products	X	X	X	X	
		Diversifying operations across multiple markets	U		U		U
		Using business disruption insurance					X
		Make back up options					
		Use a flexible supply contract for non-strategic components		X	X		X
		Use alternative suppliers	X	X			
		Prepare backup for emergency supply	X	X	X		
		Increase flebility of planning and control					
		Increase manufacturing flexibility, e.g., use flexible receipts, coordinate and redesign policies	X		X		
		Use flexible manufacturing system to enable the firm to plan for more product variety effectively	X		X		
		Allow time and capacity buffering in plants and operations (production, storage, handling and/or transportation)	X	X	X	X	
		Use event driven planning (update after event)	X				
		Do tasks parallel instead sequential	X		X		
		Use postponement	X	X	X	X	
[9]		Delayed product differentiation such as modular design, standardization, commononality, etc.)	X	X	X	X	
[6]		Production postponement at distribution centers, including activities final packaging, labelling and configuration to customer requirements	X	X	X	X	
		Use component/Material substitution	X	X	X		
		Use lead time management	X	X	X		
[16]		**Pool demand**					
[16] - [2]		**More Customers**	U				
[16]		**Expand where you have competitive advantage**					U
[16]		**Delay resource commitment**	X		X		X
[16]		**Outsource low probability demand**	X		X		
[16] - [12]		**Use dynamic assortment planning**	X		X		
[16]		**Silent product roll-over**					
[3]		**Increase use of alternative distribution channels**				X	
[3]		**Greater use of contract manufacturers**		X	X	X	
[3]		**Centralising inventory and logistics management**	U	X	U		
[12] - [8] - [13]		**Supplier/warehouse/distribution center location selection based on geographical location/decentralization; select safe locations**			X		
[12]		**Make-and-buy approach to shift production between an in-house production facility and supplier**		X	X	X	
[8]		**Use real options - (defer/time or stage/explore/lease/outsource/alter operating state/abondon/growth/compound options)**	X	X	X		
[13]		**Maintain multiple facilities with flexible/redundant resources**	U	X	X		
[13]		**Maintain redundant critical components**		X	U		
[13]		**Reduction in lead time and lead time variability**	X	X	X	X	
[13]		**Reduction in the bullwhip effect**	X	X	X		X
[13]		**Increase in customer service**				X	
[21]		**Establish a supply alliance network**	X	X	X		X
[21]		**Establish recovery planning system**	X	X		X	X

Quoted from	Classification	Mitigating Strategy	Operational Risks	Supply Risks	Resource Risks	Strategic Risks	Financial Risks
		Use IT to increase data accuracy and speed and support decision making					
		Implement real-time information systems	X	X	X		X
		Use the same information standards			X		
		Use techniques for automatic disturbance detection			X	X	
		Use tracking and tracing system			X		
		Use DSS for production planning and scheduling, inventory managment, demand management, etc.	X	X	X		
	Information System	**Create support for information transparency in the supply chain.**	X	X	X		
		Insure infrastructure to enable information exchange and sharing	X	X	X		
		Enable continous data exchange with partners in the supply chain	X	X	X		
		Collect relevant data about disturbances					
		*MTTF (mean time to failure), MTTR (mean time to repair), variances in lead times.	X	X			
		Establish secure communication links	X	X			
[13]		Increase transportation visibility	X	X	X		X
[13]		Monitor weather forecast			X		

Table 3. Mitigating Strategy & Affecting Risk Types (cont.)

Quoted from	Classification	Mitigating Strategy	Operational Risks	Supply Risks	Resource Risks	Strategic Risks	Financial Risks
		Increase collobration in supply chain					
[6]		Use information sharing to increase visibility	X	X	X		X
[6]		Establish colloborative relationships with key suppliers	X	X	X		
		Joint forecasts and planning	X		X	X	
[20]		Increase forecasting accuracy through risk pooling methods			X		
		Develeop Suppy Chain Risk Management	X	X	X		X
[11]		Communication and early supplier involvement of suppliers in strategic decisions		X	X	X	
		Joint efforts to share risk-related information	X	X	X		
		Establishment of strategic alliances, such as transport alliances, VMI, etc.		X	X		
[6] - [10] - [8]		Increase risk sharing among supply chain partners/Impose contractual obligations on suppliers	X	X	X		
		Increase coorporation and coordination between departments	X		X	X	
		Create an adaptive supply chain community					
		Establishment of risk mitigation plans together with suppliers		X	X		
		Make suppliers responsible for developing risk mitigation plans		X			
		Align objectives and define KPI's		X	X	X	
[9]		Increase trust and long term perspective among supply chain partners		X		X	
[6]	Organization	Apply collobratiive efforts to minimize fluctuations in material flows across the supply chains	X	X		X	
		Improve human resource management					
		Select experienced workers	X		X		
		Ensure proper training of employees	X		X		
[13]		Use efficient human resource management	X		X		
		Increase preparedness to disturbances					
		Enable empowerment (authorization of employees to make independent decisions)	X		X	X	
		Build awareness for crises situations	X		X	X	
		Use risk sharing supply contracts for strategic components	X	X	X	X	
		Revenue sharing contracts					
		Back-up (advance purchase) contracts					
		Quantity flebility contracts					
		Wholesale price contracts					
		Sales rebate contracts					
		Capacity reservation contracts					
		Cost sharing contracts					
		Buy-back contracts					
[9]		**Be adaptive to market dynamics**					
[9]		Create flexible product design	X	X	X		
[13]		Redesign product to pool risks	X	X	X	X	X
[8]		Share assets with other industry members			X	X	
[13]	Others	Enforce security			X	X	
[13]		Act according to terrorist threat level			X	X	
[13]		Influance customer choise			X		
[10]		Dropping specific product/geographical markets/supplier and / customer organizations		X	X	X	X

Vlajic's ([25]) study is taken as base for above table and it is enriched with this paper's authors and other authors' comments.

CONCLUSION

To cope with increasing effects of risks, it is very crucial to understand the drivers of these risks. Otherwise, the precautions taken against might not be efficient enough to achieve the targets desired. Categorization is also important since it also determines the points that can be controlled and acted. It also directs about what kind of mitigating action should be taken; avoidance/postpone/speculate/hedge/control/sharing-transfer/security. Mitigating action tool is prepared to guide researchers/professionals about the proposed action types against these risks.

This paper is part of doctorial study on supply chain risk management, supply risks. As further steps in the study, addition to this paper, supply related risk categories and mitigating actions will be studied in detail. Key risk indicators will be determined and their measurement methodology will be standardized so that risk identification period will be secured about not being skipped or identified lately. This will also enable analyzer to understand the current state of risk exposure of single company. Addition to this, mitigating action table will be enlarged to contain all risk types and will be deepened for supply related risks to become a tool for guiding on risk type & mitigating action.

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THE ELECTRIC VEHICLE ROUTING PROBLEM: OUTLOOK AND RECHARGING STRATEGIES

Merve Keskin[215], Bülent Çatay[216]

Abstract − *The utilization of battery electric vehicle (BEV) fleets in urban logistics has a growing practical relevance. Within this context, the Electric Vehicle Routing Problem (EVRP) has been introduced as an extension to the well-known Vehicle Routing Problem (VRP) where the fleet consists of BEVs instead of the internal combustion engine vehicles (ICEVs). The main difference between EVRP and VRP is that BEVs have shorter driving range because of their limited battery capacities and may need to be recharged at a charging station in order to continue servicing customers. The recharging may take place at any battery level. In this study, we provide an overview of the problem, present the mathematical programming formulations for different recharging strategies, and provide solutions for some benchmark instances from the literature. We attempt to solve the small size problems optimally using IBM ILOG CPLEX. For the large instances, we implement an Adaptive Large Neighborhood Search (ALNS) algorithm.*

Keywords − *Battery electric vehicle, vehicle routing problem , electric vehicle routing problem with time windows, metaheuristic, adaptive large neighborhood search*

INTRODUCTION

Transportation systems account for about 20-25% of global energy consumption and CO2 emissions. Road transport is a major contributor with 75% share [34]. 95% of the world's transportation energy comes from fossil fuels, mainly gasoline and diesel. In the US, about 27% of total greenhouse gas (GHG) emissions in 2013 are transport related [38]. 74% of the domestic freight in 2012 is moved by trucks and the freight volume is expected to grow by 39% in 2040 [14]. Transport accounts for 63% of fuel consumption and 29% of all CO2 emissions in the EU. Freight transport activity is predicted to grow by around 80% in 2050 compared to 2005 [37].

Transportation will continue to be a major and still growing source of GHGs. Hence, governments are considering new environmental measures and targets for reducing emissions and fuel resource consumptions. The US Administration aims at cutting the overall GHG emissions 17% below 2005 levels by 2020 and has recently established the toughest fuel economy standards for internal combustion engine (ICE) vehicles in the US history [39]. The EU targets 80–95% reduction of GHGs below 1990 levels by 2050, where a reduction of at least 60% is expected from the transport sector. The European Commission aims at reducing the transport-related GHG emissions to around 20% below their 2008 level by 2030. The use of conventionally fuelled cars will be reduced by 50% in urban transport by 2030 and phased out by 2050. City logistics in major European urban centers will be CO2-free by 2030 [34].

The targets set by governments and the new regulations imposed encourage the usage of alternative fuel vehicles (AFV) such as solar, electric, biodiesel, LNG, CNG vehicles. Many municipalities, government agencies, non-profit organizations, and private companies are converting their fleets to include AFVs, either to reduce their environmental impact voluntarily or to meet new environmental regulations [11]. Consequently, the advancements in the electric vehicle (EV) technology have gained momentum in parallel with the growing environmental concerns in societies. Hence, EV routing and scheduling has become a challenging and popular problem in the Vehicle Routing Problem (VRP) literature due to the additional complexities it involves.

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OVERVIEW OF ELECTRIC VEHICLE TECHNOLOGY

EVs move with electric propulsion and can provide emission-free urban transportation. They can be classified as battery electric vehicles (BEV), hybrid electric vehicles (HEV), and fuel-cell electric vehicles (FCEV). Within the routing context, we refer to EV as a commercial road vehicle such as a lorry or van. A BEV has only one or more electric motors and uses the power generated by the on-board battery for propulsion [10]. As reported in [24], the advantages of BEVs are lack of tailpipe emissions, high efficiency and low operating noise while they have some disadvantages such as low achievable driving range and low energy density causing long times for recharging the battery. Number of moving parts in BEVs are much less than of internal combustion engine vehicles (ICEVs) and do not require regular oil changes [13]. Also due to the regenerative breaking, break wear is used less which brings less maintenance costs [20]. [21] stated that a single charge for fright BEVs provides a range varying from 100 to 150 kilometers.

HEVs are further classified according to their powertrain architecture as parallel, series, series-parallel and complex [5]. A plug-in hybrid electric vehicle (PHEV) is an HEV which utilizes a rechargeable battery and is also equipped with both electric motor and internal combustion engine (ICE). In series type of vehicles, internal combustion engine (ICE) is used to power a generator and the propulsion comes from the electric motor while in the parallel type, both the ICE and the electric motor are used in the propulsion [5]. The main advantage of PHEVs is the ability to move using fuel when it runs out of battery power.

In the FCEV, the electricity is produced by a fuel cell via a chemical reaction which uses hydrogen as the input and produces water as the output. Then, the electricity is used to charge a battery or power the electric motor [5]. US DOE 2013a reported that fuel cells can convert approximately 50% of hydrogen’s energy to electricity and they have a durability of 10,000 operating hours [8]. Those factors are the main drawbacks of FCEVs.

The rechargeable battery is the critical component of EVs. The main types of batteries include lead acid batteries, nickel metal hybrid batteries and lithium-ion batteries [5]. Lithium-ion batteries are the most widely used type since they have high energy density, high power density, long battery life and low memory effect compared to other alternatives [8].

There are different ways for recharging EVs such as conductive charging, inductive charging and battery swapping. The most common method is conductive charging which is done by a cable and a vehicle connector. In inductive charging, the power is transferred to the battery magnetically via an on-board charger without needing any cables connectors [36]. Stationary inductive charging is used when the vehicle is stopped while in-road inductive charging can be performed even if the vehicle is moving [8]. Battery swapping includes changing the empty battery with a fully charged one in a battery swapping station. Using catenary wires is another charging option where the vehicles can be recharged using a pantograph device which slides along the electric wires and transfer the energy. It can be useful for public electric buses [4].

The battery recharging times are dependent to the battery type, charging equipment and charging level. [36] classifies the charging levels into three categories: level 1 (1.4 kW to 1.9 kW), level 2 (4 kW to 19.2 kW) and level 3 (50 kW to 100 kW). The last is also called as fast/quick charging. The charge durations are linear with respect to time at the first phase of charging which corresponds to almost full battery while the second phase is non-linear and can take hours to obtain a fully charged battery [3].

LITERATURE REVIEW OF ELECTRIC VEHICLE ROUTING PROBLEM

[2] studied the electric vehicle routing problem (EVRP) within a graph-theoretic context and suggested extensions to general shortest path algorithms that address the problem of energy-optimal routing. [33] developed a model that minimizes the number of tours and total deadhead time hierarchically. The driving range of the vehicle is assumed to be limited but the charging durations, time windows and vehicle capacities are not considered. [6] introduced the Recharging VRP (RVRP), a new variant of the VRP where the recharging can be at selected customer locations while servicing the customer and the charging time is constant. [32] investigated the operations of an electric taxi fleet. Charging times are constant and they assume that the battery is full after recharging. [22] studied an AFV routing problem with time-windows and the refueling times are assumed to be constant. [35] addressed the problem of locating recharging stations and designing EV routes simultaneously.

[11] considered the routing of AFVs while minimizing the total distance travelled where the length of the routes is restricted. Refueling times are assumed to be fixed and after refueling the tank becomes full. The model does not involve time windows and vehicle capacity constraints. [29] extended this problem within the context of EVRP with time windows (EVRPTW) and developed a hybrid metaheuristic that combines the variable neighborhood search with tabu search to solve it. [9] addressed the same problem by considering four recharging strategies (single-full recharge, single-partial recharge, multiple-full recharge, and multiple-partial recharge) and proposed a branch-price-and-cut algorithm to solve the smaller instances to optimality. [12] allowed partial recharges using different technologies, i.e. different charging levels. The problem does not involve time windows but EVs have capacity and routes have duration limits.

In their recent work, [15] extended EVRPTW to the routing of a mixed fleet of EVs and ICE vehicles, which minimizes the energy consumption dependent on speed, gradient and cargo load distribution. [17] addressed the fleet size and mix vehicle routing problem with time windows where the fleet involves EVs. [19] developed an adaptive large neighborhood search method to solve EVRPTW by allowing partial recharges.

ELECTRIC VEHICLE ROUTING PROBLEM WITH TIME WINDOWS

In this section, we describe the details of the EVRPTW by illustrating an example and presenting three different problems involving three different recharging schemes. The notation is based on the formulation given by [29] for ease of understanding.

Problem Description

The Electric Vehicle Routing Problem with Time Windows involves a set of customers which have demands, service times, delivery time windows, a set of recharging stations and a homogeneous fleet involving EVs. While the vehicle is traveling, the charge of the battery is decreased proportional to the distance. So, the vehicle may need to recharge its battery in order to continue its route. The recharging can be done at any battery level. In this study, we will give three models which have different recharging options. In the first option, battery is fully recharged while in the second option the charge level is increased by a fixed amount of level. In the last option the recharging amount is continuous which can be any value between 0 and the battery capacity. The EVs depart from the depot with fully charged batteries.

