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A MULTI-OBJECTIVE NONLINEAR OPTIMIZATION MODEL FOR CLOSED-LOOP SUPPLY CHAIN OPTIMIZATION CONSIDERING ADVERTISEMENT STRATEGIES

Ahmet Çalık[1], *Turan Paksoy*[2]

Abstract −*Environmental challenges, such as global warming, overpopulation, climate change, water pollution, etc., have forced many companies to consider green factors to take the advantage in the competitive business market place. With the increasing technology development, companies have become aware of the importance of advertising on consumer buying behavior to acquire customers or increase a company's sales. Therefore, advertisements play an important role in customers' preferences. Nowadays, most companies spend an enormous amount of money on advertisement and green issues to maintain their market share. From this viewpoint, the main aim of this study is to assess the influence of advertising on buying behavior of customers. This paper presents a novel multi-objective Closed-Loop Supply Chain (CLSC) model considering the customer behavior factors. The developed CLSC model consists of suppliers, manufacturers, collection centers and an advertising agency which have different advertisement options to increase sales of manufacturer products. A numerical example is taken to investigate the influence of advertising on buying behavior of customers.*

Keywords −*Closed-loop supply chain network optimization, customer behavior, multi-objective programming.*

1. INTRODUCTION

A CLSC can be defined as a supply chain where both forward and reverse flows are considered simultaneously. In this flow managers consider not only the traditional forward flow operations but also the reverse flow operations such as collection, inspection, recovery and disposal of return products. The design of CLSC network is a critical task because of environmental, economic and satisfaction of customers' aspects [1]

Traditional supply chain strategies have changed due to increasing pressures from governments and customers' expectations. So that, companies have started to find ways of increasing the efficiency and accuracy of their operations [2]. One of the growing interest in CLSC is to handle satisfaction of the customer expectations. In order to manage facilities efficiently and reduce rate of pollution, buying behavior of customer is one of the critical factors and needs to be taken into account by the decision makers of involved companies on the supply chain. Therefore, buying behavior of customers are directly related to companies strategies [3].

Advertisements help to companies to create the awareness in customer expectations in a positive or a negative way. People can perceive the quality of the products by gathering the information which they usually get through advertisements. The perception of the quality, awareness of the product and customer opinion drives the customer buying decision. From this viewpoint, in this study the different advertisement types are handled to evaluate the buying behavior of customers and give some insights with analyzing the role of advertisements on the customer behavior [4].

Buying behavior of customers is a popular topic especially in social sciences. These studies are generally based on questionnaire surveys and indicate that advertisements have statistically significant effects on buying behavior. Lee et al. [7] apply the Taiwan Customer Satisfaction Index model to a tourism factory to analyze customer satisfaction and loyalty by a survey in Taiwan. Kavitha and Thamarai Selvi [8] analyze demographic profile of the consumers and find out the influence of celebrity advertisement on purchase of gold jewelry. Kim-Soon et al. [9] indicate that the level of consumer's buying green product is at moderate range and there is a significant relationship between consumer's attitudes and their willingness to pay for green products. In order to understand the relationship between advertisement effectiveness and consumer buying behavior for major automobile companies of central India, Maheshwari et al. [10] use a mix of qualitative (focus group and Delphi technique) and quantitative (structured questionnaire survey) methods. Tung and Carlson [11] use structural

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equation modelling to examine the drivers of the customers' cross-buying intentions for retail banking services in Hong Kong through 269 customers. Rehman et al. [5] collect data through questionnaires based survey with a sample size of 500 people in rural areas of Lakki Marwat. According to correlation statistics and simple regression analysis, advertisements are positively correlated with consumers buying behavior but factors of rural areas are negatively correlated with consumers buying behavior. Fatima and Lodhi [4] show that advertisements are very useful in creating the awareness among the people but they are failed to build strong perceptions in the mind of consumers based on answers of 200 respondents. Hassan [6] conclude that rural residents like the TV advertisements more than urban residents and female behavior towards purchase is more prejudiced by the TV advertisements than their male counterparts.

Recently, we can find few papers in supply chain management about buying behavior of customers. Manning [12] derive that organizations corporate social responsibility activities must remain congruent with consumer social responsibility and its impact on buying behavior. Giampietri et al. [13] work on drivers of consumers' behavior towards purchasing in short food supply chains and clarifying their relationships with a literature review. Coskun et al. [3] define three consumer segments based on their purchasing behavior and their green consciousness. They proposed a goal-programming model considering three consumer segments and show that how the green determination level of consumers influences the green supply chain.

The above research studies generally use questionnaire surveys to understand buying behavior of customers. But in this study we handle buying behavior of customers in a CLSC network. Firstly we provide a multi-objective mixed-integer formulation for the CLSC design problem. Then, in order to analyze types of advertisements on customer buying behavior, we evaluate the sensitivity of the types of advertisements in the CLSC network. To our knowledge, this is the first model that considers the buying behavior of customers' decision in the supply network design phase.

The rest of this paper is structured as follows: In the next section, the proposed multi-objective CLSC mathematical model is explained. A numerical example is illustrated Section 3. Finally, in Section 4, conclusions and outlines for future studies are clarified.

2. PROBLEM DEFINITION AND MATHEMATICAL FORMULATION

As illustrated in Figure 1, the proposed CLSC network, consisting of a set of suppliers, plants, customers, collection centers and also an advertising agency. A single product is assumed, which plants can supply original part from suppliers or spare part from collection centers. The plants can produce new product and the product are directly sent to the customers. Customers consist of different segments based on the expectation on the advertisements. Customer segmentation can consists of several layers such as, demographics (age, race, religion, gender), psychographic (social class, lifestyle and personality characteristics) and socio-economic group. Considering the advertisement strategies, the customers are classified into three segments in this study.

In further assumptions about the problem are as follows:

- Customer demands are assumed to be predetermined and fixed for each period and 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, and opening new facilities is 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 the disassembly process.
- It is assumed that a certain amount of used products, defined as a percentage (η).
- All price parameters and facility opening costs are deterministic and known a priori.
- There is no difference between the original part sent from suppliers to plants and spare part renewed by collection centers.

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

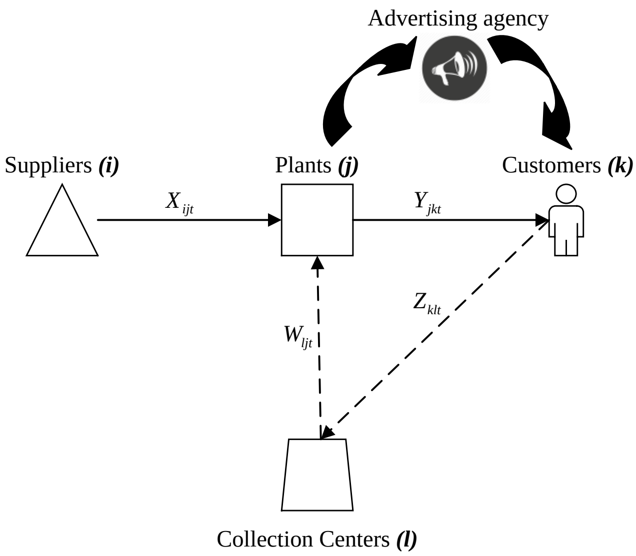

Figure 1. Structure of CLSC network

Indices

i	set of suppliers	$i = \{1, 2 \dots I\}$,
j	set of plants	$j = \{1, 2 \dots J\}$,
k	set of customers	$k = \{1, 2 \dots K\}$,
l	set of collection centres	$l = \{1, 2 \dots L\}$,
a	set of advertisements	$a = \{1, 2 \dots A\}$,
t	set of periods	$t = \{1, 2 \dots T\}$;

Parameters

d_{ij}	distance between supplier *i* and plant *j* (km),
d_{jk}	distance between plant *j* and customer *k* (km),
d_{kl}	distance between customer *k* and collection center *l* (km),
d_{lj}	distance between collection center *l* and plant *j* (km),
cap_{it}	capacity of supplier *i* in period *t* (units),
$capp_{jt}$	capacity of plant *j* in period *t* (units),
$capc_{lt}$	capacity of collection center *l* in period *t* (units),
fc_{jt}	the fixed opening cost for plant *j* in period *t* ($),
fcc_{lt}	the fixed opening cost for collection centre *l* in period *t* ($),
pc_i	unit cost of purchasing of supplier *i* for ($/units),
pcc_l	unit cost of purchasing of collection centre *l* ($/units),
$advc_a$	the cost of advertisement *a* ($),
ap_{as}	the approximate customer number which is reached by advertisement *a* for segment *s* (units),
η	percentage of collected amount which is re-sent to plants (%),
λ	percentage of customer which is attracted advertisements and decided to buy product (%),
upr	unit profit of product ($);
utc	unit cost of shipping (($/units).km);

Variables

X_{ijt}	amount of part shipped from supplier *i* to plant *j* in period *t* (units),

Y_{jkt} amount of product shipped from plant *j* to customer *k* in period *t* (units),
Z_{klt} amount of product shipped from customer *k* to collection center *l* in period *t* (units),
W_{ljt} amount of part shipped from collection center *l* to plant *j* in period *t* (units),
DE_{as} demand of customers according to advertisement *a* for segment *s* (units),
ADV_a number of advertisement *a* (units),
OP_{jt} If plant *j* is open in period *t*, 1; otherwise, 0,
OCC_{lt} If common collection centre l is open in period *t*, 1; otherwise, 0.