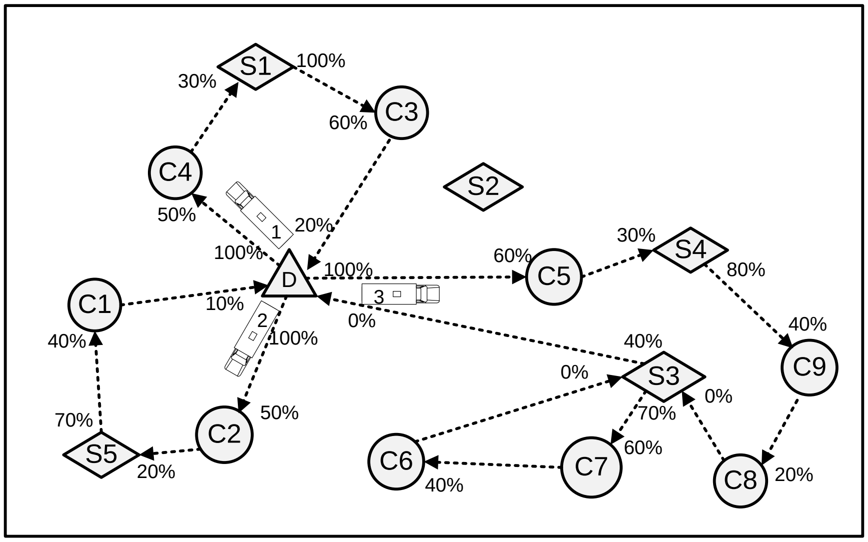


Figure 28. An Illustrative Example

Figure 1 illustrates an example involving nine customers (C1-C9), five stations (S1-S5), and the depot (D). The percentage values on the arcs show the battery state of charge when the vehicle arrives at a customer or a station and when it departs from the station after having its battery recharged. EV1 shows the first charging model in which the battery is fully recharged in S1. EV2 illustrates the second charging model in which the fixed amount of energy charged to the battery is 50%. Lastly, EV3 depicts the third model where partial charging is performed: EV3 is recharged once in S4 and twice in S3 with different charge amounts. Note that a station can be visited multiple times by the same EV (e.g. S3) or different vehicles and all stations are not necessarily visited (e.g. S2).

Mathematical Models

We provide three different mathematical models related to the problem. The first is a 0-1 integer programming model presented in [29] for the full charging case. The remaining two are 0-1 mixed integer programming models for the partial recharges. Let $V = \{1, \dots, N\}$ denote the set of customers and F denote the set of recharging stations. Since a recharging station may be visited more than once, we must create F'which is the set of dummy vertices generated to permit several visits to each vertex in the set F. Vertices 0 and $N+1$ denote the depot and every route starts at 0 and ends at $N+1$. Let V' be a set of vertices with $V' = V \cup F'$. In order to indicate that a set contains the respective instance of the depot, the set is subscripted with 0 or $N+1$. Hence $V'_0 = V' \cup \{0\}$ and $V'_{N+1} = V' \cup \{N+1\}$. Now we can define the problem on a complete directed graph $G = (V'_{0,N+1}, A)$ with the set of arcs $A = \left\{(i,j) \mid \ i,j \in V'_{0,N+1}, \ i \neq j\right\}$ where $V'_{0,N+1} = \{0\} \cup V'_{N+1}$. Each arc is associated with a distance d_{ij} and travel time t_{ij}. The battery charge is consumed at a rate of h and every traveled arc consumes $h \times d_{ij}$ of the remaining battery. Each vertex $i \in V$ has positive demand D_i, service time s_i and time window $[e_i, l_i]$. All EVs have a load capacity of C and battery capacity of Q. At a recharging station, the battery is charged at a recharging rate of g. The decision variables, τ_i, u_i and y_i keep track of the arrival time, remaining cargo level and remaining charge level at vertex $i \in V'_{0,N+1}$, respectively. The binary decision variable x_{ij} takes value 1 if arc (i,j) is traversed and 0 otherwise. Model 1 which assumes that the battery is fully recharged at the recharging stations is formulated as follows (Schneider et al., 2014):

$$min \quad \sum_{\substack{i \in V'_0 \\ j \in V'_{N+1}, i \neq j}} d_{ij} x_{ij} \tag{1}$$

$$min \quad \sum_{j\in V'_{n+1}} x_{0j} \tag{2}$$

subject to

$$\sum_{j\in V'_{N+1}, i\neq j} x_{ij} = 1 \qquad \forall i \in V \tag{3}$$

$$\sum_{j\in V'_{N+1}, i\neq j} x_{ij} \leq 1 \qquad \forall i \in F' \tag{4}$$

$$\sum_{i\in V'_0, i\neq j} x_{ij} = \sum_{i\in V'_{N+1}, i\neq j} x_{ji} \qquad \forall j \in V' \tag{5}$$

$$\tau_i + x_{ij}\big(t_{ij} + s_i\big) - l_0\big(1 - x_{ij}\big) \leq \tau_j \qquad \forall i \in V_0, \forall j \in V'_{N+1},\ i \neq j \tag{6}$$

$$\tau_i + x_{ij}t_{ij} + g(Q - y_i) - (l_0 + gQ)\big(1 - x_{ij}\big) \leq \tau_j \qquad \forall i \in F', \forall j \in V'_{N+1},\ i \neq j \tag{7}$$

$$e_j \leq \tau_j \leq l_j \qquad \forall j \in V'_{0,N+1} \tag{8}$$

$$0 \leq u_j \leq u_i - x_{ij}D_i + C\big(1 - x_{ij}\big) \qquad \forall i \in V'_0, \forall j \in V'_{N+1},\ i \neq j \tag{9}$$

$$0 \leq u_0 \leq C \tag{10}$$

$$0 \leq y_j \leq y_i - x_{ij}\big(d_{ij}h\big) + Q\big(1 - x_{ij}\big) \qquad \forall i \in V, \forall j \in V'_{N+1},\ i \neq j \tag{11}$$

$$0 \leq y_j \leq Q - (d_{ij}h)x_{ij} \qquad \forall i \in F'_0, \forall j \in V'_{N+1},\ i \neq j \tag{12}$$

$$x_{ij} \in \{0,1\} \qquad \forall i \in V'_0, \forall j \in V'_{N+1},\ i \neq j \tag{13}$$

The objective functions (1) minimizes total travelled distance and (2) minimizes the number of vehicles used. The original model uses the hierarchical objectives where the minimization of the number of vehicles is the primary and the distance minimization is the secondary objective. [18] uses both objective functions separately. Constraints (3) and (4) handle the connectivity of customers and visits to recharging stations, respectively. The flow conservations constraints (5) enforce that the number of outgoing arcs equals to the number of incoming arcs at each vertex. Constraints (6) and (7) ensure the time feasibility of arcs leaving the customers (and the depot) and the stations, respectively. Constraints (8) enforce the time windows of the customers and the depot. In addition, constraints (6)-(8) eliminate the sub-tours by maintaining the schedule feasibility with respect to time considerations. Constraints (9) and (10) guarantee that demand of all customers are satisfied and constraints (11) and (12) make sure that the battery level is never negative. Finally, (13) define the binary decision variables.

We next extend this problem to the case where the partial recharge is allowed but at a constant level, q. We introduce a binary variable z_i which takes the value of 1 if the battery is partially recharged at station i and 0 if it is fully recharged. Y_i is the battery state of charge on departure from station i. In Model 2, the objective functions (1) and (2) and constraints (3)-(11) and (13) remain the same, the new constraints are as follows:

$$0 \leq y_j \leq Y_i - (r \cdot d_{ij})x_{ij} + Q\big(1 - x_{ij}\big) \qquad \forall i \in F'_0, \forall j \in V'_{n+1},\ i \neq j \tag{14}$$

$$Y_i = (y_i + q)z_i + Q(1 - z_i) \qquad i \in F' \tag{15}$$

$$z_i \in \{0,1\} \qquad \forall i \in F' \tag{16}$$

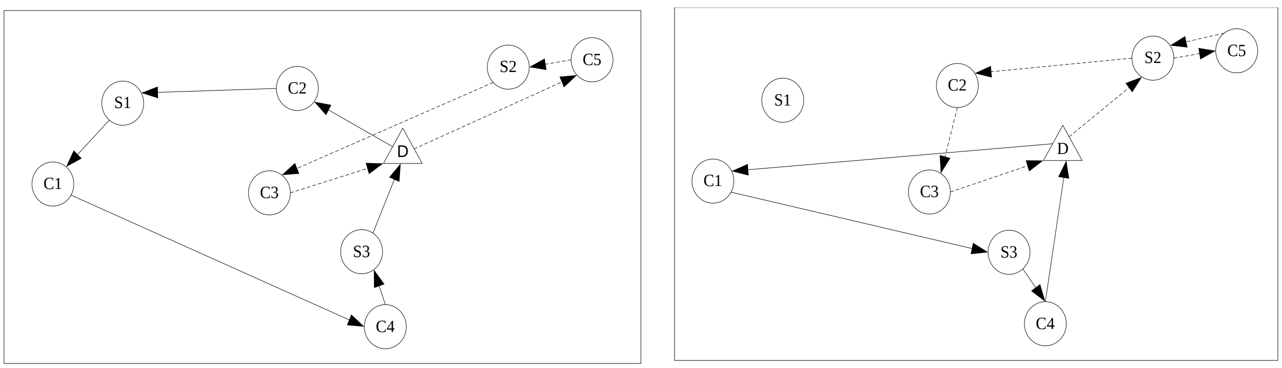
Constraints (14) along with constraints (11) keep track of the battery level and make sure that it is never negative. Constraints (15) determine the battery level after the recharge depending on the charging scheme. Constraints (16) define the binary decision variables.

In the case when partial recharging is allowed at any level, we define q_i as the amount of energy charged at station i. Constraints (3)-(6), (8)-(11), (13) and (16) remain the same. Constraints (7) will be changed as (17) and the new constraints are as follows:

$$\tau_i + t_{ij}x_{ij} + gq_i - (l_0 + gQ)\big(1 - x_{ij}\big) \leq \tau_j \qquad \forall i \in F', \forall j \in V'_{n+1},\ i \neq j \tag{17}$$

$$Y_i = y_i + q_i \qquad \forall i \in F_0' \qquad (18)$$
$$Y_i \leq Q \qquad \forall i \in F_0' \qquad (19)$$
$$x_{ij} \in \{0,1\} \qquad \forall i \in V_0', \forall j \in V_{n+1}', \quad i \neq j \qquad (20)$$
$$q_i \geq 0 \qquad \forall i \in F_0' \qquad (21)$$

Constraints (18) determine the battery state of charge after the recharge at a station. Constraints (19) make sure that the battery state of charge does not exceed its capacity. Finally, constraints (20) and (21) define the decision variables.



Optimal solution of Model 1 with objective 241.3 Optimal solution of Model 3 with objective 233.77

Figure 2. Differences between full and partial charging

Full charging may be restrictive since it consumes long time and it may prevent to catch the time windows of some customers. Figure 2 illustrates the advantage of the partial charging on a small example. In the solution given on the left hand side, the battery is fully charged at the stations while the solution on the right hand side shows how the total distance can be reduced by allowing partial charging. Notice that the routes obtained using the two recharging schemes are completely different.

NUMERICAL ANALYSIS

Since Models 1-3 are all NP-hard, [18,19] developed an adaptive large neighborhood search (ALNS) approach to solve them efficiently. In this section, we first describe the ALNS methodology briefly. Then, we perform experimental tests using benchmark instances from the literature. Our results include those found by solving the mathematical models using IBM ILOG CPLEX v.12.6.1 and obtained by using ALNS.

Solution Methodology

ALNS is based on the destroy-and-repair framework where at each iteration the existing feasible solution is destroyed by removing some customers and recharging stations from their routes and then repaired by inserting the removed customers to the solution along with stations when recharging is necessary. It employs different removal and insertion which are selected adaptively based on their past performances. The new solution is accepted according to the simulated annealing criterion. ALNS has been successfully applied to many VRP variants. We refer the interested reader to [1,7,16,23,25-28] for various implementations.

In our ALNS approach, we firstly construct an initial solution using a heuristic similar to the cheapest insertion algorithm of [30]. We iteratively insert the customer which increases the total distance the least while satisfying time and battery charge constraints. If a customer cannot be inserted because of low battery level, then its distance increase is calculated with the recharging station which should be inserted along with that customer in order to satisfy battery charge constraints. If no customer can be added to the current route due to capacity or time-window constraint, then we open a new route and continue the same procedure until all customers have been serviced.

After the initial solution has been constructed, we attempt to improve it by several destroy and repair mechanisms throughout the search. At each iteration, some nodes are removed from the current feasible solution and they are reinserted in such a way that resulting solution is a better solution than the previous. We used four types of mechanisms: Customer Removal (CR), Customer Insertion (CI), Station Removal (SR) and Station Insertion (SI). Those mechanisms are used in the search according to their performances in the preceding iterations. The new solution is accepted according to the simulated annealing (SA) rule. A better solution is accepted although a worse solution is accepted with a probability which is calculated with the SA parameters at each iteration.

Algorithm 1: ALNS algorithm

1	Generate an initial solution
2	$Number\ of\ iterations \leftarrow 1$
3	$\boldsymbol{while}\ (Number\ of\ iterations < Max\_Iter)\ \boldsymbol{do}$
4	Select CR algorithm and remove customers
5	$\boldsymbol{if}$ destroyed solution infeasible $\boldsymbol{then}$
6	Perform Greedy Station Insertion
7	Select CI algorithm and repair solution
8	Accept solution using SA criterion
9	$Number\ of\ iterations \leftarrow Number\ of\ iterations + 1$
10	$\boldsymbol{if}\ Number\ of\ iterations \equiv 0\ (mod\ N_{RW1})\ \boldsymbol{then}$
11	Update adaptive weights of CR and CI algorithms
12	$\boldsymbol{if}\ Number\ of\ iterations \equiv 0\ (mod\ N_{SR})\ \boldsymbol{then}$
13	Select SR algorithm and remove stations
14	Select SI algorithm and repair solution
15	Recall steps 8-10

In CR, we utilize Random, Worst-Distance, Worst-Time, Shaw), Proximity Based, Demand Based, Time Based, and Zone Removal algorithms. We also introduce the Multiple Random Route Removal and Multiple Greedy Route Removal algorithms. A vehicle usually visits a recharging station right before or after visiting a customer. So, CR algorithms are applied in three different ways by removing: (i) only the customer in the removal list (Remove Only Customer, ROC); (ii) the customer along with the station visited right before visiting the removed customer (Remove Customer with Preceding Station, RCwPS); or (iii) or the customer along with the station visited right after visiting the removed customer (Remove Customer with Succeeding Station, RCwSS). The procedure is also selected adaptively.

Table 27. Comparison of results obtained with CPLEX and ALNS on the small instances

	Full Charge				Partial Charge			
	Optimal Solution		Run time (sec)		Optimal Solution		Run time (sec)	
Instance	**#Veh**	**TD**	**ALNS**	**CPLEX**	**#Veh**	**TD**	**ALNS**	**CPLEX**
C101-5	3	247.15	0.03	0.34	3	247.15	0.04	0.86
C103-5	2	165.67	0.03	0.06	2	165.67	0.04	1.44
C206-5	2	236.58	0.04	0.28	2	236.58	0.05	0.45
C208-5	1	158.48	0.03	0.20	1	158.48	0.04	0.50
R104-5	2	136.69	0.03	0.06	2	136.69	0.03	0.09
R105-5	2	156.08	0.02	0.34	2	156.08	0.03	0.76
R202-5	1	128.78	0.04	0.30	1	128.78	0.05	0.19
R203-5	1	179.06	0.06	0.06	1	179.06	0.08	0.58
RC105-5	3	238.05	0.02	0.30	3	233.77	0.03	0.61
RC108-5	2	253.93	0.03	0.23	2	253.93	0.04	0.70
RC204-5	1	176.39	0.05	0.44	1	176.39	0.06	0.56
RC208-5	1	167.98	0.04	0.34	1	167.98	0.05	0.62
C101-10	3	393.76	0.05	0.27	3	388.30	0.07	34.43
C104-10	2	273.93	0.10	0.48	2	273.93	0.13	1.30
C202-10	2	243.20	0.09	0.30	2	243.20	0.11	1.12
C205-10	2	228.28	0.07	0.23	2	228.28	0.10	0.28
R102-10	3	249.19	0.06	0.37	3	249.19	0.07	0.33
R103-10	3	202.85	0.11	0.59	3	202.85	0.13	4.43
R201-10	3	217.68	0.12	0.28	3	217.68	0.15	0.31
R203-10	1	218.21	0.35	0.28	1	218.21	0.45	1.09
RC102-10	4	423.51	0.05	0.22	4	423.51	0.06	0.33
RC108-10	3	345.93	0.06	0.09	3	345.93	0.08	0.53
RC201-10	3	310.06	0.08	0.25	3	310.06	0.10	0.28
RC205-10	2	325.98	0.08	0.23	2	325.98	0.11	0.34
C103-15	4	371.70	0.20	10.28	3	348.46	0.23	841.84
C106-15	3	275.13	0.11	0.30	3	275.13	0.13	3.40
C202-15	3	376.79	0.23	0.91	3	369.56	0.26	7.07
C208-15	2	300.55	0.30	0.47	2	300.55	0.34	0.83
R102-15	5	413.93	0.09	7200	5	412.78	0.10	7200.00
R105-15	4	336.15	0.08	1.47	4	336.15	0.09	2.14
R202-15	2	358.00	0.37	1377.27	2	358.00	0.42	705.73
R209-15	2	293.20	1.06	1.31	2	293.20	1.21	8.24
RC103-15	4	397.67	0.12	15.12	4	397.67	0.13	45.44
RC108-15	3	370.25	0.13	16.57	3	370.25	0.15	169.53
RC202-15	2	394.39	0.27	16.69	2	394.39	0.31	133.18
RC204-15	2	310.58	0.60	72.68	2	310.58	0.68	166.91
Average			0.14	242.21			0.17	259.35

In CR, some customers are selected by different rules and removed from the solution resulting in a partial solution. Then, in order to make this solution feasible, a customer insertion mechanism is used to reinsert the removed customers to the solution. Since recharging stations are the crucial part of this problem, changing their positions may also improve the solution. Therefore, some stations are selected to be removed from the current feasible solution using a SR mechanism. Then a partial and probably infeasible solution is obtained. In order to make this solution feasible, a SI mechanism is selected and recharging stations are inserted in the necessary positions. The difference between CI and SI is that we do not have to insert the same stations with the removed ones while in the CI; the removed customers are inserted to the solution. We use four CI mechanisms: Greedy, Regret, Regret-2, and Zone Insertion. If the route becomes infeasible with respect to the battery charge insufficiency (refer to as battery infeasibility) due to an insertion then a station is inserted into the route using the Greedy Station Insertion.

The pseudo-code of the algorithm is given in Algorithm 1. A detailed description can be found in [18,19].

Experimental Results

[19] showed that ALNS is a promising approach giving good results in a reasonable amount of time. Here, we perform computational experiments using the EVRPTW data of Schneider et al. (2014) with distance minimization objective. The algorithm is coded on Java programming language and all experiments are performed on an Intel Xeon E5 processor with 3.30 GHz speed and 64 GB RAM, and 64-bit Windows 7 operating system. The parameters are tuned using a methodology similar to that of [7,23,27,28]. We selected six large problems and performed ten runs for each parameter. At each step, we allowed one parameter to take a number of predefined values while the rest of the parameters were kept fixed. For each parameter, we selected the value that gave the least average deviation from the best achieved solution. After a parameter value has been determined, its value was fixed and this procedure was repeated for the remaining parameters until all parameters had been tuned. The best values of the parameters can be found in [19].

Here we will give the optimal solutions of small instances of [29] by using the third model which allows continuous recharging with distance minimization objective. We compare our solutions on small instances with the optimal solutions obtained by CPLEX in Table 1. The first column denotes the instance while #Veh and TD refer to the number of vehicles and total distance. The computational times for CPLEX and ALNS are given in seconds in the next two columns. ALNS was able to find the optimal solutions in all small instances for both Model 1 and 3. As expected, the computational times of ALNS are significantly lower than those of CPLEX. Moreover, for the instance R102-15, CPLEX could not find the optimal solution within 7200 seconds but provided an upper bound. We confirmed the optimal solution for this problem by running CPLEX longer. These computational times also show that the model with partial recharging is more difficult to solve.

We also applied ALNS to the large instances of [29] both using Model 1 and 3 using distance minimization objective. This data set consists of 56 problems and was generated based on the well-known vehicle routing problem with time windows of [30]. Table 2 summarizes these average results for each problem type and also presents the improvements achieved by partial charging in column **Δ%**. The average computational time for large instances is 12.26 minutes.

Table 2. Comparison of full and partial charge results obtained with ALNS on the large instances

Instance	Full Charge		Partial Charge		
Type	*#Veh*	*TD*	*#Veh*	*TD*	Δ%
c1	11.44	1014.01	11.33	993.58	-2.01
c2	4.00	640.92	4.00	629.95	-1.71
r1	13.83	1231.66	13.67	1210.70	-1.70
r2	4.64	862.26	4.64	862.26	0.00
rc1	13.75	1404.99	13.25	1380.89	-1.72
rc2	6.25	1007.46	6.25	1007.46	0.00

Average	8.99	1026.88	8.86	1014.14	-1.19

CONCLUSION AND FUTURE WORK

In this study, we provided an overview of the electric vehicle routing problem with time windows, presented some background on the electric vehicles and batteries, formulated mathematical models for different recharging options, and gave the optimal solutions of small instances from the literature for both full and partial charging schemes using distance minimization objective. We also introduced the ALNS algorithm which is developed to solve the large instances and provided the best known solutions for benchmark instances from the literature.

As future research, the more practical heterogeneous fleet case can be addressed where the EVs have different capacities and batteries. In real life, travel times are usually dependent to the time of the day. Hence, time dependency can be added to the models which will enhance the constraints related to the time windows. In addition, the travel times may change due to accidents, construction, unpredictable events, etc. and recharging time may depend on the infrastructure of the stations. So, variability in both travel and recharging times can be investigated within the stochastic context. Finally, different VRP variants such as pick up and delivery, open, periodic, split-deliveries, multi-depot, etc. cases can be addressed using a fleet of EVs.

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PRODUCT MIX DECISION MAKING IN TRANSPORTATION MANAGEMENT

Umman Tuğba Gürsoy [217] , Özlem Akçay Kasapoğlu[218]

Abstract_*Companies use different techniques to explore and analyze data in order to discover important knowledge for competitive advantage. Having accurate forecasting helps to determine market demand, to make radical changes on services and to create new business model. Analyzing current data and previously untapped data are key point to have accurate forecasting. The clustering task consists of partitioning the data into several groups in such a way that, each cluster has instances that are very similar to each other, and the instances in each cluster are very different from the instances in the other clusters. In this paper it is aimed to cluster the retailers in a distribution channel, for ensuring the right product mix decision and right transportation management. By using Cluster Analysis the retailers are divided into homogenous groups. Stock keeping unit capacity and inventory turnover rate variables are used as similarity measures. IBM Modeler Programme and k-means algorithm is used to analyze the data. Based on outcomes of analyze, increased operation efficiency is aimed. The results obtained from the data is going to use to increase the level of efficiency in operations.*

Keywords_Cluster analysis, k-means, Product mix, Transportation management.

INTRODUCTION

Fierce competition in today's markets, the introduction of products with short life cycles and hightened expectations of customers have forced business enterprises to invest and focus attention on, their supply chain. The objective of supply chain management is to be efficient and cost effective across the entire system; total system wide costs, from transportation and distribution to inventories of raw materials, work in process and finished goods are to be minimized. Thus, the emphasis is not simply minimizing transportation cost or reducing inventories, but rather, on taking a systems approach to supply chain management [2].

Transportation management in supply chain decisisons could be considered to be between order processing and distribution management it considers both inbound (procurement) and outbound (shipping) logistics with different routing solutions. In this paper retailers are clustered in the distribution channel, regarding their stock keeping unit capacity and inventory turnover rate, to ensure the right product mix decision and right transportation management. The inventory turnover ratio is an efficiency ratio that shows how effectively inventory is managed by comparing cost of goods sold with average inventory for a period. This measures how many times average inventory is "turned" or sold during a period. In other words, it measures how many times a company sold its total average inventory dollar amount during the year. SKU (stock keeping unit, sometimes spelled "Sku") is an identification, usually alphanumeric, of a particular product that allows it to be tracked for inventory purposes. The product mix is the total variety of products a firm sells. Firms should select their product mix carefully as they will need to generate a profit from each of the products in the product mix.

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TRANSPORTATION MANAGEMENT

Transportation refers to the movement of product from one location to another as it makes its way from the beginning of a supply chain to the customer. Transportation is an important driver because products are rarely produced and consumed in the same location. To understand transportation in a supply chain it is important to consider the perspectives of four parties.The first one is shiper which requires the movement of the product between two points in supply chain. Second is the carrier which moves and transports thee product, Third, the owners and operations of transportation infrastructure which makes investment decisions regarding the transportation equipment. Such as roads, ports, canals and airports and forth the bodies that set transportation policiy world wide.

Transportation management systems manage four key processes of transportation management:

1. Planning and decision making – TMS will define the most efficient transport schemes according to given parameters, which have a lower or higher importance according to the user policy: transport cost, shorter lead-time, fewer stops possible to ensure quality, flows regrouping coefficient, etc.
2. Transportation Execution – TMS will allow for the execution of the transportation plan such as carrier rate acceptance, carrier dispatching, EDI etc..
3. Transport follow-up – TMS will allow following any physical or administrative operation regarding transportation: traceability of transport event by event (shipping from A, arrival at B, customs clearance, etc.), editing of reception, custom clearance, invoicing and booking documents, sending of transport alerts (delay, accident, non-forecast stops…)
4. Measurement – TMS have or need to have a logistics key performance indicator (KPI) reporting function for transport.

Various functions of a TMS include but not limited to: Planning and optimizing of terrestrial transport rounds, Inbound and outbound transportation mode and transportation provider selection, Management of motor carrier, rail, air and maritime transport, Real time transportation tracking, Service quality control in the form of KPI's,Vehicle Load and route optimization,Transport costs and scheme simulation, Shipment batching of orders, Cost control, KPI (Key performance indicators) reporting and statistics.

Typical KPIs include but not limited to: % of On time pick up or delivery performance relative to requested, Cost Per Metric - mile; km; Weight; Cube; Pallet, Productivity in monetary terms, e.g. cost per unit weight or shipping unit, Productivity in operational terms, e.g. shipping units/order or weight/load. However, all the above logistical functions need to be scrutinized as to how each parameter functions.

A TMS helps companies move freight from origin to destination efficiently, reliably, and cost effectively. TMS encompasses solutions for moving freight in all modes and also includes intermodal movements. The TMS processes include freight transported inbound or outbound, domestically or internationally; using transportation assets owned either by the company or an outside service provider. The main reason companies implement a TMS is to reduce freight spend. Shippers that are focused on their transportation management perform better in terms of service levels and freight savings.

There are benefits in paying attention to the transportation management. It helps the firms in increasing their customer service, time and money is not wasted with the carriers working on time all the time. Their warehause is more efficient in combination with a Warehouse Management System, combined Supply Chain visibility to make business decisions that drive further cost savings and decrease inefficiencies could be gained. They have New Delivery Capabilities; by distribution programs or set up inbound programs between multiple locations within the organization could be optimized. By accurate forecasting, inventory reductions Cash Flow Improvements could be optained [3].

Once a shipper either tracks this data themselves or a 3PL provides key transportation metrics the shipper can then implement and understand transportation best practices. Once understood, the shipper, along with the 3PL, are able to create new strategies and tactics for the logistics side of the business which will drive value and savings to the bottom line.

However, a shipper must first know the correct transportation metrics to track and understand. Using the correct set of metrics can lead you to realize if you have the proper balance between service and cost. Using the correct transportation performance metrics will not only let you know your current performance, but will also lead you to change processes to become more efficient. Transportation measures of effectiveness should be considered critical to any improvement plan. Although metrics do vary, a general overview of some common transportation metrics in use today can be seen below, but first it must be understand how to go about using these metrics [4].

Design option for a transportation network

- Direct shipment network to single destination
- Direct shipping with milk runs
- All shipments via intermediate distribution center with storage
- All shipments via intermediate transit point with cross- docking
- Shipping via Dc using milk Runs
- Tailored network

Table 1. Pros and Cons of Different Transportation Networks [1]

Network Structure	Pros	Cons
Direct shipping	No intermediate warehouse simple to coordinate	High inventory (due to large lot size)
Direct shipping with milk runs	Lower transportation costs for small lots, lower inventory	Receivig expense
All shipments via intermediate distribution center with inventoy storage	Lower inbound transportation cost through consolidation	İnscreased inverntory cost
All shipments via intermediate transit point with cross- docking	Lower inventory requirement, Lower transportation cost through consolidation	Increased handling in DC
Shipping via Dc using milk runs	Lower outbound transportation cost for small lots	Increase in coordination complexity
Tailored network	Transportation choice best matches needs of individual product and store	Highest coordination complexity

In our study the Cluster Analysis is done according to the stock keeping unit capacity and inventory turn over rate. High demand products to high demand centers are shipped to the center directly where as low demand products or shipments to low demand centers are consolidated to and from distribution centers. Tailored network is applied with the complexity of managing this network with different shipping procedures used for each product and retail center.

CLUSTER ANALYSIS AND K-MEANS ALGORITHM

Cluster analysis divides data into groups that are meaningful, useful or both. The goal is that the objects within a group be similar to one another and different from the objects in other grous.The greater the similarity or homogeneity within a group and the greater the difference between groups, the better or more distinct the clustering [5].

Cluster analysis is a method for automatically grouping data into a smaller number of subsets or clusters so that the records grouped are most statistically similar to each other based on the attributes of the data compared.

There are several different notions of a cluster that prove useful in practise. k-means is one of the most commonly used clustering techniques.

In statistics and data mining, **k-means clustering** is a method of cluster analysis which aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean. k-means cluster analysis achieves this by partitioning the data into the required number of clusters by grouping records so that the euclidean distance between the record's dimensions and the clusters centroid (point with the average dimensions of the points in the cluster) are as small as possible.

The k-means algorithm is an iteration of the following steps until stability is achieved i.e. the cluster assignments of individual records are no longer changing [6].

1. Determine the coordinates of the centroids. (initially the centroids are random, unique points, there after the mean coordinates of the members of the cluster are assigned to the centroids).
2. Determine the euclidean distance of each record to each centroid.
3. Group records with their nearest centroid.

APPLICATION

In our study the data is taken from a big retailer which is operated through Turkey. With this study, it is aimed to have right shipment schedule to store with best product mix. By applying cluster analysis, similar stores are grouped to have homogenius store clusters

Data set consists of 193 records and 3 fields. It can be seen in Table 2. The variables are Store code, Stock keeping unit capacity and Inventory Turnover Rate. Stock keeping capacity shows different product lines that store can carry. And, inventory turnover rate shows how fast product can be sold.

Table 2. Data set

Table (3 fields, 193 records) #1

File Edit Generate

	Store code	Stock keeping unit capacity	Inventory turnover rate
1	4087.000	1434.000	1.719
2	4122.000	1344.000	1.345
3	4143.000	1244.000	2.203
4	4027.000	1133.000	1.494
5	4137.000	1129.000	1.233
6	4182.000	1059.000	1.506
7	4013.000	1051.000	1.342
8	4172.000	1048.000	1.133
9	4121.000	991.000	1.259
10	4169.000	983.000	1.610
11	4049.000	966.000	2.395
12	4168.000	945.000	1.682

K-means clustering algorithm is used for the analysis. The IBM Modeler k-means model can be seen in Figure 1.