2.1. Problem formulation

The developed multi-objective CLSC model is presented with objective functions and constraints below:

$$Max\ Z = \sum_a \sum_s DE_{as} \cdot upr - \sum_a ADV_a \cdot advc_a \quad (1)$$
$$utc \cdot \big(\sum_{i\in I} \sum_{j\in J} \sum_{t\in T} X_{ijt} \cdot d_{ij} + \sum_{j\in J} \sum_{k\in K} \sum_{t\in T} Y_{jkt} \cdot d_{jk} + \sum_{k\in K} \sum_{l\in L} \sum_{t\in T} Z_{klt} \cdot d_{kl} +$$
$$\sum_{l\in L} \sum_{j\in J} \sum_{t\in T} W_{ljt} \cdot d_{lj}\big) + \quad (2)$$
$$\sum_{i\in I} \sum_{j\in J} \sum_{t\in T} X_{ijt} \cdot pc_i + \sum_{l\in L} \sum_{j\in J} \sum_{t\in T} W_{ljt} \cdot pcc_l + \quad (3)$$
$$\sum_{j\in J} \sum_{t\in T} OP_{jt} \cdot fc_{jt} + \quad (4)$$
$$\sum_{l\in L} \sum_{t\in T} OCC_{lt} \cdot fcc_{lt} + \quad (5)$$

Constraints

$$\sum_{j\in J} X_{ijt} \leq cap_{it}\ \forall\ i \in I, t \in T \quad (6)$$
$$\sum_{k\in K} Y_{jkt} \leq capp_{jt} \cdot OP_{jt} \forall\ j \in J, t \in T \quad (7)$$
$$\sum_{k\in K} Z_{klt} \leq capc_{lt} \cdot OCC_{lt}\ \forall\ l \in L, t \in T \quad (8)$$
$$\sum_{j\in J} Y_{jkt} \geq DE_{as}\ \forall\ k \in K, t \in T, a \in \mathrm{A} \quad (9)$$
$$\left(\sum_{i\in I} X_{ijt} + \sum_{l\in L} W_{ljt}\right) - \sum_{k\in K} Y_{jkt} = 0\ \forall\ j \in J, t \in T \quad (10)$$
$$\sum_{j\in J} Y_{jkt} - \sum_{l\in L} Z_{kl(t+1)} = 0\ \forall\ k \in K, t \in T \quad (11)$$
$$\eta \cdot \sum_{k\in K} Z_{klt} - \sum_{j\in J} W_{ljt} = 0\ \forall\ l \in L, t \in T \quad (12)$$
$$DE_{as} \geq ADV_a \cdot ap_{as} \cdot \lambda\ \forall\ \mathrm{a} \in \mathrm{A}, \mathrm{s} \in \mathrm{S} \quad (13)$$
$$\sum_a advc_a \cdot ADV_a \leq bud\ \forall\ \mathrm{a} \in \mathrm{A} \quad (14)$$
$$ADV_a \geq 1 \forall\ \mathrm{a} \in \mathrm{A} \quad (15)$$
$$X_{ijt} \geq 0\ \forall\ i \in I, j \in J, t \in T \quad (16)$$
$$Y_{jkt} \geq 0\ \forall\ j \in J, k \in K, t \in T \quad (17)$$
$$Z_{klt} \geq 0\ \forall\ k \in K, l \in L, t \in T \quad (18)$$
$$W_{ljt} \geq 0\ \forall\ l \in L, j \in J, t \in T \quad (19)$$
$$ADV_a \geq 0 \forall\ a \in A \quad (20)$$
$$DE_{as} \geq 0 \forall\ a \in A, s \in \mathrm{S} \quad (21)$$
$$OP_{jt} = \{0,1\} \forall\ j \in \mathrm{J}, t \in T \quad (22)$$
$$OCC_{lt} = \{0,1\}\ \forall\ l \in L, t \in T \quad (23)$$

The objective function has six components. The first component represents the total selling price which gained by the sale of the products (1). The second component represents the cost of transportation (2). The third component represents the cost of purchasing over all product parts (3). The fourth and fifth components represent the fixed opening costs associated with locating the plants and collection centers (4-5). Constraints (6)-(8) indicate that the total quantity of purchased parts and products from suppliers, plants and collection centers cannot exceed the assembly capacity of those facilities during any period, respectively. Constraint (9) ensure that the total quantity of products should be greater than the customers segments' demand during any period. Constraints (10)–(12) are the balance equations for plants, customers and collection centers: the quantities that enter these facilities must be equal to the amount of products/parts that leave the facilities. Constraint (13) ensures the demands of all segments should be greater than the approximate customer number which reach by advertisements. Constraint (14) ensure that the total quantity of advertisements cannot exceed the budget of plants. Constraint (15) ensure the plants give at least one advertisement to increase the demand of customers. Constraints (16)–(21) enforce the non-negativity restriction on the decision variables. Lastly, Constraints (22)-(23) represent the binary variables.

3. COMPUTATIONAL EXPERIMENTS

To show the applicability of the proposed model, a numerical example is presented. A hypothetical data is produced, based on randomly generated parameters, to illustrate the properties of the problem

3.1. Description of data

To assess the performance of the integrated CLSC model we solved a multi-objective mixed-integer non-linear programming CLSC model. 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_{ij}, d_{jk}	~ Uniform (100, 300)
d_{kl}, d_{lj}	~ Uniform (0, 200)
cap_{it}, $capp_{jt}$	~ Uniform (500,100)
$capc_{lt}$	~ Uniform (500,1250)
fc_{jt}, fcc_{lt}	~ Uniform (10000, 100000)
pc_i, pcc_l	~ Uniform (100, 500)

The network consists of six suppliers, four plants, three customers and three collection centers. The unit transportation cost (utc) was accepted as 1 cents per ton-km. The unit profit of product is accepted 1000 ($). It is assumed that advertising agency provides four different advertisement options for plants: TV, Billboard, Radio and Internet, respectively. The cost of advertisements ($advc_a$) are 1000, 500, 300 and 400 ($), respectively. The approximate customer number which can be reached by advertisements (ap_{as}) are generate by uniform distribution ($Uniform\ (1000, 3000)$). The percentage of used products which must be collected in customer zones, defined as a percentage $\eta = 0.25$ and the percentage of customer which is attracted advertisements and decided to buy product is accepted $\lambda = 0.30$.

3.2. The solution of the numerical problem

All computational experiments are conducted on a PC with an Intel I5 2.67 GHz processor with 3 GB of RAM, and the computation time required to solve the model to optimality using the GAMS-CPLEX 24.1.3 solver, no more than one CPU second. Table 1 gives the primary performance measures (incomes and costs) as a percentage of the overall value of the objective function. When the proposed model is solved for the given example, the total income, which includes advertisement, transportation, purchasing, and fixed costs, is found to be $298,273,400 for all periods.. The results given in Table 1 shows that the total profit is calculated at 168,969,903.67$ for all periods and the total profit of the system accounts for a 56.64%. While the maximum share is actualized by total profit with 56.64%, the minimum share is actualized by total fixed costs of potential plants and collection centers with 0.27%.

Table 2. Objective function values and percentages

	Performance Criteria (PC)	Value ($)	Percentage of Total Cost (%)
PC1	Total profit	168,969,903.67	56.64
PC2	Total income	298,273,400.00	100.00
PC3	Total transportation cost	60,253,283.08	20.20
PC4	Total purchasing cost	68,222,105.25	22.87
PC5	Total fixed cost	828,108.00	0.27

The optimal result for the problem instance is shown in Table 2. When the model is designed, it is assumed that the product must use at least one period before enter into collection so that nothing returned from customers during the first period as seen Table 2. In last two periods, 89484,30 and 89484,30 ton of products collected, respectively. According to the Table 2, in first period, 89484,30 ton of parts are sent from suppliers to plants. As seen in Table 2, 5958,58 ton of parts are refurbished and sent to the plants. For the next period 38783,58 ton of parts are entered the loop respectively. While plants purchased original parts (total 223710,75) from suppliers, they purchased spare parts from collection centers (total 44742,16).

Table 3. Optimal results for the test problem

		Period 1	Period 2	Period 3	Total
Purchased amounts	Part	89484,30	67113,23	67113,22	223710,75
Purchased amounts	Product	89484,30	89484,30	89484,30	268452,90
Collected amounts	Product		89484,30	89484,30	178968,60
Collection centres – plants	Part		5958,58	38783,58	44742,16
Opened plants		1-2-4	1-2-4	1-2-4	
Opened collection centres			1-2-3	1-2-3	

In addition, we analyze the advertisement effects in the solutions to handle at the buying behavior of customers. It is assumed that the buying behavior of customers dependent on advertisements. Thus, the demands of customers are changed according to the advertisements. Table 3 gives the results of advertisement effects. According to Table 4, the most important advertisement type is Internet. It is followed by $TV > Radio > Bilboard$. We find that plants obtain maximum profit by giving advertisement to Internet. While the maximum demand is observed on Internet, the minimum demand is observed in Billboard. As a result, this kind of CLSC model that based on advertisement types, has a very limited solution to analyze buying behavior of customers. However, the results show that the proposed model is able to handle an accurate, capable, and efficient solution for closed-loop logistics.

Table 4. Optimal results for advertisement options

		Customer			Number of advertisement
		1	2	3	
Advertisement	1	600	900	300	1
	2	2250	2550	3510	5
	3	2430	1170	904	3
	4	8210.4	3036	3967	8

CONCLUSION

This study is conducted to find out the impact of advertisements on the buying behavior of the customers in supply chain management .To do this, buying behavior of customers is captured by proposing a multi-objective optimization CLSC model with four echelons. The objectives are (1) maximization of total income, (2) minimization of transportation cost, (3) minimization of purchasing cost, and (4)-(5) minimization of fixed cost. The study contributes to the literature by proposing a multi-objective nonlinear CLSC model considering different advertisement alternatives. In the future, the uncertainty of parameters such as capacity, demand or other relevant parameters of the problem can be handled with fuzzy, Grey theory and stochastic modelling approaches. Heuristics algorithms such as Genetic Algorithm, Simulated Annealing and Particle Swam Optimization can be used for the performance of CLSC model.

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OPTIMIZATION PRACTICES FOR SUSTAINABILITY: A CASE OF CONTAINER TERMINAL OPERATIONS

Elifcan Dursun[1], Orhan Özgüven[2], Buğra Bilginer[3],

Abstract - *Strong link between container terminals and supply chain lead to a growing attention both in business and academics. For the last few decades in order to gain advantage, the focus of the container terminals have been mainly on the technological advances and performance improvement.*
Recent studies have indicated that the term sustainability has become one of the main concerns as much as technological advances and performance improvement among container terminals.
The objective of this paper is twofold. Firstly, main obstacles in container terminal yard planning, effects on the performance and contributions of the study have been discussed. An optimization algorithm have been developed and suggested to increase the container terminal yard and vessel operation performance. As a result, there has been a 76 % decrease in yard clashes which describe the multiple vessels requiring loading moves from same location about the same time. Secondly, the possible effects of the yard optimization on sustainability have been discussed.

Keywords – *Container Terminal, Supply Chain, Sustainability, Yard Optimization*

INTRODUCTION

Increasing global competition has led container terminals to improve their performances. Quay cranes, yard cranes, internal and external trucks play major roles in the container terminal operations. Quay cranes are utilized for berth operations, handling the containers to the vessel and from the vessel. Yard cranes are utilized for yard operations such as offloading the containers from the truck, mounting the containers to the truck, shuffling. Terminal trucks are utilized for transferring the containers inside of the terminal (Said, Mahmoud and El-Horbaty, 2014).

The flow of the containers is between the gates, yard and berth. After a container enters to the port, moves to the area where it will be stored until loaded the vessel. Different types of equipment are utilized to ensure quayside and landside container flow. Container flow consists of several activities. These activities include handling the containers in quayside, transferring the containers from the landside to the quayside and vice versa, stacking the containers in the storage area before loading on the vessel (Said, Mahmoud and El-Horbaty, 2014).

All activities should be managed efficiently to prevent delays and unexpected costs. Especially for the container terminals serving Container Freight Station activities, it gets more challenging to manage container flow efficiently. Container terminals have been developing methods to solve the problems related with the yard and berth planning.

Due to its complex structure, container terminal operations are gaining importance to improve the operational quality with less cost and time. Yard planning is one of the major subjects that researchers pay attention to improve the container terminal operations quality. Yard planning mostly consists of container yard allocation. Yard allocation is an activity to arrange the container storage space within the duration it stays inside the port. Container location should be arranged before it is discharged from the vessel and after it enters to the port until it is loaded on the vessel. Yard allocation plays an important role since it directly affects operational costs. This paper is not only concerns the allocation of the containers but also preventing the yard clashes and its cost/environmental effects. Yard clash describes the multiple vessels requiring loading moves from same

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location about the same time. A good yard planning remove the risk of yard clash, reshuffling and environmental problems related with the traffic among the yard and air pollution. In addition, it will decrease the costs related with improper planning.

The rest of this paper is organized as it follows: the literature review, problem description, developed model to prevent yard clashes, discussion on environmental effects of yard allocation and research findings.

LITEREATURE REVIEW

It has been observed that plenty of research has studied as "Yard Allocation Problem" in container terminals and in logistics. The objective of the problem is to assign container locations before they are discharged from the vessel and before they loaded to vessel with minimum cost. Containers can enter the port in two ways. One way is to enter the port by road/rail and the other way is to enter by vessel (discharging). During their stay inside the port, containers have been through many processes including idle movements and truck waiting times for the equipments. Idle movements and truck waiting times resulted in extra costs to container terminals. With an optimal yard planning, obstacles and extra costs related with idle movements can be removed. Lee, Jin and Chen (2012) presented an integer programming model for yard allocation problem in a large container terminal hub with multiple terminals. To minimize the cost of the transshipment flows, 2-level heuristic algorithm has been developed. Numerical experiments showed that integrated model can gain significant improvement without an optimization consideration.

Said, Mahmoud and El-Horbaty (2014) addressed the applications of different types of techniques for solving container terminals problems. They searched truck scheduling and yard allocation problems, yard cranes scheduling, storage space allocation problem, yard cranes, housekeeping process, scheduling loading operations, stacking containers. They discussed the techniques used to solve these mentioned problems and developed discrete event simulation study in Alexandria Container Terminal. Developed simulation model resulted in better terminal efficiency.

Ayachi, Kamarti, Ksouri and Borne (2010) presented a genetic algorithm to solve the container storage problem in order to have optimal arrangements for different type of containers such as dry, open side, open top, tank, empty and refrigerated. Their objective mainly is to meet the customer delivery deadlines, minimize the stop time of the vessel. Genetic algorithm has provided encouraging results compared to manual planning.

Zhang, Lu, Wan, Murty and Linn (2003) studied space allocation problem in container terminals. They solve the problem by using rolling-horizon approach. For each planning horizon, problem is decomposed into two levels and formulated by mathematical programming. Numerical runs showed that with short computation time, method significantly reduced the work in balances and contributed great to prevent the bottlenecks inside the terminal

Bazzazi, Safaei and Javadian (2009) presented an extended version of storage space allocation problem including the different type of containers. They verified genetic algorithm model by verifying by numerical examples. The obtained results showed a relative gap about 5% between genetic algorithm and optimum solution in terms of the objective function value.

Jiang, Chew, Lee and Tan (2014) developed a systematic method called "space allocation given long-term plan". Model is planned to utilize not only short term planning but also long term planning which requires forecasting techniques. The numerical experiments indicated that "space allocation given long term plan" method improved efficiency but its performance affected by the portion of long term planning.

Han, Lee, Chew and Tan (2008) studied storage yard management problem in a transshipment hub. They aimed to reduce the number of reshuffles, vessel turnaround time and potential traffic congestion inside the port. A mixed integer programming model is formulated to determine the storage locations of incoming containers. In addition, a tabu search based heuristic algorithm is used to generate an initial yard template. Numerical experiments showed that proposed method can generate excellent results within a reasonable time, even for the extreme cases.

Jiang, Lee, Chew, Han and Tan (2012) studied the storage yard management problem in a busy transshipment hub. They used a consignment strategy with a static yard template to reduce the level of reshuffles. However, it was observed that because of exclusive storage space reservation land utilization was sacrificed. They developed two space-sharing approaches to improve the land utilization and proposed a framework which integrates space reservation and workload assignment. Experimental results showed that framework is able to provide solutions for containers handling within much less storage space.

Kim and Park (2003) studied dynamic space allocation method outbound containers. Their main objective was to utilize space efficiently and make loading operations more efficient. They formulated a mixed integer linear program with two heuristic algorithm suggested based on the port stay of the containers. They compared the two heuristic algorithm.

Ku, Lee, Chew and Tan (2010) designed a generic problem specification with yard planning strategies and formulated a mathematical model that solves optimum weekly yard plan template. They gave importance to the model run time which was executed hundreds of times in search engine for optimum plan. Experiments showed that re-modelling a set of integer variables into multiple binary variables improved the run time tremendously. In addition, sharing yard space between services yield better utilization for yard space.

Vis and Roodbergen (2009) studied scheduling of container storage and retrieval in a container terminal. They consider the problem is a special case of the directed rural postman problem. They showed that problem can be modeled as an asymmetric Steiner traveling salesman problem. They solved the model by a combination of optimal assignments in bipartite networks for parts of the problem and dynamic programming. They developed an algorithm to construct a shortest directed multiple-row storage and retrieval tur to execute all requests. They showed that optimal approach outperforms the common rule of first-come-first-served.

Wan, Liu and Tsai (2009) discussed the assignment of storage locations to containers for a container stack. Their objective was to minimize the number of reshuffles in assigning storage locations for incoming and reshuffled export containers. They indicated that problem is hard for its dynamic nature. The optimum reshuffle sequence is given by an integer program. The integer program captures the evolution of stack configurations and heuristics based on the integer program are derived than. Numerical runs are tested for accuracy and then IP-based heuristics applied to the dynamic problem. Numerical runs confirmed that IP-based heuristic is competitive.

Cordeau, Laporte, Moccia and Sorrentino (2011) studied yard management problem in an automotive transshipment terminal. Their objective was to minimize total handling time. Problem was modeled as an integer linear program. It is found that, solving the problem with this solver was not easy. So that, they developed a metaheuristic algorithm to help the planner in updating yard allocations as soon as new information becomes available. Experimental results on real-life data show the efficiency of the metaheuristic algorithm compared to integer linear programming.

PROBLEM DESCRIPTION

The main objective of this study is to prevent manual yard planning, develop and implement algorithms for automated yard planning and increasing the efficiency of the port operations. In the port we study, yard has been planned manually by yard planners via Terminal Operating System. Due to the complex nature of the port, manual planning is not always giving the optimal results. Moreover, manual planning is open to human failure risks, low performance indicators and higher costs.

Yard planning process starts at the liner side. Agents which represents the vessel liners load the container loading list to the terminal operating system. According to the information at the terminal operating systems, yard planners start to assign the containers to the particular bay, row and tier. Containers stay at the assigned container locations until they are loaded on the vessel. During the assignment stage, one of the most important constraint is yard capacity. Planners have to consider capacity facts while assigning the containers. However, even if the capacity constraint is clear, it is not always possible to forecast the exact amount of the containers to be loaded days ago. Because agents can update the container loading list before it is declared as the final. Terminal operating system is designed as not to exceed the yard capacities while assigning the container locations. Even if the capacity is not exceeded, it doesn't mean that planners assigned the containers optimally. In addition to the yard capacity constraint, each container has different type of characteristics such as loading port, size, status, weight and etc. These characteristics are the constraints which restrict stacking of the containers to the same bay, row and tier. Yard planners have to consider many constraints to avoid extra costs. After the container is stated in the container list, either it will be assigned to a particular bay, row and tier immediately or it will be assigned during the port entrance at the gate. Planners can assign the containers when they arrive the entrance gate after the location request pops up on their screen. But, it results with longer service times, random planning and higher costs. So that, our intention is to plan every loading container location optimally before they reach to the port. Figure 1 shows a typical container yard segregated into the parts. Bay refers to the area consist of multiple rows, row refers to the area of the containers consist of tiers and tier refers to the level of the container. With optimum yard plans, crane and truck idling will be diminished.

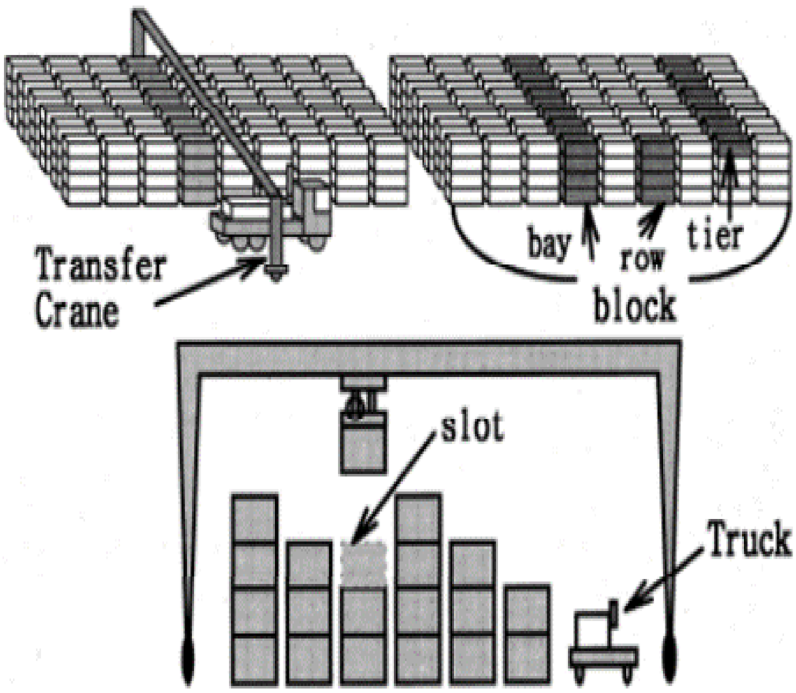

Figure 1.Yard Block

Another effect of poor yard planning is container reshufflings. Reshufflings refer to the location changing of the container for several reasons (Jiang, Lee, Chew, Han and Tan, 2012). Reshufflings are consist of transferring the containers within the same bay, another bay or another yard. Every shuffling results in extra fuel consumption and transferring cost. We observe that one of the main reason that cause reshuffling is yard clashes which is a result of poor yard planning. A vessel yard clash describes the multiple the multiple vessels requiring loading moves from same location about the same time. There are other yard clash types during the operations but our focus is mainly on the vessel yard clash in this study. Figure 2 shows vessel yard clash in a container yard.