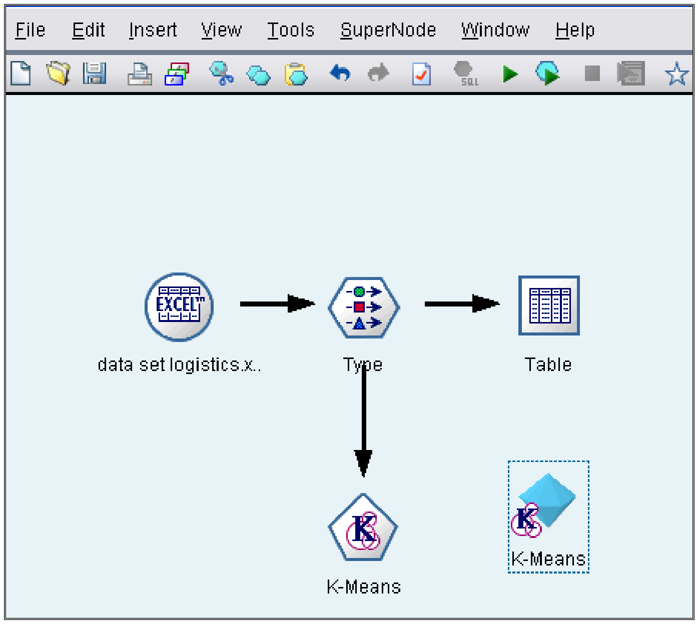


Figure 1. K- means Model

After trying different cluster numbers, 6 clusters identified as a best result. (Figure 2)

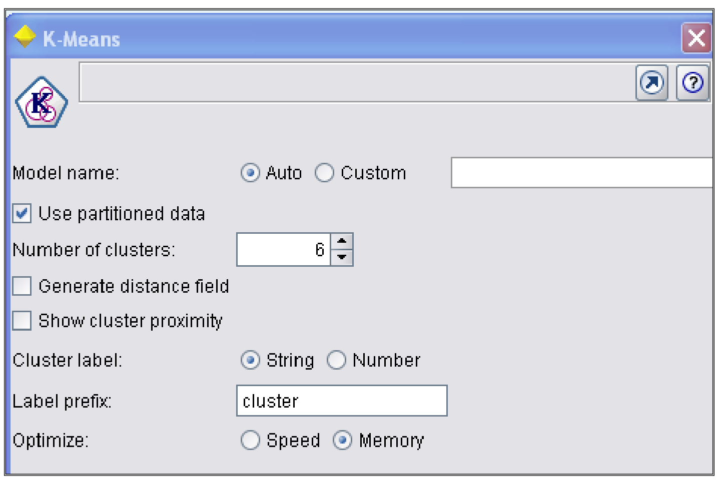


Figure 2. Number of Clusters for K-means

When Figure 3 is analyzed, it can be seen that:

1- There are 11 stores in Cluster 1 with an average 1108 sku score. Based on this, it can be said that those stores are big. And also, they are fast selling sores with an average 1,679 inventory turnover rate.

2- There are 30 stores in Cluster 3. They are small stores because of 490 sku score. In contrast, selling potential is very high becasue of 2,001 inventory turnover rate.

Based on results of Figure 3, firm should make shipment to stores in Cluster 1 for wider product line with higher quantity. For stores in Cluster 3, firm should make shipment for less product line with higher quantity.

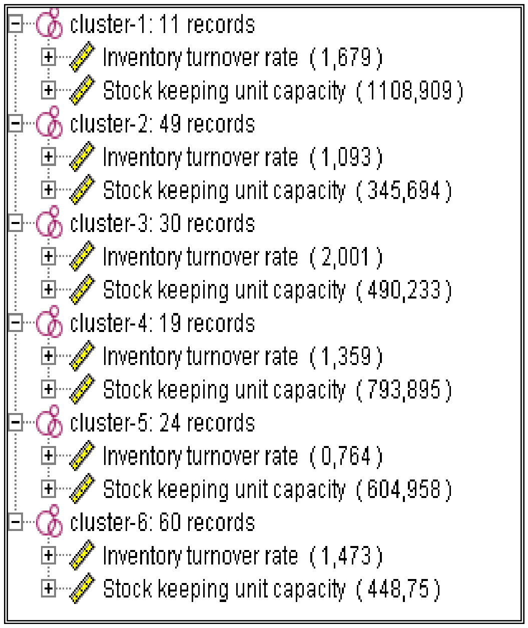


Figure 3. K-means Results

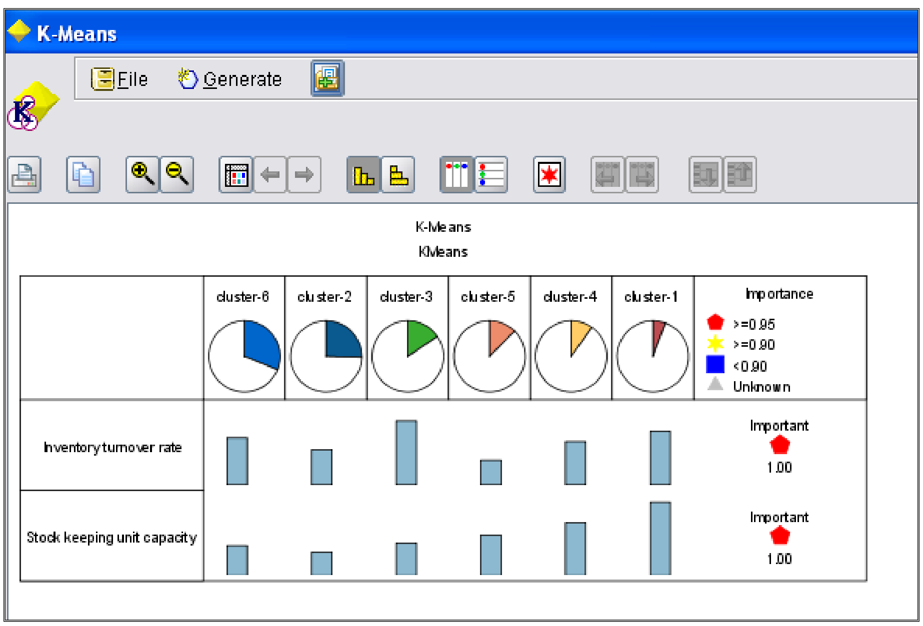
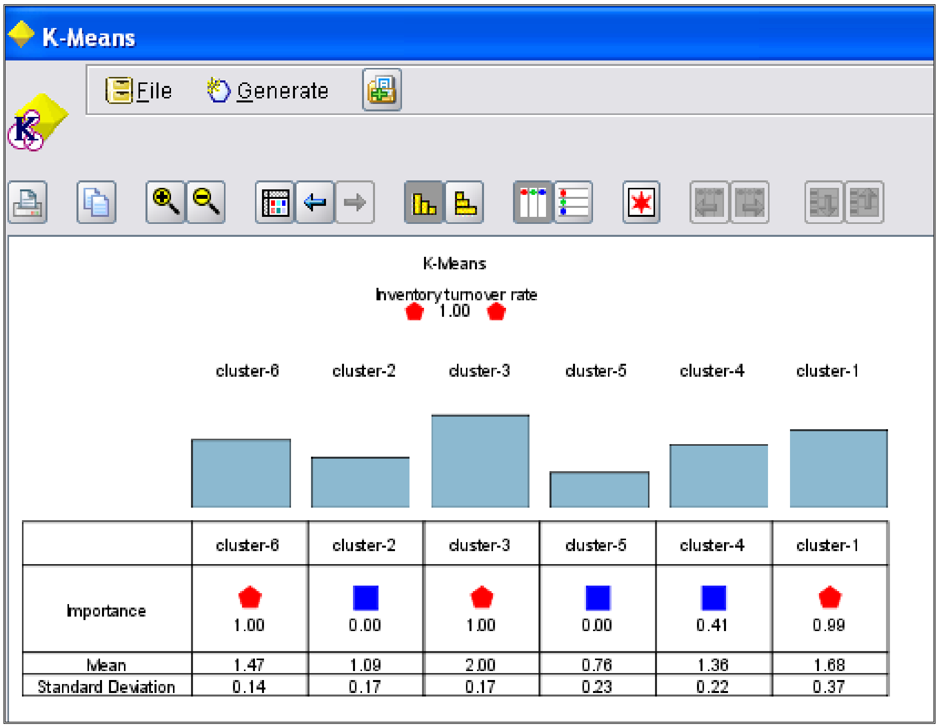


Figure 4. K-means Results

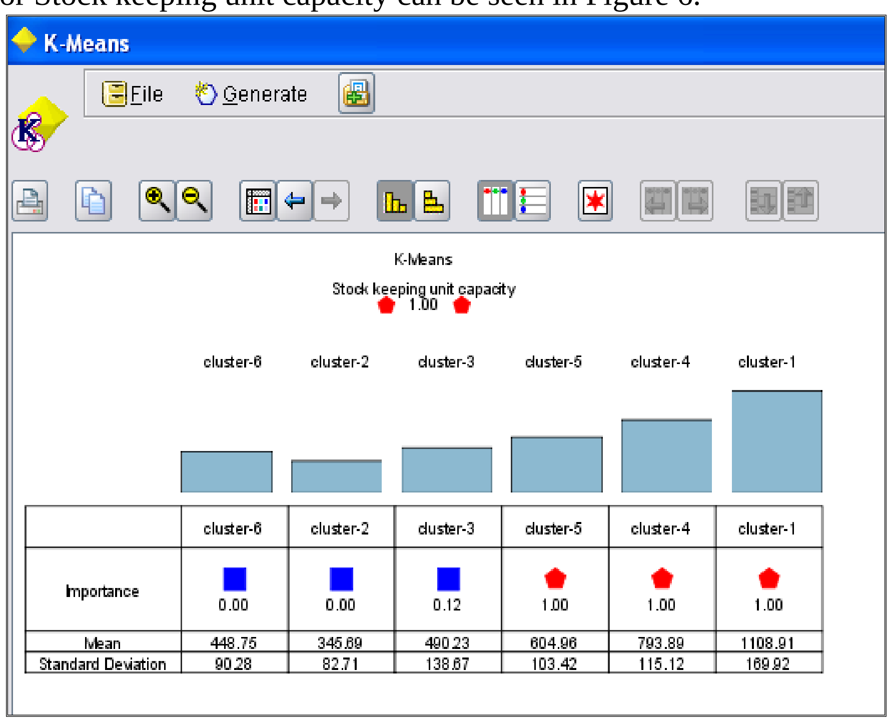
K-means results for Inventory turnover rate can be seen in Figure 5.



	cluster-6	cluster-2	cluster-3	cluster-5	cluster-4	cluster-1
Importance	1.00	0.00	1.00	0.00	0.41	0.99
Mean	1.47	1.09	2.00	0.76	1.36	1.68
Standard Deviation	0.14	0.17	0.17	0.23	0.22	0.37

Figure 5. K-means Results for Inventory Turnover Rate

K-means results for Stock keeping unit capacity can be seen in Figure 6.



	cluster-6	cluster-2	cluster-3	cluster-5	cluster-4	cluster-1
Importance	0.00	0.00	0.12	1.00	1.00	1.00
Mean	448.75	345.69	490.23	604.96	793.89	1108.91
Standard Deviation	90.28	82.71	138.67	103.42	115.12	169.92

Figure 6. K-means Results for Stock Keeping Unit Capacity

CONCLUSION

Data mining define as the process of discovering useful patterns or knowledge from data sources. The patterns must be valid, potentially useful and understandable. There are many data mining tasks. Some of the common ones are classification, association rule mining, sequential pattern mining and clustering.

Cluster analysis has long played an important role in a wide variety of fields: social sciences, biology, statistics, marketing, pattern recognition, informaion retrieval and data mining. K-means is the best known clustering algorithm. It is perhaps also the most widely used among all clustering algorithms due to its simplicity and efficiency.

In this paper, the data is taken from a big retailer which is operated through Turkey. The purpose is to have right transportation to store with best product mix. By applying Cluster analysis and k-means algorithm, similar stores are grouped to have homogenius store clusters. Stock keeping capacity and, inventory turnover rate variables are used for the analysis.

According to analysis' results it is identified that, there are 11 stores in Cluster 1 with an average 1108 sku score. Based on this, it can be said that those stores are big. And also, they are fast selling stores with an average 1,679 inventory turnover rate. There are 30 stores in Cluster 3. They are small stores because of 490 sku score. In contrast, selling potential is very high becasue of 2,001 inventory turnover rate.

Based on results, the retailer company should make shipment to stores in Cluster 1 for wider product line with higher quantity. For stores in Cluster 3, the retailer company should make shipment for less product line with higher quantity. The results obtained from the data is going to use to increase the level of efficiency in operations.

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EVALUATION OF VESSEL TRAFFIC IN ISTANBUL STRAIT ACCORDING TO VESSEL TYPES

Olgay Oksas[219]

Abstract – *Istanbul Strait is one of the most important natural waterway in the world due to its geographical location, narrowness, strong currents, sharp bends, uncertain weather conditions. On the other hand approximately 150 vessels are passing through Istanbul Strait every day where is the only gate of the Black Sea countries to the world. This vessel traffic is a potential danger for the Istanbul city and people living around Istanbul Strait. Not only vessels themselves are dangerous but also the cargoes carried by these vessels are points that to be taken into consideration. At this point, types of vessels passing through Istanbul Strait becomes more important. This study is based on the statistics of vessel types passed through Istanbul Strait in the last nine years and it's examined which vessel types are commonly using Istanbul Strait, what is the percentage of more dangerous vessels in this traffic and what is the expected traffic in the future.*

Keywords – *Istanbul Strait, Maritime Transport, Vessel Types.*

INTRODUCTION

Istanbul Strait is the most important natural narrow waterway in the world, due to its geographical situation, narrowness, strong currents, sharp bends, uncertain weather conditions and 2500 regional maritime traffic activity in which approximately 2 million people were transported, 150 non-stopover vessels and 23 vessels carrying hazardous cargo passed every day [1]. In this perspective, both people living around Istanbul Strait and people using Istanbul Strait as a transport route are under potential risk and danger due to this heavy traffic.

Turkish Straits are the only gateways to the world for the Black Sea countries and still has an important role in political relations. Today, Montreux Convention and IMO rules and recommendations arranges Turkish Straits passing procedure and since 2003, it's operationally controlled by Directorate General of Coastal Safety with Turkish Straits Vessel Traffic Services.

Ships passing through Istanbul Strait constitute a serious threat due to the carried cargo types as much as the navigational risks. Serious accidents occurred in the Straits are usually tanker accidents as they have important implications to daily life, environment and marine pollution, human life and even world economy. In this context, cargo types of vessels are important as well as the number of ships passing through the Straits. In this study, vessel types passing through Istanbul Strait are summarized and the proportion of the tankers which are in a more dangerous position is calculated. Using time series analysis with the help of last nine years statistics both tanker and total vessel traffics are estimated in the future.

VESSEL STATISTICS OF ISTANBUL STRAIT

Statistical datas were received from the website of Directorate General of Merchant Marine which are available for the nine year period from 2006-2014 [2,3,4,5,6,7,8,9,10]. These datas were summarized and shown as tables / graphics below.

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Datas were handled from the detailed vessel types table of Turkish Straits and total number of vessels were calculated for each year of Istanbul Strait. This study is based on the statistics of number and gross tonnage of vessels passing through Istanbul Strait yearly.