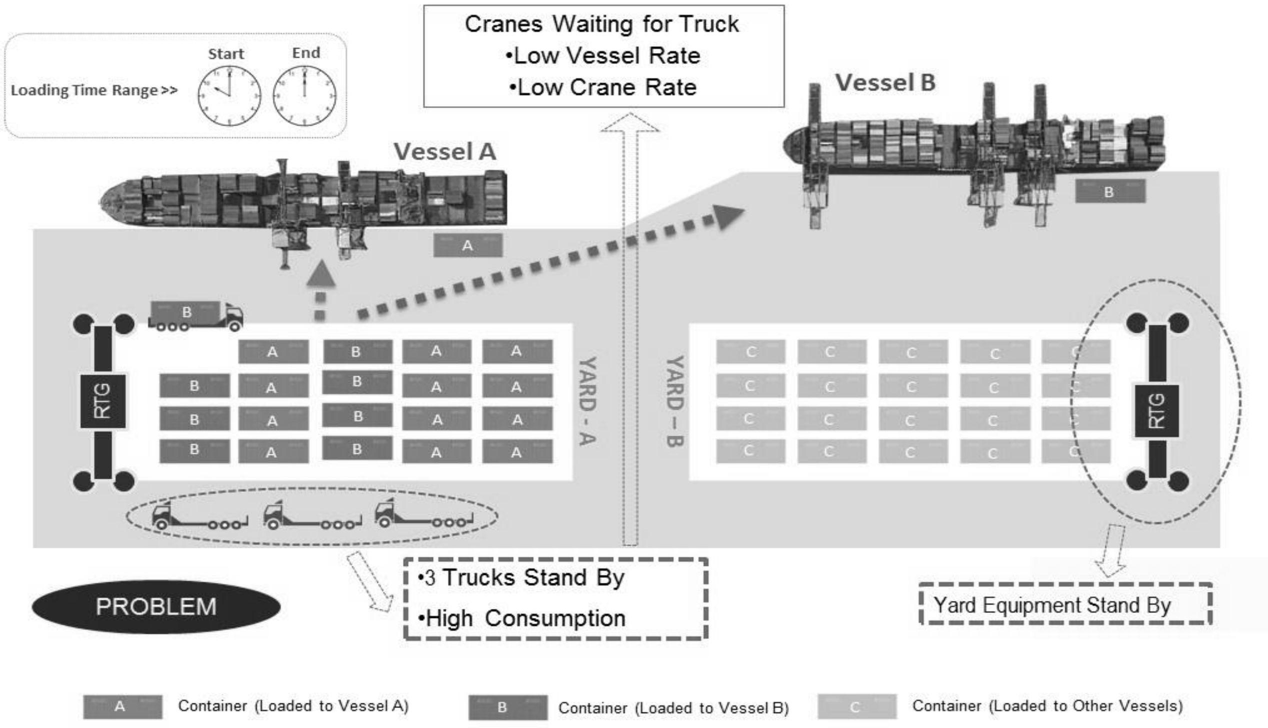

Figure 2.Vessel Yard Clash

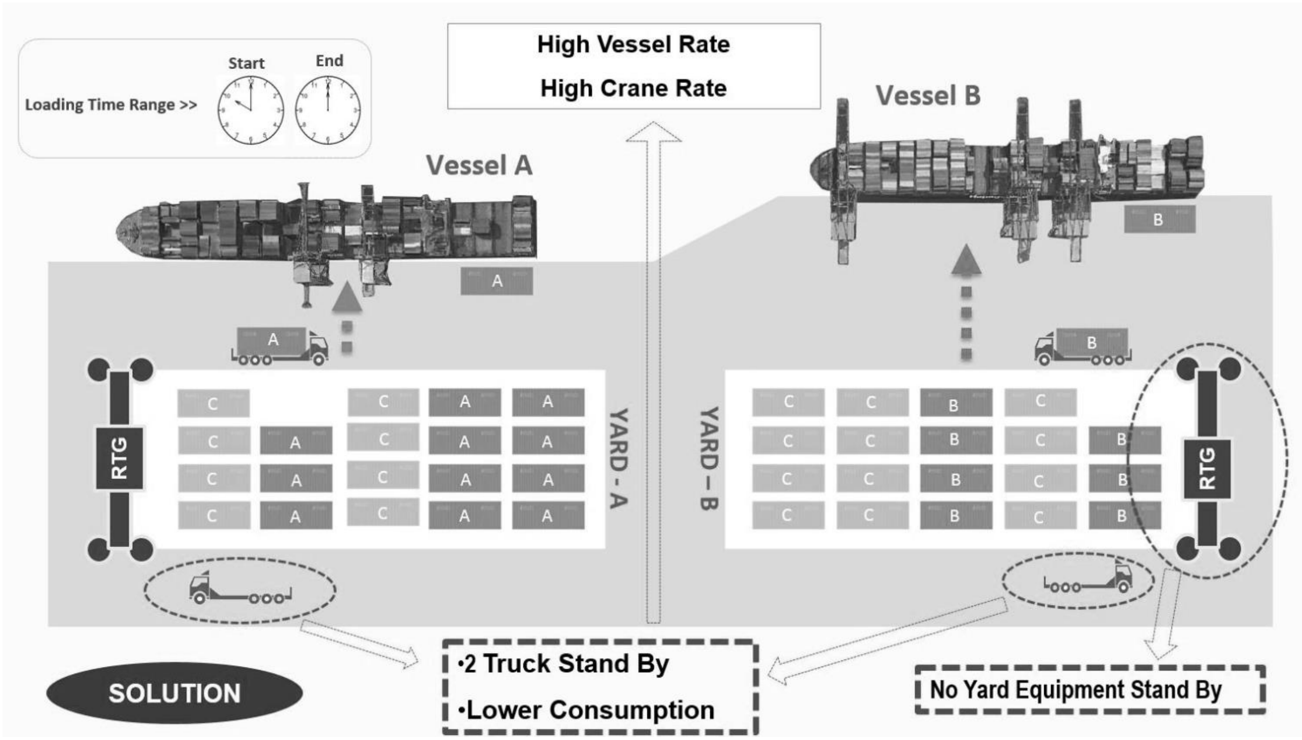

Figure 3.Ideal Initial Planning

MATHEMATICAL MODEL

According to the problem description, heuristic algorithm has been developed to be able to have the optimal result in a short time. Integer programming have been initially used for container location assignment. Developed mathematical model have been coded in the "CPLEX Optimization Studio" program.

Parameters:

K=Group of container (k)

S=Group of yard (s)

G=Group of vessel (g)

C=Group of vessel loading operation clash (c)

Z=Group of time (z)

V=Cartesian product of time and yard (v)

at=Group of container needs to be assigned

L_K=Location of the group of container k at the initial time period

S_K=If the container group k is on yard initially

KG_k=Entrance period of group of container k into the port

G_k=The vessel&voyage name of group of container k to be loaded

P_k=The port name that group of container k will be discharged

Y_k=The loading time of the group of container k

BOX_k= Total number of container that belong group of container k

TEU_k=Total number of container TEU equivalent that belong group of container k

SL_s=The name of the s yard

SK_s=The TEU capacity of s yard

V_g =The voyage name of the vessel g

ELT_g= The estimated start time of the loading operation of vessel g

ECL_g= The estimated completion time of the loading operation of vessel g

$C1_c$= The vessel&voyage name which has loading at the same time period with vessel C2 at the line c

$C2_c$= The vessel&voyage name which has loading at the same time period with vessel C1 at the line c

ZL_z= Period of time

ZK_v=Time code of v at the cartesian product of time and yard

ZS_v=Yard code of v at the cartesian product of time and yard

KK_v=Yard capacity of v at the cartesian product of time and yard

YO_{sk}= Group of containers k in terms of TEU in yard s

CA_{zsk}= From entrance till loading, assignment information of the group of container k at time z and yard s

PY_{zs}= Total TEU information at the time z and yard s

STT_{zsk}=Assignment information of the group of container k at the time z that on the yard initially

$XSTT_{sk}$=Integrated information of the containers on the yard s initially and group of container k to be assigned to yard s.

CB_{cs} =Amount of containers assigned to yard s for the vessel C1 at the line c in vessel clash list.

CC_{cs} = Amount of containers assigned to yard s for the vessel C2 at the line c in vessel clash list.

NYC_{cs}= Difference between the amount of containers assigned to yard s for vessel C1 and C2 at line c

Decision Variable:

$$X_{ijk} = \{ \begin{array}{l} 1\ if\ container\ k\ is\ assigned\ to\ yard\ j\ at\ the\ time\ \ i \\ 0\ other \end{array}$$

Model:

1) $YO_{sk} = \sum_{z \in R} (X_{zsk}) * TEU_k$

2) $CA_{zsk} = YO_{sk}\ , \quad \forall KG_k \leq \forall ZL_z\ ;\ \forall Y_k \geq \forall ZL_z;\ \ \forall KG_k = \forall ZL_Z$

3) $PY_{zs} = \sum_{k \in R}(CA_{zsk})$

4) $STT_{zsk} = 1,\ \forall S_k = 1,\ \forall L_k = \forall SL_s,\ \forall KG_k = \forall ZL_z$

5) $XSTT_{sk} = \sum_{z \in R}(X_{zsk+}\ STT_{zsk}) * BOX_k$

6) $CB_{cs} = \sum_{k \in R} XSTT_{sk}\ ,\ \ \forall C1_c = \forall G_k$

7) $CC_{cs} = \sum_{k \in R} XSTT_{sk}\ ,\ \ \forall C2_c = \forall G_k$

8) $NYC_{cs} = |CB_{cs} - \ \ CC_{cs}|$

Objective Function:

9) $Mak\ Z = \sum_{c \in R} \sum_{s \in R} NYC_{cs}$

Constraints:

10) $\sum_{z \in R} \sum_{s \in R} \sum_{k \in R} X_{zsk} = at$

11) $PY_{zs} \leq \sum_{R \in R}(\mathrm{KK}_v)\ ,\ \ \forall ZS_v = \forall SL_s\ ;\ \forall ZL_z = \forall ZK_v$

12) $\sum_{z \in R} \sum_{s \in R} X_{zsk} = 0,\ \forall S_k = 1$

13) $\sum_{z \in R} \sum_{s \in R} X_{zsk} \leq 1,\ \forall S_k \neq 1$

14) $X_{zsk} = 0, \qquad\qquad \forall KG_k \neq \forall ZL_z$

The output of the model is assignment of the containers which have same specifications i.e same gate entrance period, vessel, voyage, port of loading, loading time and loading crane. The objective function of the model is to maximize the situation of no yard clash, in other words minimizing the container loadings which have different specifications, different vessel loadings from same yard at the same time. With the optimization, yard clashes and equipment idling will be decreased, performance will be increased. These results will contribute a decrease in the operational cost especially reshuffling costs. In the model, every four hour is accepted as one period.

1), 2) and 3) indicate the yard inventory amount for each yard and time period which consists of the time the container enters the port until loading on the vessel

4),5),6),7) and 8) indicate the yard restriction of the container loadings which has different specifications, different vessel loadings but same loading time. So that as long as containers have different specifications, different loading vessel names but same loading period, they cannot be assigned to the same yard to prevent yard clashes.

9) is the objective function maximizing the no yard clash.

10) is the constraint that every container enters the port will be planned.

11) is the constraint that not to exceed the yard capacity for each period

12) is the constraint that not to assign the containers at the yard initially.

13) is the constraint that to assign the container which will enter the port only one location.

14) is the constraint that to assign the containers only at the entrance of the port.

SUSTAINABILITY EFFECTS

At present, one of the most important concerns in the port industry is sustainability. Apart from the performance and cost effects, yard clashes and low productivity have considerable effects on sustainability. Thousands of external trucks enter and exit the port each day. In addition to that, containers are transferred inside the port by internal trucks and prime movers. Container stacking has been carried out by yard cranes, reach stackers and empty stackers. Due to the utilization of multiple type of equipment and truck, there are many sources for air pollution in container terminals. Most of the engines are diesel powered. Ports have been developing strategies to prevent air pollution and environmental costs to ensure sustainable operations. In our study, we pay attention on sustainability related with the yard clashes, in other words poor yard planning. Yard clashes lead to longer haulier service time and lower prime mover productivity. Yard equipment or yard crane have idle waiting due to the poor yard planning. During the equipment idle waiting times, equipments still emit carbon dioxide, nitrogen oxides, volatile organic compounds and particulate matter (Geerling and Duin, 2011). It is observed that one truck idle waits approximately 6 minutes per yard clash. One terminal truck consumes approximately 2 liter per movement, one diesel powered RTG (Rubber Tyred Gantry Crane), reach stacker and empty stacker consumes approximately 1 liter per movement. There is not an exact standard to measure the each equipment hazardous gas emission. However, the quantity of the fuel determines the emissions: for example the burning of a liter of diesel produces around 2.65 kg of CO_2 (Geerling and Duin, 2011).Considering the approximate movements of each equipment in one year, 3 million movement has been done by terminal trucks, diesel powered yard cranes and RTGs. That means container terminal produces avg. 7,950,000 kg of CO_2 in one year.

There are several ways to reduce the amount of CO_2 emitted during the container terminal operations. One of them is to increase the service level of external trucks. Since the container location is already assigned before it enters the port with automated yard planning, container doesn't have to wait at the gates for location assignment. This will result in lower haulier service time, equipment idling and less fuel consumption. Further research on yard optimization-sustainability relationship is needed to have an exact result.

RESEARCH FINDINGS

We have studied mainly on the container location assignment to prevent yard clashes as a result of poor yard planning. An integer model developed for container location assignment and a heuristic algorithm developed to be able the have the optimal result in a short time. The developed model provides a new framework to the container terminal yard operations. Developed model has been implemented and tested at the studied container terminal. Figure 3 demonstrates the yard clashes before and after the yard optimization at container terminal yards. Numerical experiments for a particular month have indicated that yard optimization improves the yard planning and decrease 76% of the yard clashes. Figure 4 indicates the yard clash improvement. Data analysis captures one month. In addition to the contribution with a decrease in yard clashes, our optimization model guides the yard planners to monitor yard plans, equipment and operator performance and considers the negative effects of poor planning on sustainability. Further research will be conducted to ensure sustainable yard plans.

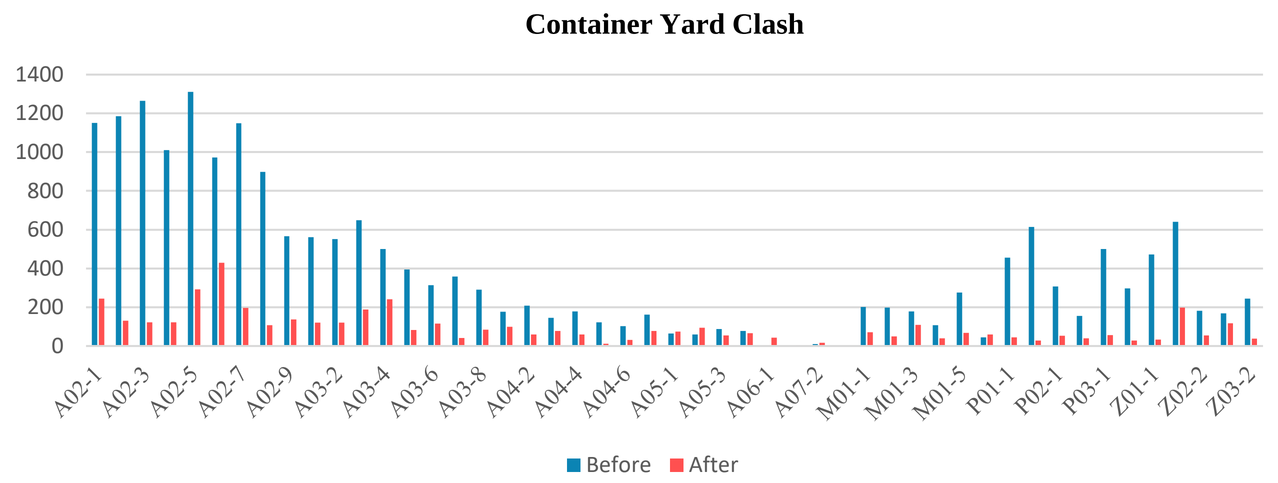

Figure 2.Yard Clash Amount Before and After Optimization

Table 1. Yard Clash Improvement

	Yard Clash Amount (Box)		
Yard No	**Before**	**After**	**Decrease %**
A	14,527	3,550	-76%
M	1,005	395	-61%
P	2,332	248	-89%
Z	1,706	441	-74%
General Amount	19,570	4,634	-76%
Duration:		33 Days	
Yard Occupancy:		67%	
Loading Box Amount:		23,893	
Loading TEU Amount:		36,036	

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A MATHEMATICAL MODEL FOR THE J-DEGREE CYCLIC FLOW SHOP ROBOTIC CELL WITH MULTIPLE ROBOTS AND COLLISION AVOIDANCE

Atabak ELMI[1], Cihan ÇETİNKAYA[2], Eren ÖZCEYLAN[3]

Abstract – This paper deals with the cyclic flow shop robotic cell scheduling problem with multiple robots, where parts are processed successively on multiple machines with time window processing times and the transportation of parts among the machines is executed by the robots. A mixed-integer linear programming model for the J-cyclic flow shop robotic cell scheduling problem considering the robots collisions has been proposed and solved using GUROBI 6.05. The validity of the proposed model is examined by a computational study on a randomly generated problem instance.

Keywords – Collision avoidance, cyclic scheduling, mixed-integer linear programming, multiple robots, robotic cell.

INTRODUCTION

In this research, we focus on the sequencing and scheduling problem of a particular type of automated material handling system in cellular manufacturing: cyclic robotic cells. A robotic flow shop usually consists of an input device, an output device, a sequence of processing machines, and a crew of identical programmable robots. Parts to be processed enter the system from the input device, then are processed successively through machines, and finally leave the robotic cell from output device. Each machine can process only one part at a time. Because there are no buffers for intermediate storage between the machines and each machine can hold only one part, a robotic cell is, in essence, a flow shop with blocking, where there are single gripper robots that transfer the parts between machines. In this paper, the multi-degree cyclic flow shop scheduling problem with multiple single-gripper robots is considered. A novel mixed-integer linear programming model is proposed for the problem to minimize the cycle time and thus to maximize the throughput.

Given the processing requirements, the objective that is most interested by manufacturers is the maximization of cell productivity. A natural and widely used measure of productivity is throughput; the number of finished parts produced per unit of time [1]. In the blocking flow shop robotic cells, a crew of computer-controlled robots performs the movements of parts between the machines. By optimally assigning the robots to these moves and sequencing the transportation operations at the same time, the throughput of the cell would be maximized.

LITERATURE REVIEW

Sethi et al. [2] performed the purely analytic study of robotic cells containing two and three machines. Logendran and Sriskandarajah [3] extended this work to cover different configurations of cells and more general times for the robot's actions. Crama and Van de Klundert [4] and Dawande et al. [5], each developed polynomial-time algorithms to find the optimal one-unit cycles considering machine numbers. More thorough reviews of the cyclic robotic flow shop cells literature can be found in surveys by Hall [6], Crama et al. [7], and Dawande et al. [8] and in the book by Dawande et al. [1].

Agnetis [9] studied the two and three machine one-cyclic robotic cells with a single robot and developed polynomial algorithms to solve the considered problem. Levner et al. [10] extended the same problem to m-machine using the notion of prohibited intervals. They considered more than one robot in large robotic cells to eliminate material handling bottlenecks. Karzanov and Livshits [11] studied the system with parallel tracks where robots run along their respective tracks and proposed an algorithm to find the minimal number of robots

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for a given cycle time. Furthermore, Liu and Jiang [12] proposed an efficient algorithm for cyclic scheduling of two robots in a no-wait robotic cell.

Moreover, many researchers have noted and verified that multi-degree cyclic schedules usually have larger throughput than one-cyclic schedules. Kats et al. [13] studied the k-cyclic robotic cells with a single robot and proposed a sieve method based algorithm to optimize the cycle time. On the bases of their problem, Che et al. [14] proposed an exact algorithm based on branch-and-bound procedure for the no-wait robotic cells. They have noted that the proposed algorithm is polynomial for a fixed k-cyclic (k > 1), but becomes exponential if k is arbitrary. Lately, Che and Chu [15] showed that the no-wait multi-degree robotic cell scheduling problem with two parallel robots can be also solved in polynomial time for a fixed k-cyclic (k > 1), but exponential if k is arbitrary. However, the algorithm cannot be mechanically extended to the multi-robot case because it explores some properties specific to the cells with two robots.

Table 1. Literature review for flow shop robotic cell scheduling problem

Num	**Reference**	**Robot Number**	**Part Number**	**Machine Number**	**Pickup Criterion**	**Main contribution**
1	Chen et al. [16]	1	1	M	Time Window	A branch-and-bound algorithm for generating an optimal cyclic schedule.
2	Che and Chu [14]	1	K	M	No-Wait	An exact algorithm based on a branch-and-bound procedure.
3	Che and Chu [15]	2	K	M	No-Wait	A polynomial algorithm to find the minimum cycle time.
4	Geismar et al. [17]	1	K	M	Free	A polynomial algorithm to find the minimum time cyclic solutions for the three most common robotic cell classes: additive, constant, and Euclidean travel-time.
5	Leung and Levner [18]	R	1	M	No-Wait	A polynomial algorithm to find the minimum number of robots for all feasible cycle times, and subsequently to find the optimal cycle time for any given number of robots.
6	Alcaide et al. [19]	R	K	M	Time Window	Multiple robots moving in a carousel mode. A graph model of the production process is developed, making it possible to apply PERT–CPM solution techniques.
7	Jiang and Liu [20]	R	1	M	No-Wait	A polynomial algorithm to obtain an optimal schedule with minimum cycle time.
8	Kats and Levner [21]	1	2	M	No-Wait	A polynomial-time method
9	Che and Chu [22]	R	K	M	No-Wait	A polynomial algorithm to find the minimum number of robots for each k-unit schedule, and subsequently to find the optimal cycle time for any given number of robots.
10	Che et al. [23]	R	2	M	No-Wait	A polynomial algorithm to find the minimum number of robots for all feasible cycle times, and subsequently to find the optimal cycle time for any given number of robots.
11	Zhou et al. [24]	1	K	M	Time Window	Mathematical model which finds the optimum cycle time for each k-unit separately
12	Che et al. [25]	R	K	M	No-Wait	A polynomial algorithm for scheduling multiple robots in re-entrant robotic flow shop.