Table 1 : Number of Vessels Passing Through Istanbul Strait

Years	Tanker	Bulk	General Cargo	Container	Passenger	Others*	Total Number of Vessels
2006	10153	5417	33039	3409	1658	1204	54880
2007	10054	5144	34705	2727	1702	2274	56606
2008	9303	5971	32704	2773	1147	2498	54396
2009	9299	6630	30835	2014	786	1858	51422
2010	9274	5857	30859	2292	631	1958	50871
2011	9103	6341	29267	2718	481	1888	49798
2012	9027	7163	27125	2707	583	1723	48328
2013	9006	6894	25521	2618	474	2019	46532
2014	8744	7263	24107	3073	651	1690	45528

* Others : Naval Vessels, Livestock Vessels, Fishing Vessels, Reefer Vessels, RO-RO Vessels.

According to Table 1 basic vessel types which are passing through Istanbul Strait can be summarized under four main types (tankers, bulk carriers, general cargo and container vessels). Number of tankers is approximately %18 of total number of vessels which is shown in Table 2. This means one of five vessels passing Istanbul Strait is more dangerous as per cargo type.

Table 2 : Percentage of Tankers Passing Through Istanbul Strait

Years	Total Number of Vessels	Total Number of Tankers	Percentage(%)
2006	54880	10153	18,50
2007	56606	10054	17,76
2008	54396	9303	17,10
2009	51422	9299	18,08
2010	50871	9274	18,23
2011	49798	9103	18,27
2012	48328	9027	18,67
2013	46532	9006	19,35
2014	45528	8744	19,20

When the Montreaux Convention went into force in 1936, transport of dangerous cargo in Turkish Straits posed little concern due to the infrequent passages and small vessel sizes. However, the increases in traffic and vessel sizes have raised with the severity of accidents. Some major accidents have occurred since 1960, when the Greek-flagged M/T World Harmony collided with the Yugoslavian-flagged M/T Peter Zoranic, leading to the death of 20 crew members, severe oil pollution and fire that lasted several weeks, suspending the transit traffic. In 1979, Romanian-flagged Independenta and the Greek freighter M/V Evriyalı collided at the southern entrance of the Strait. 43 crew members died, 64,000 tons of crude oil spilled into the sea and 30,000 tons burned into the atmosphere. In yet another catastrophe, the Greek Cypriot vessels M/T Nassia and M/V Shipbroker collided in the Strait. 29 officers and crewmen perished and 20,000 tons of crude oil burned for five days, suspending the traffic for a week [11]. These accidents are the physical indications of the risk and danger in Istanbul Strait.

In order to control and mitigate maritime accident risks and improve the safety of navigation in the described dire environment, The Bureau of Turkish Strait's Maritime Traffic Services (BMTS) set up Vessel Traffic Control & Monitoring System (VTS), (covering not only the Strait, but also 20 miles into the Black Sea and the Sea of Marmara) and established a set of stringent Maritime Traffic Rules and Regulations (R&R). The vessels arriving at the northern and southern entrances of the Strait of Istanbul enter and then navigate through the Strait according to the di-rections of the BMTS, which are based on the VTS inputs and the R&R [12].

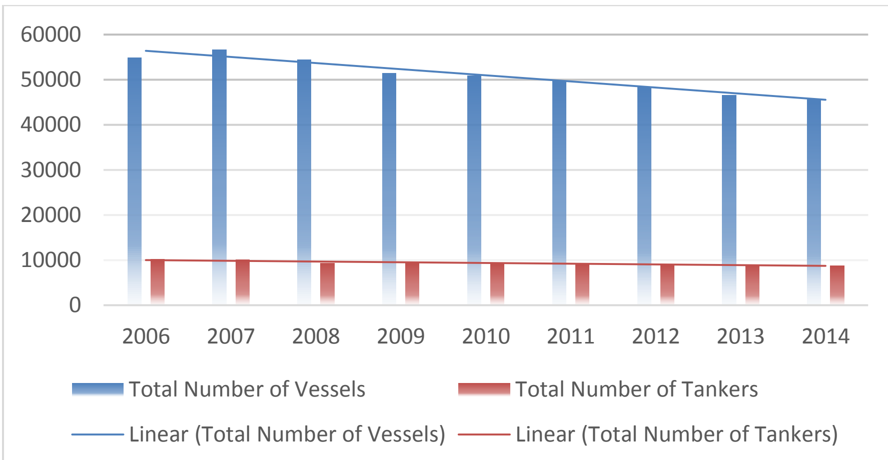

Figure 1 : Total Number of Vessels and Tankers

It's seen on Figure 1 and tables above, total number of both tankers and vessels are decreasing. But number of vessels is not the only parameter to evaluate the risk and danger, as a matter of fact gross tonnages of vessels are increasing every passing year. Figure 2 shows the gross tonnages of vessels passing through Istanbul Strait. In the year of 2014 total gross tonnage were 582.468.334 while it was 475.796.880 at 2006. The increase of trend is obviously seen on the Figure 2.

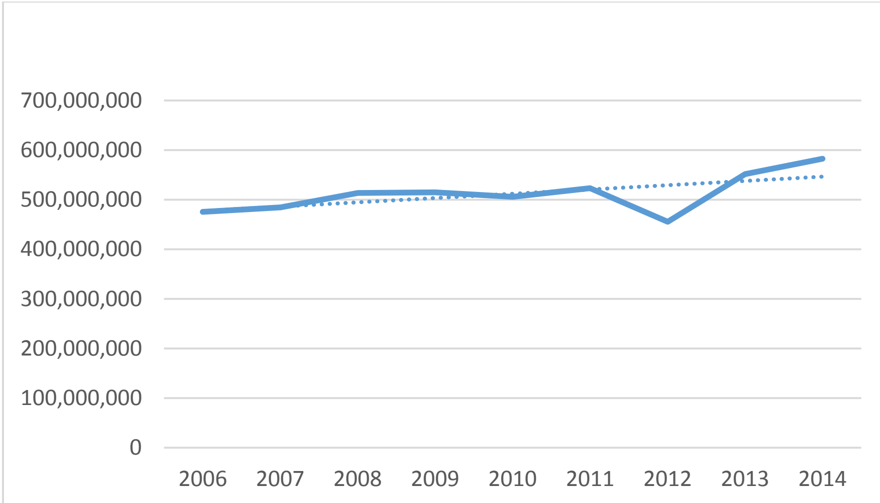

Figure 2 : Total Gross Tonnage of Vessels as per Years

ESTIMATION OF VESSEL TRAFFIC IN ISTANBUL STRAIT

In this study, time series data has been used for estimation with the method of trend analysis which is a kind of simple linear regression model. Only difference from simple linear regression is the independent variable is time. In this case dependent variables would be number of tankers, number of total vessels and total gross tonnages each year. The forecasting equation for the linear trend model is shown as Equation (1) below [13].

$$\hat{Y}_i = \alpha + \beta t_i \tag{1}$$

Table 3 shows the datas of independent variable and dependent variables as a summary. Linear trend lines also can be seen on Figure 1 and Figure 2 above.

Table 3 : Independent Variable (t) and Dependent Variables(Y_1, Y_2, Y_3)

Years	Time Period (t)	Number of Vessels (Y_1)	Number of Tankers (Y_2)	Gross Tonnages (Y_3)
2006	1	54880	10153	475.796.880
2007	2	56606	10054	484.867.696
2008	3	54396	9303	513.635.614
2009	4	51422	9299	514.656.446
2010	5	50871	9274	505.615.381
2011	6	49798	9103	523.543.509
2012	7	48328	9027	455.682.544
2013	8	46532	9006	551.775.136
2014	9	45528	8744	582.468.334

Simple linear regression model has been applied to above datas for each pair and solved by data analysis add-in in MS Excel program. Results and final equations (2), (3), (4) are as below:

$$\hat{Y}_{total\ vessel} = 57.711{,}5 - 1.356{,}5t \quad (2)$$

$$\hat{Y}_{tanker} = 10.123{,}22 - 158{,}5t \quad (3)$$

$$\hat{Y}_{gross\ tonnage} = 468.638.860{,}6 + 8.673.151t \quad (4)$$

According to these equations estimation of total number of vessels would be 44147, number of tankers would be 8535 and gross tonnage would be 555.370.371 for the year of 2015.

Table 4 : Estimations for the year of 2015

Total Number of Vessels	Number of Tankers	Total Gross Tonnages
44147 ⬇	8538 ⬇	555.370.371 ⬇

When we check the results of data analysis significance F values are respectively 0,00001 ; 0,0004 and 0,07 for total number of vessels, number of tankers and gross tonnages. These figures means coefficient of time is statistically significant at the 5 percent level except for value of gross tonnage.

R square values are respectively 0,94 ; 0,84 and 0,37 for total number of vessels, number of tankers and gross tonnages. R squared values should be between 0 and 1. If the value is closer to 1 there is a strong linear relationship between Y and t or vice versa. The figures shows that value of gross tonnage is lower than others and close to 0 which means weaker relationship.

It can be easily seen on Figure 2 that the decrease of gross tonnage in 2012 affects the linearity of the trend, hence the test values of gross tonnage gives lower results about statistically significant. On the other hand forecast of total number of vessels and total number of tankers are statistically significant.

CONCLUSIONS

Turkish Straits are one of the most important waterway systems in the world, besides Istanbul Strait is in the middle of Istanbul city where almost 15 million people lives. As the Istanbul Strait is the only maritime link of Black Sea countries to the Mediterranean, the vessel traffic is directly related to world economy, international trade and transport of energy resources from the Caspian Sea, Russia and Ukraine. This study aimed to forecast the vessel traffic passing through the Istanbul Strait for the year of 2015. When the datas were summarized it's been seen that number of vessels are in a decreasing trend but total gross tonnage of vessels are increasing with the highest value of 582.468.334 GT in 2014. According to model results forecasts would be respectively 44147, 8535 and 555.370.371 for total number of vessels, number of tankers and gross tonnages for the year of 2015. Even all results are lower than previous year, numbers of vessels and tankers are in a considerable amount of the risk as well as the gross tonnage. The main reason of decrease in number of vessels would be the scrapping of old vessels and new constructions with higher gross tonnages. Especially crude oil tankers reached huge sizes to carry more oil in the same voyage. It's obvious that Turkish Straits will always be strategical points for the world and this region. Due to the high risk of navigation at Istanbul Strait and high amount of tanker vessels passing, the control of the traffic becomes more crucial. This study would help authorities to plan vessel traffic system for coming year and provide to make the risk analysis of Istanbul Strait in advance.

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A FIX AND OPTIMIZE HEURISTIC FOR TRANSPORTATION PLANNING IN A SINGLE PRODUCER MULTI BUYER SYSTEM

Mehmet Serkan Tokgoz[220], Kadir Ertogral[221]

We address the transportation planning problem for a producer who supplies products to geographically dispersed customers with known demands for a finite planning horizon. The problem originated from a real case which involves a producer of dry pulses, who serves entire Turkey from two production plants. The producer uses services of logistic companies in transporting goods in the form of both renting trucks from a company and using parcel transportation service from a carrier. The decisions that the producer has to make in each period are which customers' demand to load to which trucks, and for which customers' demand to use parcel carrier service. Total cost of transportation is the summation of the fixed renting cost of sending a truck to a zone, a cost depending on the total number of customers visited, and parcel cost. We introduced a mathematical programming model of this problem for the first time in the literature, and suggested a fix and optimize type heuristic solution procedure. We showed the effectiveness of the suggested heuristic on a set of random problems.

Keywords – Transportation planning, Mathematical modeling, fix-and-optimize

1. INTRODUCTION

The logistic costs represent a significant portion in the overall revenue in several industries. It ranges approximately from 3% to 15% depending on the industry. The problem we study originated from a real life and it is about reducing logistics or distribution costs. It involves a producer of dry pulses, who serves entire Turkey from two production plants. The producer uses services of logistic companies in transporting goods to its retailer customers. Goods are transported using both rented trucks from a company and parcel transportation service from a carrier. Customers are divided into zones and a truck can visit only a single zone in a given period during the planning horizon. A customer can belong to more than one zone. The producer has to decide which customers' order to load to which trucks in which periods. Alternatively, any customer demand can be transported using parcel carrier. There are different sizes of trucks available with different costs and capacities. The cost of renting a truck depends on both the zone that truck goes and the number of customers the truck visits. The parcel carrier cost per unit transported is significantly more costly option than using the rented trucks. The aim is to minimize the total transportation costs during the finite planning horizon.

To the best of our knowledge, out problem setup has not been introduced and handled in the literature. The main relevant problems to the problem we deal here are production routing problem (PRP), inventory routing problem (IRP) and bin packing problem (BBP). The IRP is about distributing a single product from a single facility to a set of customers during a finite planning horizon. Each customers demand rates are known and they can hold inventory within a capacity. The objective is to find a vehicle routing and delivery plan for each period in the planning horizon so that the total distribution costs are minimized. Because of the difficulty and complexity of IRP most of the solution approaches have been heuristics [4][5][10]. PRP is a generalization of IRP, where we integrate the production lot sizing and vehicle routing problems, and it is even more complicated than IRP. The objective is to find a production plan and vehicle routes to distribute the goods to the customers with known demand in a finite planning horizon with the objective of minimizing production and routing related cost. PRP has

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been extensively studied in the literature. It has been shown that one can gain up to 20% cost saving due to the integrated approach of PRP compared to solving the subproblems separately in a sequential fashion [1][2][3]. Unlike our problem, both of these problems assume that we own a fleet and they involve finding exact routings and minimizing related routing costs. In our problem we use 3rd party logistic providers for transportation, and we are not concerned with routing costs or production plan.

BPB is about finding the minimum number of homogeneous bins to pack a given set of objects with different sizes. BPB is an NP-hard problem [6][9]. If we had a single period, single type of vehicle, single zone, with no parcel carrier option, and with much higher cost of sending a vehicle to a zone compared to visit cost, our problem turns into a bin packing problem. Thus, our problem also belongs to NP-hard class.

In the next section, we introduce the details and mathematical formulation of our problem. The heuristic solution approach for the problem is given in section 3. Section 4 gives the details of the random problems generated and solutions obtained using the suggested heuristic. We conclude with section 5.

2. PROBLEM DEFINITION AND FORMULATION

We assume that there is a single producer who has to transport goods to M retailers dispersed geographically into B zones during a planning horizon of T periods. A customer can belong to more than one zone. There are K types of goods and V different types of vehicles. The demand quantities for each type of product in each period by each customer are known. Cost of renting a type of vehicle only depends on the zone the vehicle goes and the number of customers it visits and we can rent as many vehicles as desired in a period. The parcel carrier cost depends on the volume/weight of a load and the customer the load is sent. We assume that we must send the demanded items on their due period or earlier within certain time window. We also assume that we are not allowed to split any demand into different trucks.