13	Jiang and Liu [26]	R	1	M	Time Window	Mathematical model and branch-and- bound algorithm, Collisions are not considered.
14	Elmi and Topaloglu [27]	R	K	M	Free	Ant Colony Optimization
15	Elmi and Topaloglu [28]	R	K	M	Time Window	A novel mathematical programming model, Collisions are not considered.
16	Current research	R	K(Fixed)	M	Time Window	Mathematical programming model, Considering the Collisions between the multiple robots.

Furthermore, Che and Chu [22] considered the k-cyclic robotic cell scheduling problem with multiple robots in a no-wait system. They have proposed a polynomial algorithm to find the minimum number of robots for all k-cyclic (k > 1) schedules and thus the optimal cycle time for any given number of robots. On the basis of their work, Che et al. [25] extended the proposed method to the cyclic scheduling of a no-wait re-entrant robotic flow shop with multiple robots. Zhou et al. [24] proposed a mixed-integer programming model for the fixed k-cyclic robotic cells considering time window constraints and a single robot.

To the best of author's knowledge, the robots collisions for the problem of J-degree cyclic scheduling of multiple robots in a flow shop robotic cell has not been addressed in the literature.

PROBLEM DEFINITION

The robotic flow shop under study consists of multiple computer-controlled robots for material handling and M machines assigned in a row. These machines are indexed as $m \in \{1,2,\dots,M\}$, where m_1 and m_M are the loading and the unloading stations, respectively. All the parts are of the single type and processed in the robotic flow shop by successively visiting the machines. The part flow can be described as follows. After a part is moved into the robotic flow shop from the loading station m_1, it is processed sequentially through machines $m \in \{2,3,\dots,M-1\}$, and finally leaves the flow shop from the unloading station m_M.

In the cyclic flow shop, all the parts are categorized to classes and the parts of the same class have the same conditions in consecutive cycles. In other words, if there are J parts that would be processed in a cycle, the parts are indexed as classes $\{1,2,\dots,J\}$ according to their sequence of entering the system during the cycle. There are parts from the same class in each cycle. Thereupon, some of the consecutive processing operations of parts may be continued in the next cycles. This means that only one part from the same class is completed per cycle. Therefore, if there are p parts from the same class, the processing operations of this class are divided to p sets of consecutive operations in a cycle.

The objective is to find the sequences of transportation operations, and appropriate robots assignments to perform each transportation operation so that the cycle time is minimized.

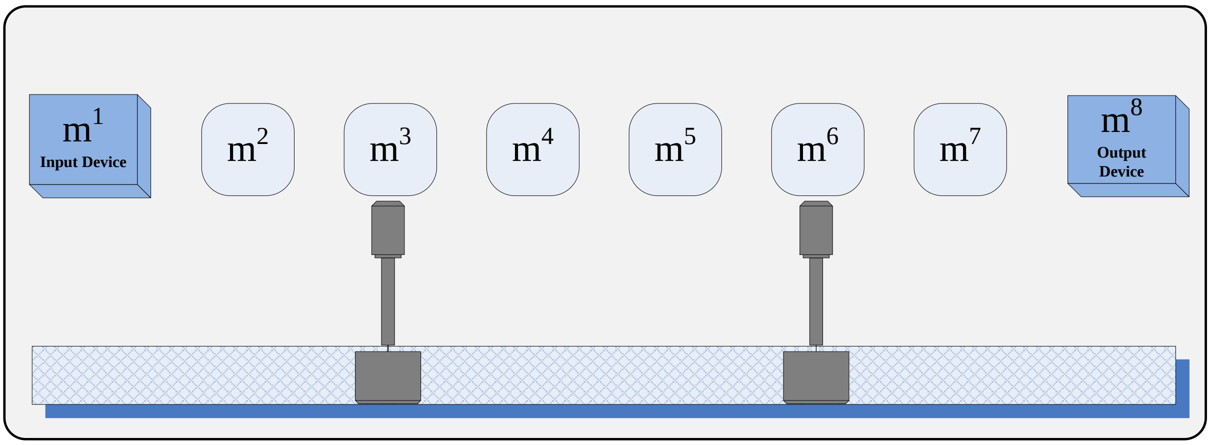

Figure 1. An example for the flow shop robotic cell containing two robots

MATHEMATICAL PROGRAMMING

For simplicity, the robot move of transporting a part of class j from machine m to machine $m+1$ is called transportation operation $[j,m]$. A transportation operation $[j,m]$ is made up of three simple robot sub-operations: (1) unloading a part of class j from machine m; (2) transporting the part of class j to the next machine $m+1$; and (3) loading it onto machine $m+1$. It is understandable that there are totally $J\times(M-1)$ transportation operations in a J-cyclic schedule. Under this definition, we define the time required for any robot to perform transportation operation $[j,m]$(such a travel is also called a completemove $[j,m]$) as θ_m, and the time required for any robot without transporting parts to travel from machine m to machine n (such a travel is also called an empty move $[\![m,n]\!]$) as $\delta_{[\![m,n]\!]}$. Note that a cyclic schedule can be described by the starting times of all moves in the system. All the robots are considered to be free at the start of a cycle but not all the processing machines.

Indices:

J	The maximum number of identical parts that can enter during a cycle, $j \in \{1,2,\dots,J\}$,
M	Number of machines including input and output devices where, $m \in \{1,2,\dots,M\}$,
R	Number of single gripper robots where, $r \in \{2,\dots,R\}$,
$[j,m]$	A complete move for any robot to transport part j from machine m to machine $(m+1)$,
$[\![m,n]\!]$	A void move for any robot to travel from machine m to machine n without any part.

Parameters:

LoP_m	The lower bound for the processing time due to the time window processing, where the processing times of all parts at input and output stages are equal to zero,
UpP_m	The upper bound for the processing time due to the time window processing, where the processing times of all parts at input and output stages are equal to zero,
θ_m	Standard handling time of a part from machine m to the next machine $(m+1)$,
$\delta_{[\![m,n]\!]}$	The time required for any robot to perform void move $[\![m,n]\!]$,
BM	A sufficiently large positive value, (big M).

Decision variables:

$Z_{[j,m],r}$	1 if the complete move $[j,m]$ is done by the rth robot, 0 otherwise,
$Y_{[j,m],[j',m']}$	1 if complete move $[j,m]$ is done before complete move $[j',m']$, 0 otherwise,
$S_{[j,m]}$	Start time of a complete move $[j,m]$,
T	The cycle time for all the parts entered,

Mixed-integer linear programming model:

$Minimize : T$

Subject to:

$$S_{[j,m-1]} + \theta_{m-1} + LoP_m - BM \times \left(1 - Y_{[j,m-1],[j,m]}\right) \le S_{[j,m]};\quad j \in \{1,2,\dots,J\};\ m \in \{2,\dots,M-1\} \tag{1}$$

$$S_{[j,m-1]} + \theta_{m-1} + LoP_m - BM \times Y_{[j,m-1],[j,m]} \le S_{[j,m]} + T;\quad j \in \{1,2,\dots,J\};\ m \in \{2,\dots,M-1\} \tag{2}$$

$$S_{[j,m-1]} + \theta_{m-1} + UpP_m + BM \times \left(1 - Y_{[j,m-1],[j,m]}\right) \ge S_{[j,m]};\quad j \in \{1,2,\dots,J\};\ m \in \{2,\dots,M-1\} \tag{3}$$

$$S_{[j,m-1]} + \theta_{m-1} + UpP_m + BM \times Y_{[j,m-1],[j,m]} \ge S_{[j,m]} + T;\quad j \in \{1,2,\dots,J\};\ m \in \{2,\dots,M-1\} \tag{4}$$