We use the following notation in the problem formulation;

Parameters

B= Set of districts

$B_{b=}$ *Set of customers in district b*

M= Set of customers

K= Set of commodities

V= Set of vehicles

$d_{jit} = Amount\ of\ commodity\ i\ demanded\ by\ customer\ j\ in\ period\ t$

$p_{ij} = Cost\ of\ transporting\ unit\ of\ commodity\ i\ to\ customer\ j\ with\ parcel\ carrier\ option$

$C_{vb} = Cost\ of\ sending\ vehicle\ v\ to\ district\ b$

$Cap_v = Capacity\ of\ vehicle\ v$

Sv = Cost of per stoppage of vehicle v

$distance_j = Maximum\ distance\ to\ customer\ j$

w = time window

Decision Variables

$$X_{jitvt'} = \begin{cases} 1, if\ commodity\ i\ demanded\ by\ customer\ j\ at\ period\ t'\ transported\ in\ period\ t \\ \quad by\ vehicle\ v \\ 0, otherwise \end{cases}$$

$$y_{vbt} = \begin{cases} 1, if\ vehicle\ v\ transported\ to\ district\ b\ in\ period\ t \\ 0, otherwise \end{cases}$$

$L_{vt} = Amount\ of\ load\ transporting\ by\ vehicle\ v\ in\ period\ t$

$R_{jit} = Amount\ of\ commodity\ i\ demanded\ by\ customer\ j\ transported\ with\ partial\ transportation$
$\quad in\ period\ t$

Using the notation above, we introduce the formulation of the problem as follows;

$$Min\ z = \sum_{v\in V}\sum_{t\in T} C_{vb}y_{vbt} + \sum_{j\in M}\sum_{i\in K}\sum_{t\in T} R_{jit}p_{ij} + \sum_{i\in K}\sum_{t\in T}\sum_{V\in V}\sum_{t'=1}^{T}\sum_{t=t'}^{T}\sum_{j\in M}\sum_{i\in K} X_{jit'vt}S_v$$

Subject to

$$\sum_{v\in V}\sum_{t'=1}^{t} X_{jit'vt} \leq 1 \qquad \forall j \in M;\ \forall i \in K;\ \forall t \in T \qquad (1)$$

$$\sum_{v\in V}\sum_{t'=1}^{t-w} X_{jit'vt} = 0 \qquad \forall j \in M;\ \forall i \in K;\ \forall t \in T \qquad (2)$$

$$L_{vt'} = \sum_{j\in M}\sum_{t=t'}^{T}\sum_{i\in K} X_{jit'vt}d_{jit} \qquad \forall t' \in T;\ \forall v \in V \qquad (3)$$

$$R_{jit} = d_{jit} - \sum_{v\in V}\sum_{t'=1}^{t} X_{jit'vt}d_{jit} \qquad \forall j \in M;\ \forall i \in K;\ \forall t \in T \qquad (4)$$

$$L_{vt} \leq \sum_{b\in B} y_{vbt}Cap_v \qquad \forall v \in V;\ \forall t \in T \qquad (5)$$

$$\sum_{t=t'}^{T}\sum_{i\in K}\sum_{j\in B_b} X_{jit'vt} \leq y_{vbt'}M \qquad \forall b \in B; \forall v \in V;\ \forall t' \in T \qquad (6)$$

$$\sum_{b\in B} y_{vbt} \leq 1 \qquad \forall v \in V;\ \forall t \in T \qquad (7)$$

$$X_{jit'vt} \in \{0,1\} \qquad (8)$$

$$y_{vbt} \in \{0,1\} \qquad (9)$$

$$L_{vt} \geq 0 \tag{10}$$

$$R_{vit} \geq 0 \tag{11}$$

The objective consist of three cost components, respectively; cost of renting for sending vehicles to zones, cost of parcel carrier, and cost of visiting customers by the vehicles. Constraint 1 assures that demand of a period is assigned to at most one vehicle that visits the customer before the due period of each demand. Constraint 2 prevents a demand to be sent too early. Constraint 3 and 5 keeps track of the load in each vehicle in each period and assures that the capacity of a vehicle is not violated. Parcel carried quantity is calculated by constraint 4. Finally, constraint 7 prevents a vehicle from going to more than one zone in a period.

3. THE HEURISTIC SOLUTION APPROACH; FIX & OPTIMIZE METHOD

As we pointed out earlier, our problem is NP-hard, and therefore we introduce a heuristic approach for the solution. The heuristic approach is an adaptation of so called fix-and-optimize approach from the literature [7][8][11]. The fix-and-optimize approach is about splitting the decision problems into groups and solving the problem only for the target group of decision problems iteratively, while keeping rest of the decision problem either as fixed or as linear decision variables. Let us say that we split the binary decision problems in our problem in to Z consecutive groups based on periods, and let S_i be the set of variables in group i. Our solution approach has following two stages. In the first stage we find a quality solution to our problem, and in the second stage we try to improve the solution. We describe these stages as follows;

Stage 1; Finding a quality solution
1. Let iteration counter i=1
2. Set the binary decision variables in S_k, k=1,2,i-1, to the values found in iteration i-1, if i > 1. Relax the binary decision variables in S_k, k =i+1,i+2,..Z, as linear decision variables between 0 and 1, if i < Z. Keep the binary decision variables in Si as binary. Solve the model.
3. Set i=i+1. If i < Z go to step 2, STOP otherwise.

Stage 2; Improving the solution
1. Set all the decision variables values to the solution obtained in stage 1.
2. Let iteration counter i=1, and set improvement indicator r=0
3. Set the binary decision variables in S_k, k=1,2,i-1, to the values found in iteration i-1, if i > 1. Set the binary decision variables in S_k, k =i+1,i+2,..Z, to the values found in iteration i-1, if i < Z. Keep the binary decision variables in Si as binary. Solve the model.
4. If the solution found is better than the best solution so far, update the best solution as the current solution and set r=1.
5. Set i=i+1. If i < Z go to step 2, otherwise go to step 6.
6. If r=1, go to step 2. STOP and report the best solution, otherwise.

Briefly speaking, in stage 1 we solve a series of problems where variables up to the target group of variables are fixed to the solution found in previous iteration, relax the variables after the target group as linear, and solve the problems where the target group of variables are binary. Thus, we solve drastically simplified or reduced models. We obtain a solution at the end of stage 1. In stage 2, we again solve a series of problems where we set the decision variables other than the target group of decision variables to the solutions obtained in the previous iteration, and only decide the target group of variables. We keep shifting the target group until there is no improvement obtained.

For example, consider a problem with nine periods. We can split the decision variables into Z=3 groups, corresponding to periods (1,2,3), (4,5,6), and (7,8,9). In the first iteration of stage 1, we keep the decision variables for periods 1,2,3 as binary, relax the decision variables for periods 4,5,6,7,8,9 as linear between 0 and 1, and solve the model. In the second iteration, we set the decision variables for periods 1,2,3 to the values found in the previous iteration, keep the decision variables for periods 4,5,6 as binary, relax the decision variables for periods 7,8,9 as linear between 0 and 1, and solve the model again. In the last iteration of stage1, we set the decision variables for periods 1,2,3,4,5,6 to the values found in the previous iteration, we keep the decision variables for periods 7,8,9 as binary and solve the model again.

In the second stage, we solve the problem for the target group only iteratively while setting the rest of the decision variables fixed to the values obtained in the previous iteration. We continue the iterations until we do not observe any improvement in the solution.

4. NUMERICAL EXAMPLES

We test suggested solution procedure on a set of randomly generated data. We solved two sets of problems, each of which has 5 problems. All the problems have 9 periods in the planning horizon, 9 customers, 3 zones with three customers in each zone, single type product, and two types of vehicles with capacities of 16 tons and 25 tons.

To characterize the economic advantage of using big vehicle we let scale dependent economic factor (sef) be the cost of unit capacity of the big vehicle to the small vehicle and set sef=0,7 in all the problems. Another factor is the coefficient of variation (cv) of the demand and we used cv=0,5 for all the problems. We also used a factor α to represent the ratio of the average demand to the capacity of a small vehicle. For the first and second set of 5 problems, we use α=0.1 and α=0.25, respectively. Setting α=0.1 and α=0.25 means we can pack approximately ten and four customer demands in the small vehicle, respectively.

As the cost parameters, we used 100$ as the renting cost for small vehicle to the first zone and 10$ for the visit cost of small vehicle. We increased the renting cost for zone two and three by 10%. We calculated the cost parameters for big vehicle using the sef factor described above.

We have code the solution method using IBM ILOG CPLEX 12.4 solver and Eclipse Java programming language. The results obtained for the two sets of problems are given in the following tables;

Table 1. Results for problem set 1

α=0,10 CV=0,50 Sef=0,70	Optimal	Fix & Optimize(Stage 1)	Fix & Optimize(Stage 2)	Deviation from optimal (%)
1	1751,24	1768,13	1758,21	0,955
2	1824,84	1834,22	1834,21	0,501
3	1793,65	1811,26	1811,26	0,972
4	1751,13	1761,03	1761,03	0,566
5	1803,91	1824,91	1819,36	0,849

Table 2. Results for problem set 2

α =0,25 CV=0,50 Sef=0,70	Lower Bound	Fix & Optimize(Stage 1)	Fix & Optimize(Stage 2)	Deviation from lower bound (%)
1	2402,03	2582.84	2582.84	7,00
2	2455.33	2651.12	2651.12	7,38
3	2399.50	2594.01	2583.42	7,11
4	2439.21	2546.87	2546.87	4,22
5	2475.00	2615.78	2607.33	5,07

For the first set of problems, we report deviations of the solution obtained by using the suggested heuristic from optimal. We observe that for this set of problems we obtain quality solutions with less than 1% deviation from optimal. We achieved improvement in stage 2 in 2 out of 5 problems which indicates the importance of the second stage of the heuristic.

In table 2, we report the results for the second set of problems where we used a lower bound instead of optimal since finding optimal solutions to his set of problems took too much computation time. We obtained the lower bound by relaxing the decision variables for periods 8 and 9 as linear and solving the model. Percent deviations from the lower bound show the potential of the solutions procedure to produce quality solutions. Again, we see improvement in stage 2 in 2 out of 5 problems in this set as well.

5. CONCLUSION

In this study we introduce a new transportation planning problem and its mathematical formulation to the literature, originated from a real life problem. The problem belongs to NP-hard class. We suggested a heuristic approach based on a fix-and-optimize approach. We showed the efficiency of the solution procedure on two sets of randomly generated problems.

Future work on this problem can involve development of effective lower bounds, solving some other sets of problems with different characteristics. One can also look into the performance of a fix-and-optimize procedure based on grouping variables not based on periods but based on other factors, such as zone or customers.

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PERFORMANCE EVALUATION OF TURKISH E-GOVERNMENT WEBSITE IN TERMS OF QUALITY OF USER INTERFACE WITH AHP APPROACH

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Abstract − *The concept of performance evaluation has many key indicators for website quality. In literature, response time, load time, size, number of items, mark-up validation, broken links are some of them. This research conducts some tests to measure performance in terms of quality of user interface between selected five countries in E-government Development Index. The measurement made with web diagnostic tools online. We propose a methodology for determining and evaluate the best e-government sites based on many criteria of website quality. Analytical hierarchy process (AHP) has been used to analyze the research indicators. The result of this study confirmed that the e-government websites' e-government development index.*

Keywords − *E-government, Performance evaluation, Analytical hierarchy process (AHP), User interface*

INTRODUCTION

Internet tools are designed to improve interaction with users. Websites are one of internet application which has different aims. Generally, the main aim is to reach more people. Also user loyalty is important for a sustainable website. On the other hand, people use websites to reach the information which is needed. Web designers try to meet with offer and demand. Website performance evaluation is getting more complicated. Various evaluation systems try to improve operational effectiveness and efficiency of the website. Different indicators have been published about website performance evaluation. Evaluation indicators for websites may be stated into the criteria that are illustrated in Table 1 [1].

Table 1: A Summary of generic Website evaluation categories

Criterion	**Example of factor**	**Examples of check**
Functionality	Site maps	Is there a summary of site organization by showing broad categories of pages?
Authority	Affiliation	Is an organization responsible for governance of the site?
Validity	Referring links	How many other sites provide links to this one?
Obtainability Relevance	Format support	Does the site require 'plug-ins' for full functionality?
Relevance	Currency	Is there an indication of how frequently it is updated?
Substance	Evidence	Are statements supported by illustrations or quoted sources or linked Websites?

Source: Middleton, Michael R., 2007, "Approaches to evaluation of websites for public sector services", In Kommers, Piet, Eds. Proceedings IADIS Conference on e-Society, pp. 279-281

The indicators are generally designed according to users. The website evaluation systems are improved to be simple. It means, the systems give opportunity to professional and public users to test their website easily. Cassone et.al. 2012, suggest several testing process to evaluate a website. They are summarized as below [8]:

- Record user activity (tool feature). A script will be generated;
- Identify data and parameters of the application (workload characterization);
- Modify the script according to the data just identified, in order to reflect the activity of several

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users (e.g. in an e-commerce site, every user buys different things);

- Playback the script increasing the numbers of simulated users (virtual users);
- Extract response time of main user transactions or pages.

Every user may use different computer systems. Various computer components have been produced. Technology sector are improving quality of computers year to year. Also, internet connection speeds vary in different locations and with different service providers. For that reason, it is complicated to evaluate websites for every user. Standard of the website performance indicators are showed below in table 2. These indicators include response time, component per page, loading time and size in byte [9].

Table 2: Standard of the website performance

Measured Factors	Standard
Average server response time	< 0.5 second
Number of component per page	< 20 objects
Webpage loading time	< 30 seconds
Webpage size in byte	< 64K

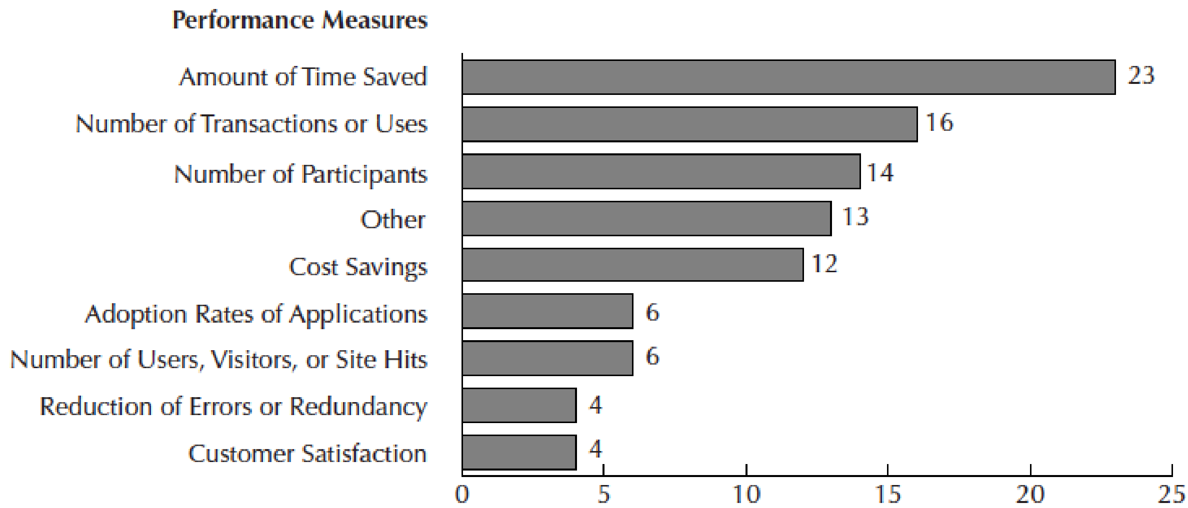
Source: Jati, H., 2008, International Graduate Conference on Engineering and Sciences "Performance Evaluation of Malaysian University Website" pp.1-4

The study shows that the average website loading time should be below 30 seconds. If it exceeds 30 seconds, users may lose their patience and ignore to enter website. Also objects are influencing website performance. Lots of objects mean size and complicated view on website. Users try to find the information in simple way. For that reason, if the objects are above 20, it may cause confusing on users side. The connection speed has critical role on loading website. 5Kbps (kilobytes per second) is accepted for average internet speed. 64 byte can be uploaded in 8 second if we accept average internet speed. This assumption called "eight second rule" [9].

RELATED WORKS

E-governments include all transactions over electronic systems. Websites are a surface for e-government systems. Many researchers has examined e-government website infrastructure to improve their performance. Stowers 2004, investigated e-government performance measurement in 23 states in the USA. Frequently used performance measures are mentioned figure 1 below [6] .

Figure 1: E-government performance measures in 23 states in the USA



Amount of time saved is placed on first place. It means, citizens prefer e-government applications to save time. Services which are applied on e-government website also generally used as a performance indicator.