$$S_{[j,m]} - BM \times \left(1 - Y_{[j,m],[j',m']}\right) - BM \times \left(Z_{[j,m],r} + Z_{[j',m'],r} - \left|Z_{[j,m],r} - Z_{[j',m'],r}\right|\right) \leq S_{[j',m']} + \theta_{m'};$$
$$j,j' \in \{1,2,\dots,J\};\ m,m' \in \left\{\{1,\dots,M-1\} \mid m < m'\right\} \tag{5}$$
$$S_{[j',m']} - BM \times Y_{[j,m],[j',m']} - BM \times \left(Z_{[j,m],r} + Z_{[j',m'],r} - \left|Z_{[j,m],r} - Z_{[j',m'],r}\right|\right) \leq S_{[j,m]} + \theta_m;$$
$$j,j' \in \{1,2,\dots,J\};\ m,m' \in \left\{\{1,\dots,M-1\} \mid m < m'\right\} \tag{6}$$
$$S_{[j,m]} + \theta_m + \delta_{[\![m+1,m']\!]} - BM \times \left(3 - Z_{[j,m],r} - Z_{[j',m'],r} - Y_{[j,m],[j',m']}\right) \leq S_{[j',m']};$$
$$j,j' \in \{1,2,\dots,J\};\ m,m' \in \left\{\{1,\dots,M-1\} \mid m < m'\right\};\ r \in \{1,2,\dots,R\} \tag{7}$$
$$S_{[j',m']} + \theta_{m'} + \delta_{[\![m'+1,m]\!]} - BM \times \left(2 - Z_{[j,m],r} - Z_{[j',m'],r} + Y_{[j,m],[j',m']}\right) \leq S_{[j,m]};$$
$$j,j' \in \{1,2,\dots,J\};\ m,m' \in \left\{\{1,\dots,M-1\} \mid m < m'\right\};\ r \in \{1,2,\dots,R\} \tag{8}$$
$$\textstyle\sum_{r=1}^{R} Z_{[j,m],r} = 1;$$
$$j \in \{1,2,\dots,J\};\ m \in \{1,\dots,M-1\} \tag{9}$$
$$S_{[j,m]} + \theta_m \leq T;$$
$$j \in \{1,2,\dots,J\};\ m \in \{1,\dots,M-1\} \tag{10}$$
$$\textstyle\sum_{\mathrm{j}=1}^{J} Y_{[\mathrm{j},m-1],[\mathrm{j},m]} \geq J - 1;$$
$$j \in \{1,2,\dots,J\};\ m \in \{2,\dots,M-1\} \tag{11}$$
$$\textstyle\sum_{\mathrm{j}=1}^{J} \left(Y_{[(\mathrm{j}\%J)+1,m-1],[(\mathrm{j}\%J)+1,m]} - Y_{[(\mathrm{j}\%J)+1,m-1],[\mathrm{j},m]}\right) = \mathrm{J} - 1;$$
$$j \in \{1,2,\dots,J\};\ m \in \{2,\dots,M-1\};\ \text{where,}(\mathrm{j}\%J) \equiv Module(\mathrm{j},J) \tag{12}$$
$$S_{[j,m]} + \theta_m + \delta_{[\![m+1,m']\!]} - BM \times \left(3 - Y_{[j,m],[j',m']} - Z_{[j,m],r} - \textstyle\sum_{t=r}^{R} Z_{[j',m'],t}\right) \leq S_{[j',m']}$$
$$\forall \{j,j' \in \{1,2,\dots,J\};\ m,m' \in \{1,\dots,IM-1\};\ r \in \{1,2,\dots,R\};\ j \neq j' \vee m > m'\} \tag{13}$$
$$S_{[j',m']} + \theta_{m'} + \delta_{[\![m'+1,m]\!]} - BM \times \left(3 - Y_{[j',m'],[j,m]} - Z_{[j,m],r} - \textstyle\sum_{t=r}^{R} Z_{[j',m'],t}\right) \leq S_{[j,m]}$$
$$\forall \{j,j' \in \{1,2,\dots,J\};\ m,m' \in \{1,\dots,IM-1\};\ r \in \{1,2,\dots,R\};\ j \neq j' \vee m > m'\} \tag{14}$$
$$S_{[j,m]} + \theta_m + \delta_{[\![m+1,m']\!]} - BM \times \left(3 - Y_{[j,m],[j',m']} - Z_{[j,m],r} - \textstyle\sum_{t=1}^{r} Z_{[j',m'],t}\right) \leq S_{[j',m']}$$
$$\forall \{j,j' \in \{1,2,\dots,J\};\ m,m' \in \{1,\dots,IM-1\};\ r \in \{1,2,\dots,R\};\ j \neq j' \vee m < m'\} \tag{15}$$
$$S_{[j',m']} + \theta_{m'} + \delta_{[\![m'+1,m]\!]} - BM \times \left(3 - Y_{[j',m'],[j,m]} - Z_{[j,m],r} - \textstyle\sum_{t=1}^{r} Z_{[j',m'],t}\right) \leq S_{[j,m]}$$
$$\forall \{j,j' \in \{1,2,\dots,J\};\ m,m' \in \{1,\dots,IM-1\};\ r \in \{1,2,\dots,R\};\ j \neq j' \vee m < m'\} \tag{16}$$

Constraint sets (1, 2) guarantee the processing restrictions of a part and ensure that each part is processed on a machine only if its processing is completed on the previous machine. Constraint sets (3, 4) guarantee that the processing time on each machine would not pass its upper bound due to the time window restrictions. Constraint sets (5, 6) are used to ensure the proper sequence of transportation operations performed by different robots. Whereas constraint sets (7, 8) guarantee the proper sequence of transportation operations considering they might be assigned to the same robot. Constraint set (9) asserts that a transportation operation should be performed by only one robot. Constraint set (10) guarantees that all the transportation operations are completed in the cycle. Constraint set (11) states that each machine can be occupied at most by one part at the start time of a cycle and it also determines the occupied machines and their related parts. Constraint set (12) determines the cyclic operational sequence of consecutive parts on the same machines. These constraints guarantee the cyclic consecution of parts between the cycles. The constraint sets (13-16) considers the collisions of robots and avoids the collisions during the scheduling.

NUMERICAL EXAMPLE

To illustrate validity of the proposed model, an example is solved using GUROBI 6.05 solver on a PC including Intel(R) Core(TM)i7, CPU 3.30 GHz and 4 GB RAM.

The robotic cell considered in this example contains 6 processing machines plus input and output devices. There are two single gripper robots that perform the transportation operations between the machines. Table 2 provides the processing times of each machine and the times to perform the indicated transportation operations. Figure 2 illustrates the Gantt chart for the aforementioned robotic cell problem. The conjunctive arrows illustrate the transportation operations between the machines, which are done by different robots (1st robot blue and 2nd robot red colour). In addition, disjunctive arrows show the empty moves of robots between the machines and devices. Also, the start times of all transportation operations (unloading parts from machines) are provided in Table 3.

Table 2.Cell data for the example problem

Data (sec.)		**Machines**							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
$\boldsymbol{LoP_m}$		0	53	40	41	64	37	31	0
$\boldsymbol{UpP_m}$		0	77	59	54	76	53	60	0
$\boldsymbol{\theta_m}$		14	13	15	15	14	13	13	0
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Empty move $(\delta_{[\![m,n]\!]})$	**1**	0	3	5	8	11	13	15	17
	2	3	0	2	5	8	10	12	14
	3	5	2	0	3	6	8	10	12
	4	8	5	3	0	3	5	7	9
	5	11	8	6	3	0	2	4	6
	6	13	10	8	5	2	0	2	4
	7	15	12	10	7	4	2	0	2
	8	17	14	12	9	6	4	2	0
Number of Robots: 2									
Number of parts completed during the cycle: 3									

Table 3. Start times of transportation operations (unloading parts from machines)

Parts	Machine						
	1	2	3	4	5	6	7
1	0	76	148	211	290	0	70
2	128	195	261	330	52	116	189
3	245	314	23	92	171	233	306

The cycle time: $\mathrm{T} = 357$ sec.
The cycle time per part: 119
The throughput rate: 0.5042 parts/min

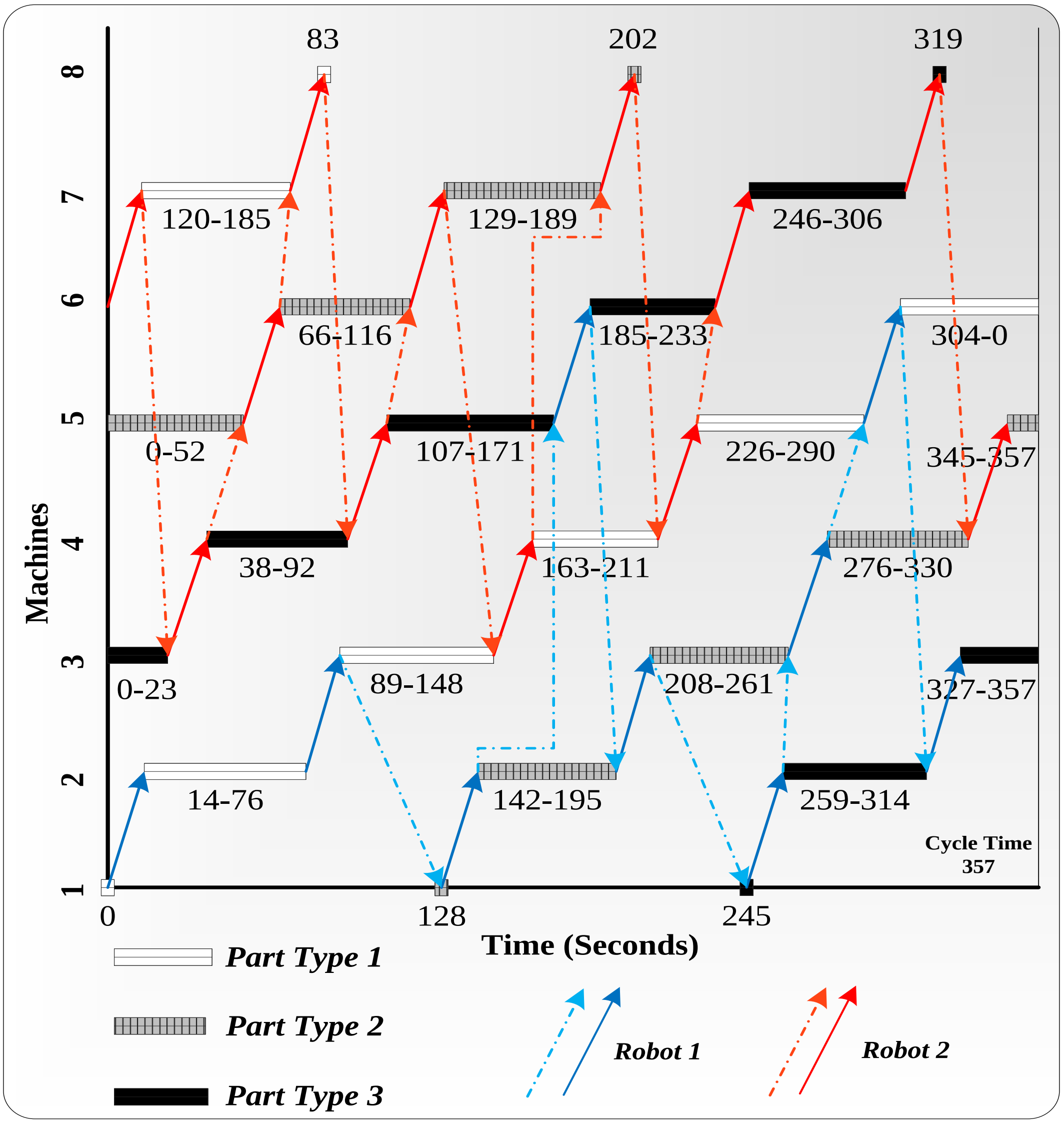

Figure 2. The Gantt Chart of the example problem solved using GUROBI 6.05 (3-cyclic schedule)

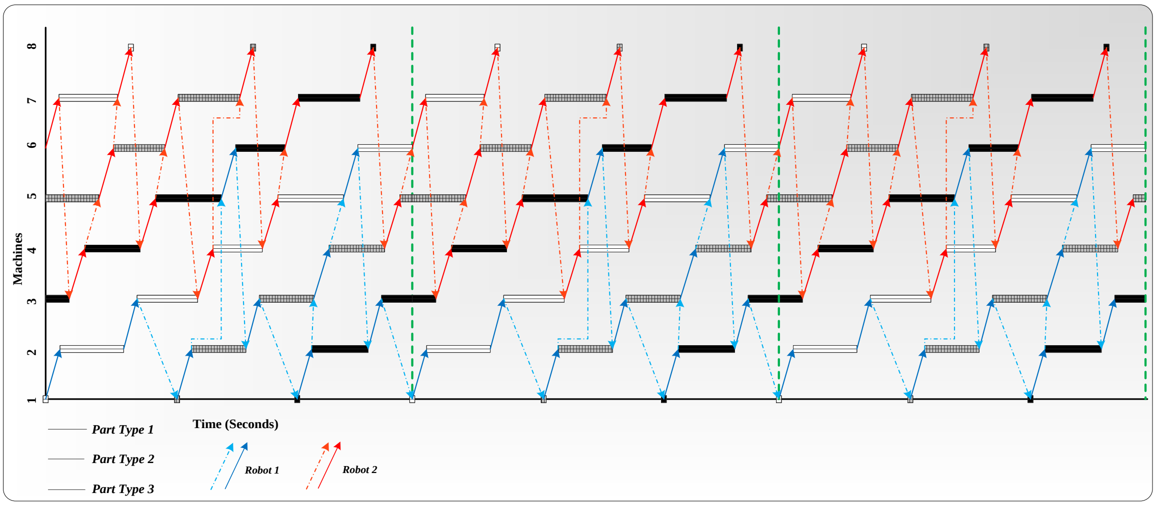

Figure 3. The Gantt chart of three consecutive cycles for the example problem (3-cyclic schedule)

CONCLUSION

This paper proposes a mixed-integer linear programming model for the multi-cyclic robotic flow shop scheduling problem considering multiple robots and avoiding the collisions between robots. The validity of the proposed model is examined on a randomly generated instance. In further research, a metaheuristic approach would be proposed to solve the large scale instances in robotic flow shops with multiple robots.