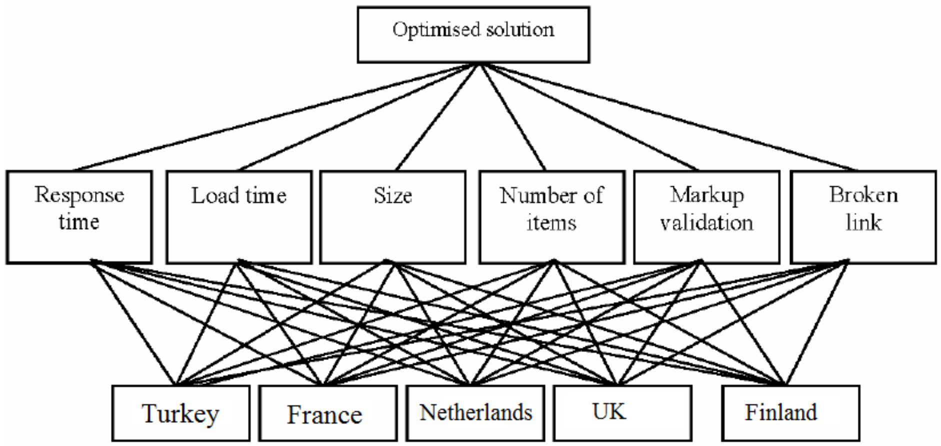
E-government applications are widely used in major countries as different types of e-government models - Government-to Citizen (G2C), Government-to-Business (G2B) and Government-to-Government (G2G) [2]. E-government websites are an interface for activities in the internet. Governments give an option to their citizens make their transactions easily with the website. E-Government transactions have to be available 24 hours a day, 7 days a week which means all sides of public can reach government transactions out of office hours [3]. United Nations (UN) define e-government concept as "E-government holds tremendous potential to improve the way that governments deliver public services and enhance broad stakeholder involvement in public service" [4] .

Web-based evaluation systems are spreading over web designers. It is also applied on e-government websites. Fong, 2009 tried to find a solution on web-based evaluation system for e-government websites. The author established a system which is called Web-based Monitoring Server (WMS) [10].

METHODOLOGY

This research has been adopted from Dominic v.d., 2010 [7]. The paper has been focused to evaluate e-government websites' performance with AHP approach. Dominic v.d., 2010, has selected the sample data in Waseda University World E-government ranking, 2008. However In this study, United Nations Public Administration Country Studies' (UNPACS) "E-Government Development Index 2014" has been examined for selected countries, which is used on the research. The Index has been refined to European continent. It shows that France is the first country in Europe. Netherlands, United Kingdom and Finland are following countries [5]. Also Turkey added to sample data. It is shown in Asia continent in the index.

Figure 2: Research Model



Source: Adapted from Dominic, P.D.D., Jati, H., and Kannabiran, G., "Performance Evaluation on Quality of Asian E-government Websites – an AHP approach", Int. J. Business Information Systems, Vol. 6, No. 2, pp. 219-239

Each country has their own e-government website. There are "www.turkiye.gov.tr" for Turkey, "www.gouvernement.fr" for France, "www.overheid.nl" for Netherlands, "www.gov.uk" for UK, "www.valtioneuvosto.fi" for Finland. Selected criteria of performance analyzed with different online web tools. The values may change in different speed or server conditions. For that reason every criteria has measured 30 times and taken their average value.

The indicators are response time, load time, size, number of items, mark-up validation and broken links. "www.websitepulse.com" is a website which is used for to measure response time. Response time is given by second. Load time page size and number of items were measured with "www.tools.pingdom.com" website. "www.validator.w3.org" website was used for to check mark-up validation and number of broken links. All values listed in table 3.

Table 3: Criteria of performance website and country

	Turkey	**France**	**Netherlands**	**UK**	**Finland**
Response time (Second)	1,75	0,63	0,99	0,59	1,48
Load Time (Second)	15,7	7,1	8,3	3,5	18,3
Size (Kbytes)	513,0	1800,0	219,9	424,6	3800,0
Number of items (Number of items)	46	107	91	24	130
Mark-up validation (Number of error)	60	30	20	1527	631
Broken link (Number of broken link)	2,0	31,0	0,0	0,0	29,0

When we investigate table 3, we see that there are six indicators, which are response time, load time, size, number of items, mark-up validation and broken link. Response time means the time, which is responded by the server. Every website has an IP number. The number shows identity of the website. When we browse the IP address, host server reply against the signal. Second one is load time. It means the time which is fully load the website. After load time, we see the website with full function. Fourth one is number of items. It represent the items (file, picture, video etc.) in the website. It effects also load time of website. Fifth one is mark-up validation. Webpage can have html errors which are not seen by users. But it also effect quality of website. We see the number of errors in the table. Every website may have links inside. The links can transfer users to another page. If there is a broken link, we get error when we try to click links.

In six e-government website, UK has the fastest response time. It is also same result when we look for load time. Netherlands e-government site has the smallest size in six countries. Netherlands also has the lowest number of errors in six countries. UK has the lowest number of items in the website. Netherlands and UK don't have broken links in the website.

Table 4: Preference criteria matrix

	Response time	**Load Time**	**Size**	**Number of items**	**Mark-up validation**	**Broken link**
Response time (Second)	1	0,33	3	7	9	5
Load Time (Second)	3	1	5	7	7	7
Size (Kbytes)	0,33	0,2	1	5	7	5
Number of items (Number of items)	0,14	0,14	0,2	1	5	0,33
Mark-up validation (Number of error)	0,11	0,14	0,2	3	5	1
Broken link (Number of broken link)	0,2	0,14	0,2	3	5	1
Sum	4,78	1,95	9,6	26	38	19,33

The preference criteria matrix has been adopted from (Jati,2010). The table shows that load time is more important than response time. When we take an example of response time and load time, we divide first and second cells in first column. It is also same for all indicators. If we want to find response and size, we divide response cell and size cell in the first column.

The following step is to find weight for every indicators by normalized the data in Table 4. The steps applied to the criteria matrix and weights will be calculated.

- We calculate sum of elements for every column
- We divide each cell to sum of the column which is below of table.
- We find each value on the table 3
- Weighted averages of each line in the table 4

Table 5: Weights of criteria

	Response time	Load Time	Size	Number of items	Mark-up validation	Broken link	Weight
Response time (Second)	0,209	0,169	0,313	0,269	0,237	0,259	0,243
Load Time (Second)	0,628	0,513	0,521	0,269	0,184	0,362	0,413
Size (Kbytes)	0,069	0,103	0,104	0,192	0,184	0,259	0,152
Number of items (Number of items)	0,029	0,072	0,021	0,038	0,132	0,017	0,052
Mark-up validation (Number of error)	0,023	0,072	0,021	0,115	0,132	0,052	0,069
Broken link (Number of broken link)	0,042	0,072	0,021	0,115	0,132	0,052	0,072
Sum	1	1	1	1	1	1	

Table 6: Original response time matrix

	Turkey	France	Netherlands	UK	Finland
Turkey	1,000	0,143	0,200	0,111	0,333
France	7,000	1,000	5,000	0,333	5,000
Netherlands	5,000	0,333	1,000	0,200	3,000
UK	9,000	3,000	3,000	1,000	7,000
Finland	3,000	0,200	0,333	0,143	1,000
Sum	25,000	4,676	9,533	1,787	16,333

In table 5, the sum of Turkey is 25,000, France is 4,676, Netherlands is 9,533, UK is 1,787, Finland is 16,333, when we look for response time matrix. Priority vectors for every country are displayed in table 7.

Table 7: Normalise matrix for response time

	Turkey	France	Netherlands	UK	Finland	Sum	Priority vector
Turkey	0,040	0,031	0,021	0,062	0,020	0,174	0,035
France	0,280	0,214	0,524	0,187	0,306	1,511	0,302
Netherlands	0,200	0,071	0,105	0,112	0,184	0,672	0,134
UK	0,360	0,642	0,315	0,560	0,429	2,304	0,461
Finland	0,120	0,043	0,035	0,080	0,061	0,339	0,068
Sum	1	1	1	1	1		

In table 7, the priority vector of Turkey is 0,035, France is 0,302, Netherlands is 0,134, UK is 0,461, Finland is 0,068. The highest priority vector weight is 0,461 (UK) and the lowest one is 0,035 (Turkey)

Table 8: Original load time matrix

	Turkey	France	Netherlands	UK	Finland
Turkey	1	0,2	0,333	0,142	3
France	5	1	3	0,333	7
Netherlands	3	0,333	1	0,2	5
UK	7	3	5	1	9
Finland	0,333	0,142	0,2	0,111	1
Sum	16,33	4,676	9,533	1,787	25

In table 8, the sum of Turkey is 16,33, France is 4,676, Netherlands is 9,533, UK is 1,787, and Finland is 25 when we check the load time matrix.

Table 9: Normalise matrix for load time

	Turkey	France	Netherlands	UK	Finland	Sum	Priority vector
Turkey	0,061	0,043	0,035	0,080	0,120	0,339	0,068
France	0,306	0,214	0,315	0,187	0,280	1,301	0,260
Netherlands	0,184	0,071	0,105	0,112	0,200	0,672	0,134
UK	0,429	0,642	0,524	0,560	0,360	2,514	0,503
Finland	0,020	0,031	0,021	0,062	0,040	0,174	0,035
Sum	1	1	1	1	1		

In table 9, the priority vector of Turkey is 0,068, France is 0,206, Netherlands is 0,134, UK is 0,503, Finland is 0,035. The highest priority vector weight is 0,503 (UK) and the lowest one is 0,035 (Finland)

Table 10: Original matrix for size

	Turkey	France	Netherlands	UK	Finland
Turkey	1	3	0,2	0,333	5
France	0,3333	1	0,142	0,2	3
Netherlands	5	7,00	1	3	9
UK	3	5	0,333	1	7
Finland	0,2	0,333	0,111	0,142	1
Sum	9,533	16,33	1,787	4,67	25

In table 10, the sum of Turkey is 9,533, France is 16,33, Netherlands is 1,787, UK is 4,67, Finland is 25 when we examine the size matrix. Priority vectors for every country are displayed in table 11.

Table 11: Normalise matrix for size

	Turkey	France	Netherlands	UK	Finland	Sum	Priority vector
Turkey	0,105	0,184	0,112	0,071	0,200	0,672	0,134
France	0,035	0,061	0,080	0,043	0,120	0,339	0,068
Netherlands	0,524	0,429	0,560	0,642	0,360	2,514	0,503
UK	0,315	0,306	0,187	0,214	0,280	1,301	0,260
Finland	0,021	0,020	0,062	0,031	0,040	0,174	0,035
Sum	1	1	1	1	1		

In table 11, the priority vector of Turkey is 0,134, France is 0,068, Netherlands is 0,503, UK is 0,260, and Finland is 0,035. The highest priority vector weight is 0,503 (Netherlands) and the lowest one is 0,035 (Finland)

Table 12: Original matrix for number of items

	Turkey	France	Netherlands	UK	Finland
Turkey	1,000	5,000	3,000	0,333	7,000
France	0,200	1,000	0,333	0,143	3,000
Netherlands	0,333	3,000	1,000	0,200	5,000
UK	3,000	7,000	5,000	1,000	9,000
Finland	0,143	0,333	0,200	0,111	1,000
Sum	4,676	16,333	9,533	1,787	25,000

In table 12, the sum of Turkey is 4,676, France is 16,333, Netherlands is 9,533, UK is 1,787, Finland is 25 when we check the number of items matrix. Priority vectors for every country are displayed in table 13.

Table 13: Normalise matrix for number of items

	Turkey	France	Netherlands	UK	Finland	Sum	Priority vector
Turkey	0,214	0,306	0,315	0,187	0,280	1,301	0,260
France	0,043	0,061	0,035	0,080	0,120	0,339	0,068
Netherlands	0,071	0,184	0,105	0,112	0,200	0,672	0,134
UK	0,642	0,429	0,524	0,560	0,360	2,514	0,503
Finland	0,031	0,020	0,021	0,062	0,040	0,174	0,035
Sum	1	1	1	1	1		

In table 13, the priority vector of Turkey is 0,260, France is 0,068, Netherlands is 0,134, UK is 0,503, Finland is 0,035 when we check the number of items matrix. The highest priority vector weight is 0,503 (UK) and the lowest one is 0,035 (Finland)

Table 14: Original matrix for mark-up validation

	Turkey	France	Netherlands	UK	Finland
Turkey	1,000	5,000	0,333	0,333	3,000
France	0,200	1,000	0,143	0,143	0,333
Netherlands	3,000	7,000	1,000	1,000	5,000
UK	3,000	7,000	1,000	1,000	5,000
Finland	0,333	3,000	0,200	0,200	1,000
Sum	7,533	23,000	2,676	2,676	14,333

In table 14, the sum of Turkey is 7,533, France is 23,000, Netherlands is 2,676, UK is 2,676, and Finland is 14,333 when we check mark-up validation matrix. Priority vectors for every country are displayed in table 15.

Table 15: Normalise matrix for mark-up validation

	Turkey	France	Netherlands	UK	Finland	Sum	Priority vector
Turkey	0,133	0,217	0,125	0,125	0,209	0,809	0,162
France	0,027	0,043	0,053	0,053	0,023	0,200	0,040
Netherlands	0,398	0,304	0,374	0,374	0,349	1,799	0,360
UK	0,398	0,304	0,374	0,374	0,349	1,799	0,360
Finland	0,044	0,130	0,075	0,075	0,070	0,394	0,079
Sum	1	1	1	1	1		

In table 15, the priority vector of Turkey is 0,162, France is 0,040, Netherlands is 0,360, UK is 0,360, and Finland is 0,079 when we check mark-up validation matrix. The highest priority vector weights are 0,360 (UK and Netherlands) and the lowest one is 0,040 (France)

Table 16: Original matrix for broken link

	Turkey	France	Netherlands	UK	Finland
Turkey	1,000	0,333	0,200	5,000	3,000
France	3,000	1,000	0,333	7,000	7,000
Netherlands	5,000	3,000	1,000	9,000	9,000
UK	0,200	0,143	0,111	1,000	0,333
Finland	0,333	0,200	0,143	3,000	1,000
Sum	9,533	4,676	1,787	25,000	20,333

In table 16, the sum of Turkey is 9,533, France is 4,676, Netherlands is 1,787, UK is 25,000, and Finland is 20,333 when we check the number of broken links matrix. Priority vectors for every country are displayed in table 17.

Table 17: Normalise matrix for AHP pairwise comparison for broken link

	Turkey	France	Netherlands	UK	Finland	Sum	Priority vector
Turkey	0,105	0,071	0,112	0,200	0,148	0,636	0,127
France	0,315	0,214	0,187	0,280	0,344	1,339	0,268
Netherlands	0,524	0,642	0,560	0,360	0,443	2,528	0,506
UK	0,021	0,031	0,062	0,040	0,016	0,170	0,034
Finland	0,035	0,043	0,080	0,120	0,049	0,327	0,065
Sum	1	1	1	1	1		

In table 17, the sum of Turkey is 0,636, France is 1,339, Netherlands is 2,528, UK is 0,170, and Finland is 0,327 when we check the number of broken links matrix. The highest priority vector weight is 0,506 (Netherlands) and the lowest one is 0,034 (UK). The next step is calculating weight of criteria. For this step we find the priority vector value from all normalise matrix. For example, In table 7, Priority factor is 0,035 for Turkey according to response time. We place the value in table 18 as response time and Turkey cell.

Table 18: Weight of criteria and website

	Turkey	France	Netherlands	UK	Finland	Weight
Response time (Second)	0,035	0,302	0,134	0,461	0,068	0,243
Load Time (Second)	0,068	0,260	0,134	0,503	0,035	0,413
Size (Kbytes)	0,134	0,068	0,503	0,260	0,035	0,152
Number of items (Number of items)	0,260	0,068	0,134	0,503	0,035	0,052
Mark-up validation (Number of error)	0,162	0,040	0,360	0,360	0,079	0,069
Broken link (Number of broken link)	0,127	0,268	0,506	0,034	0,065	0,072

Table 19: Final result

	Turkey	France	Netherlands	UK	Finland
Response time (Second)	0,008	0,073	0,032	0,112	0,016
Load Time (Second)	0,028	0,107	0,055	0,207	0,014
Size (Kbytes)	0,020	0,010	0,076	0,039	0,005
Number of items (Number of items)	0,013	0,003	0,006	0,026	0,001
Mark-up validation (Number of error)	0,011	0,002	0,024	0,024	0,005
Broken link (Number of broken link)	0,009	0,019	0,036	0,002	0,004
Sum	0,090	0,216	0,232	0,412	0,048

In according to table 19, results shows that UK has the highest score when we compare rest of the e-government websites. The result of proposed AHP model shows that UK (score: 0,412) has first, Netherlands (score: 0,232) second, France (score: 0,216) third, Turkey (score: 0,090) forth and Finland (score: 0,048) last rank.

CONCLUSION

This study aimed to apply the AHP e-government performance evaluation method to selected countries which are including Turkey, France, Netherlands, UK and Finland. E-Government Development Index 2014 ranked e-government websites according to their own evaluation systems. When we refine ranking as Europe, the ranking is France, Netherland, UK, Finland. Turkey is on 71st place on the overall rankings. Turkey added the list because of to see Turkish e-government website's place in the first four ranking of E-Government Development Index 2014 . Five countries has compared with AHP performance evaluation method. After applied the method, we see that rankings are changed. The new ranking is UK, Netherlands, France, Turkey and Finland. It indicates that, when we handle the indicators as response time, load time, size, number of items, mark-up validation, broken links, Turkey's place has changed to 3rd. It shows that different evaluation method can change the ranking on overall. On the other hand, when we compare the values with selected countries Turkish e-government website should be improved according to response and load time. Future works may exemine how to improve website performance with selected criteria.

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KNOWLEDGE BASED APPROACH TO GRAY BOX NEW PRODUCT DEVELOPMENT

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Abstract - *The necessity of emphasizing the importance of industrial production for the sustainable growth and development of Turkey has been a topic of discussion in political and academia circles. The growth in industrial production (output) depends on the investment in manufacturing sectors and the demand for the products. Although there is a high share of industrial goods in total exports, an imbalance of trade continues to exist. While a major portion of trade deficit is due to energy imports, the question is why not Turkey's export more than its current level. As long as Turkey cannot produce high-tech products its trade imbalance will continue to grow. Therefore it should be a national policy to develop technology and high-tech products and the state should work side by side with the private sector in order to implement it. Manufacturing sector is highly eligible to produce value added products. Deficiency of R&D and innovation investment has been highlighted by several academicians and business associations. While Germany's value added production is 32%, South Korea's 21% and Turkey's around %3,5 of total production and export. An efficient way of developing new products is to involve suppliers in the process. There are 3 ways of developing parts for the end product: Black box, gray box and white box. While in the black box approach suppliers are completely responsible for the new parts, in white box approach suppliers act like a contract manufacturer. Gray box approach however requires true collaborative efforts between companies and their suppliers. In this paper we will investigate how to improve supplier involvement and gray box new product development (NPD) process based on Knowledge based view of the firm.*

Keywords Innovation, Knowledge Management, Supply Chain

Introduction

New Product Development (NPD) as a competitive advantage for firms as well as nations has never become more important. The competitiveness and even survivability of a firm lies on the quality and speed of the NPD process. While there are many sources of ideas for new parts/products/technologies, suppliers perhaps could be the most important provider of intellectual capability. Suppliers have been proven to be a valuable partner in NPD if they are involved early in the process by avoiding design errors, giving new ideas, providing alternatives, and clarifying specifications.

However involving suppliers in NPD can be a delicate task. Picking suppliers' brain, intellectual property issues and developing trust between parties require time, energy, experience, a well thought plan, necessary

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contracts and willingness on both sides. Yet among the rewards of involving suppliers in NPD process are improved NPD performance, product quality [1], access to new markets and technologies, lower development costs [2] , increased buyer and supplier revenues [3], accelerated time-to-market [4], and market performance superiority [5].

NPD is a highly knowledge intense process including knowledge sharing, transforming and more importantly generation activites. The difficulties of these activities with suppliers should not be underestimated. Petersen at. al. (2005) [6] divided NPD process and hence supplier integration into three: White box, gray box and black box. White-box NPD refers to complete in-house design of a product where black-box refers to outsourcing total design responsibility to the suppliers. Gray-box design on the other hand refers to collaborative design efforts with selected suppliers.

Turkey is one of the promising developing countries in Eurasia. While Turkey's exports increased dramatically in the last decade, only 4% of exports are high-tech, 31% are mid-tech and 37% low-tech in 2014 (http://www.zaman.com.tr/ekonomi_turkiye-yuksek-teknoloji-ihracatinda-fiji-ve-namibya-ile-ayni-ligde_2309366.html). Compared on a dollar/kg basis, Turkey's export is 1.6, Germany's 4.1, Japan's 3.5, and South Korea's 3.0 in 2014 (http://www.hurriyet.com.tr/ekonomi/kobi/28487485.asp). The long term solution to Turkey's and similar developing as well as underdeveloped countries economic problems are to produce and export value added products. One of the ways to achieve this difficult task is for firms to be more innovative by collaborating with their suppliers. Therefore our main proposal is for firms to actively integrate their suppliers into their NPD process in order to achieve competitiveness and international success.

Our study looks into the relationships between knowledge management, supplier NPD integration (SNPDI) and performance outcomes. We look into process and knowledge based views of the firm literature to find support for our hypothesis. The model is presented in figure 1.

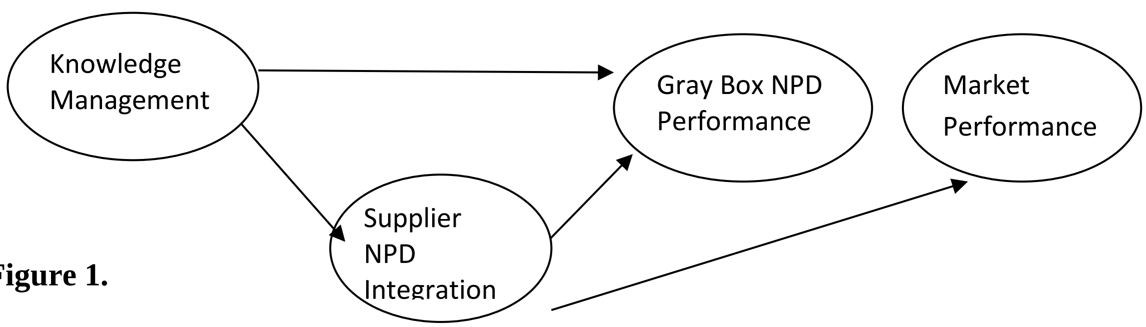

Figure 1.

Literature Review

Knowledge Management

Knowledge is one of the most popular concepts in philosophy since old eras [7]. Definition of knowledge is '*information plus the causal links that help to make sense of this information'* and Knowledge Management is*'a process that establishes and clearly articulates such links*' , [8, cited by 9]. Moreover, knowledge as "*information possessed in the mind of individuals: it is personalized information (which may or may not be new, unique, useful or accurate) related to facts, procedures, concepts, interpretations, ideas, observations and judgments"* [7]. A knowledge-based perspective implies how services offered by tangible resources can transform organization's know-how [7]. The knowledge can be buried and transfer through assets such as; organization culture, policies and employees [10]. Knowledge-based resources are difficult to copy and it can change from organization to organization, therefore knowledge assets bring competitive advantage. Information is processed data and knowledge is authenticated information. Text, graphics, words are different types of knowledge to introduce and these bring a common language and same understanding for managers [10,11].

Knowledge is analyzed with different ways; a state of mind, an object, a process, a condition of having access to information and a capability. First, knowledge as a state of mind implies the facilitating employees to magnify the personal knowledge and using for the organizations. Secondly, the perspective that knowledge as an object presumes knowledge is stored and manipulated. Moreover, the idea of knowledge as a process relates with knowing and acting [12]. The fourth one is a condition of accessing to information. This idea shows the importance of organizational knowledge that should be organized to simplify the access to it. Lastly, the evaluation of what or which type of information is needed in future actions is an important potential asset for organizations [13, 14, 15 cited by 7].

There are two types of knowledge; tacit and explicit. Tacit knowledge is embedded in action and experience. It includes cognitive and technical elements [16]. The cognitive one refers to person's mental models; beliefs and viewpoints. The technical one is know-how, skill and ingenuity. For example, situation of teacher in a class when students are speaking with each other. She can shout, warn calmly or leave from the classroom. These are possible ways to affect students, but which is the best solution is not clear, it depends on circumstances. The explicit knowledge can be codified and formed with symbolic or natural language [7]. For instance, user manual of any machine in a factory is explicit knowledge for employees. There are other types of knowledge mentioned in the literature; declarative (know-about), causal (know-why), conditional (know-when) and relational (know-with) [17, 18 cited by 7].

Knowledge Management (KM) is a key point for organizations to use their intangible resources efficiently. It determines and administrates knowledge to help organization's processes and improves the innovation activities inside a firm. In the last years, integration of information systems with KM to generate, transfer and apply it in organizations has been discussed [7]. A survey of KPMG showed that nearly half of the organizations faced with problems when their key employees left. Additionally, another survey indicated that most firms thought some of necessary knowledge is embedded inside them but the essential problems are to find, store and use it [18,19,20 cited by 7].

Generally, knowledge management have three goals; (1) making knowledge clear and stating the importance of it in a firm, (2) establishing a knowledge-intensive culture with stimulating behaviors like knowledge sharing, (3) establishing a knowledge infrastructure, both of technical (i.e. e-mail system, servers etc.) and social (i.e. collaborating, meetings) [7].

Knowledge generation refers to exposing the capabilities of new and beneficial ideas and solutions. This process is based on human interaction, so companies should encourage their employees to join knowledge generation activities. Firms get new knowledge via R&D activities, benchmarking, and meetings. In addition to these, companies can reach new solutions with imitation, buying, and outsourcing.

Knowledge generation with discussions, meetings and brainstorming brings new ideas and solutions to problems of companies. Kaizen, Business Process Reengineering (BPR) or other continuous improvement processes for quality management are examples of knowledge generation processes. With the help of technology such as; software, ERP, servers etc., organizations can code, store and share their knowledge. After the usage of new ideas or solutions, organizations can decrease their costs, increase profits and improve their efficiencies. Therefore, KM enhances their competitive advantages against rivals.

Knowledge sharing covers all processes for accessing knowledge. This transfer can occur both within an organization and among organizations. Some companies, like Chevron, increased their revenues by applying knowledge transfer processes [11]. In comparison with other resources, the value of knowledge increases with sharing. Knowledge can be used in relationships between firms and customers, in organizations, and among supply chain members [11].

In the literature, there is very little research that looks the relationship between KM and supply chain performance. Wal-Mart, Toyota, and Dell have used their supply chain management skills effectively, and they acquired competitive advantage and excellent performance [21]

Knowledge management in the supply chain was discussed as a detailed literature review by [22]. The study indicates that the source of knowledge, both external and internal, and characteristics of knowledge flows, depend on firm-specific and country-specific variables.

Supplier NPD Process Integration

The key to implementing SCM depends on identifying critical supply chain members and key business processes along which the partners are integrated. It is identified that eight processes representative of those being integrated by the firms they interviewed [23]. They are:

- Customer relationship management
- Customer service (FAQ, one Web page, one representative)
- Demand management
- Order fulfillment
- Manufacturing flow management
- Procurement
- Product development and commercialization
- Returns

Effective integration of suppliers into supply chain will be a key factor for some manufacturers in achieving competitive advantage [24]. A number of studies suggest that the higher the level of integration with suppliers and customers in the supply chain, the greater the potential benefits [25, 26]

The study [26] confirms that a company's customer relations and purchasing practices can impact its financial and market performance. It is found strong and consistent evidence between integrated supply chains and a variety of performance improvements [24].

Supply chain integration likely improves performance because of eliminating inefficiencies and inconsistencies, streamlining processes, providing customers what they want when they want it, reducing excess inventories, and proactively managing demand.

Conceptualizing integration as process integration, Supplier NPD Integration (SNPDI) refers to integration of NPD process with suppliers. Supplier Integration (SI) refers to supplier integration along several processes such as logistics, production, manufacturing and order fulfillment if not all of them.

Continuous increase in the amount of supplier share of the products not only requires buyers and suppliers collaboration on manufacturing but design activity as well. It is not uncommon to involve suppliers in NPD process in order to increase innovation capability and quality [27]. This kind of collaboration brings alongside the use of resources together for the same end.

Shortcoming of the suppliers (or buyers) capabilities, the possibility of the supplier copying or leaking technology, over dependence on the supplier and loosing the capability to develop parts/components/products alone are some of the risks involved in SNPDI. Considering the difficulties and risks of grey-box NPD, from a resource based view (RBV), some researchers claim that companies accept such a risk only if they don’t have the necessary resources and/or capabilities within the firm [28]

However the complexity of the products and the focus on core competency make it mandatory to outsource the design and production of parts to suppliers (Handfield and Nichols, 2002). Moreover supply base rationalization which means reducing the number of suppliers made it possible to work with a group of competent and trustworthy firms. The reduction of suppliers increased suppliers’ expectation of high returns from the relationship and incentivized them to be more productive and cooperative [29]

Supplier integration will involve some forms of partnership, co-development activities, joint planning meetings and shared information systems [30]

Hypotheses Development

Sharing information, joint planning, joint problem solving and joint decision-making are the examples of collaboration argued in the literature. Similarly, joint planning which is performed by groups from contractors who come together regularly to discuss operational problems reduce and eliminate inter-company barriers [31]. Having close relationship with suppliers is important to get crucial knowledge for organizations who want to innovate their supply chain operations [31]. Furthermore, these type of arrangements construct trust and long term relationship among contractors [32]. Virtual collaboration is a different integration among

Innovation depends on knowledge and tacit knowledge gains competitive advantage to organizations. It provides innovative thoughts [33]. One of the main aims of KM is to transform the tacit knowledge and make it explicit [34]. KM leads different benefits such as increased creativity, innovation, improved quality and process management [35,36]

Supplier may help the buyer’s innovation process with its R&D projects so innovation costs are shared by both of them. Additionally, supplier may have crucial knowledge in manufacturing process that affect the performance. Collaboration enhances the knowledge sharing between organizations and this positively affects the innovation process [37 cited by 31]. The innovation in supply chain can be observed as new product development, process improvements, service delivery, inventory management, technology transfer and capacity planning [31].

H1: Knowledge Management positively triggers the Supplier Integration

H1a: Knowledge sharing is positively related to Supplier NPD Integration.

H1b: Knowledge generation is positively related to Supplier NPD Integration

H2: Knowledge Management affects NPD positively.

H2a: Knowledge sharing affects grey box NPD positively.

H2b: Knowledge generation affects grey box NPD positively.

Hypothesis 3. Supplier NPD integration is positively related to grey box NPD performance.

Hypothesis 4. Supplier NPD integration is positively related to market performance.

Conclusion

Our study looks into complicated relationships between KM, supplier integration into NPD process and performance outcomes. The importance of NPD in today’s ever changing marketplace cannot be denied. The more complicated the products there is more need for integrating suppliers into NPD process. While outsourcing the design altogether to suppliers are possible the interconnectedness of parts and components won’t permit a %100 what is called black box NPD. Therefore the question is to the extend gray box NPD is used how can this process be executed more effectively and efficiently. Looking into KM and SCM literature will shed some light on this significant question.

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