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A MODEL FOR EVACUATING SURVIVORS BEFORE CONTAMINATED BY CHEMICAL AGENT

Tolga Boyraz[1], İbrahim Akgün[2], Ahmet Aktaş[3]

Abstract ─ *The study describes effective evacuation system under the threat of chemical agents. Proportion of contaminated area in the network is changed according to time periods and while dispersion extends uncontaminated nodes and their in/out arcs become contaminated. In this context dynamic network flow problem and facility location are handled together. In the dynamic network flow problem, maximum number of survivors who are under the threat of getting contaminated are evacuate to safety area. Decontamination site is selected among candidate places in the facility location problem. For this reason mixed integer linear programming model is developed and results are obtained using cplex branch and bound method. The model and effective solution methodology used by decision makers for the different purposes are proposed.*

Keywords ─ *CBRN, mixed integer programming, evacuation, disaster management*

INTRODUCTION

CBRN agents which are used by terrorists/criminals or are included in accidents/wars can cause too many lives lost and preventing the use of environment. There are several occasions in the history where the disastrous affects or the feeling of panic caused by CBRN incidents have been reported (Abrahamian, 2008) - (The Week, 2013).

When the disastrous effects of CBRN incidents are taken into account, governments must be ready to encounter CBRN disasters by preparing their plans and making their emergency teams respond quickly, safely, and effectively to minimize casualties and recovery time. Most lives are saved in the first few hours following a disaster (Sayyady & Eksioglu, 2010).

LITERATURE REVIEW

The literature considers the evacuation problem in the context of disaster/emergency management. Disaster/Emergency management has four phases, namely, mitigation, preparadness, response, and recovery and evacuation is one component of the relief operations in the response phase (Coppola, 2011). We refer the reader to (Altay & Green III, 2006) - (Galindo & Batta, 2013) for a comprehensive survey of OR/MS studies in disaster/emergency management.

Some of the optimization studies for emergency evacuation are as follow (Sayyady & Eksioglu, 2010), (Sherali, Carter, & Hobeika, 1991) - (Wang, Ip, & Zhang, 2010). On the other hand, the simulation approach is used for some studies (Sheffi, Mahmassani, & Powell, 1982) - (Tayfur & Taaffe, 2009). In addition, there are some studies where both optimization and simulation approaches are applied (Zou, Yeh, Chang, Marquess, & Zezeski, 2005) - (Stepanov & Smith, 2009).

Each component of CBRN has different behaviors after the attacks occurred (Meyer & Eldredge, 2000). Therefore, each component should be studied separately. In this study, we propose a model to meet the lack of studies on evacuation from areas contaminated by chemical agents. By means of proposed model, we help managers determine appropriate courses of action under the threat of chemical hazard. This model facilitates managers find the answers to the questions in their heads. So, courses of action can be tested prior to disaster and effective disaster management can be realized.

PROBLEM DESCRIPTION

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In this paper, the focus is on the rural area and specifically on military environment, i.e., military installations or operations areas. When a chemical attack/incident occurs in the military area, the hazardous material does not stay in the attack/incident area. Emitted vapor and aerosol begin to travel with the wind and can cover a large area downwind of the attack area. If the wind speed is 10 kmph or less, the dispersion model can be seen as circular shape. Otherwise, the dispersion model can be seen as canonical shape as shown in Figure 1.

Contaminated area is a first-degree risky area and called as hot area. Around hot area, a second-degree risky area called as mild area or buffer zone is determined. The area out of mild area is considered as not risky and termed as cold area. All personnel, equipment, and vehicles must be decontaminated before leaving hot area. Decontamination takes place at decontamination and first aid centers (DFACs). DFACs are located in the mild area close to the contaminated area considering factors such as decontamination type, terrain, mission, threat, road network, and availability of water (US ARMY FM 3-5, 2000). The general structure of a DFAC is given in Figure 2. Until dispersion stops, all efforts are directed to evacuate the units from predicted hazardous area before getting casualty. After dispersion stops extending, contaminated area is marked and all exit points are taken under the control to prevent spread of contamination by warning the personnel and to help planners prepare the evacuation plan.

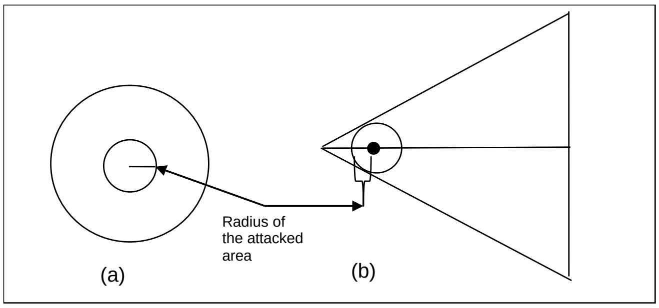


Figure 1. Dispersion Models.

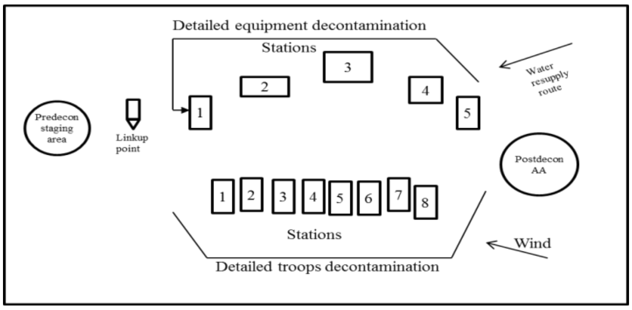


Figure 2. A Typical Structure of A DFAC

Because vehicles entering hot area are considered as contaminated, all of the roads used by those vehicles are also considered as contaminated. In this regard, the underlying network structure must be arranged such that contaminated (non-contaminated) vehicles move through only contaminated (non-contaminated) parts of the network. Similarly, contaminated (decontaminated) personnel must be coupled with contaminated (non-contaminated) vehicles. Moreover, the activities at a DFAC must be arranged such that contaminated and decontaminated personnel do not mix up.

FORMULATION OF THE PROBLEM

We focus on evacuating survivors from non-contaminated area to safe area (cold area) before getting contaminated. The problem is defined on a network. It can be helpful to define the areas as hot, mild and cold for the purpose of the modeling of the evacuation. Figure 3 represents hot, mild and cold areas for conic or circle shapes of dispersion as a symbolic. A hot area is a first degree risky area where a contamination occurs. All personnel are considered as contaminated in the hot area. A mild area is adjacent to the hot area. It represents the buffer zone. After dispersion stops extending, DFACs are established in this area. A cold area is a third area which has no risk. AAs are located in the cold area.

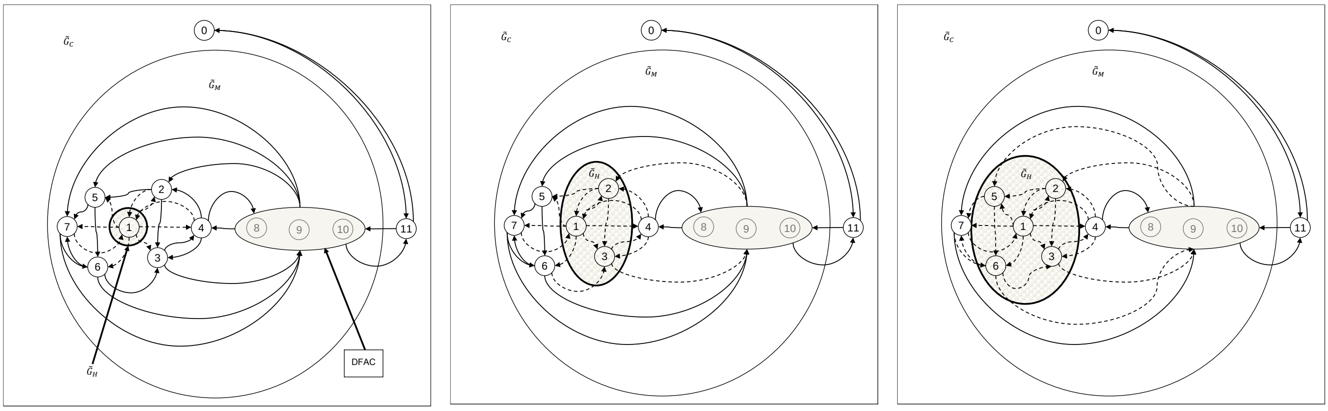
Hot area consists of nodes $\left(\widetilde{\mathrm{N}}_{\mathrm{H}}\right)$ that represent places $(\mathrm{N}_{\mathrm{H}_{\mathrm{t}}})$ where contaminated survivors are gathered to be evacuated and arcs $\left(\widetilde{\mathrm{A}}_{\mathrm{H}}\right)$ that represent roads which connect these places and are used by vehicles. This area is symbolized $\widetilde{\mathrm{G}}_{\mathrm{H}}=\left(\widetilde{\mathrm{N}}_{\mathrm{H}},\widetilde{\mathrm{A}}_{\mathrm{H}}\right)$ as network representation. Mild area consists of nodes $\left(\widetilde{\mathrm{N}}_{\mathrm{M}}\right)$ which represent mild nodes $(\mathrm{N}_{\mathrm{M}_{\mathrm{t}}})$ and candidate places $(\mathrm{N}_{\mathrm{D}})$ where DFACs are established and arcs $\left(\widetilde{\mathrm{A}}_{\mathrm{M}}\right)$ that represent roads which connect these places and are used by vehicles. This area is symbolized $\widetilde{\mathrm{G}}_{\mathrm{M}}=\left(\widetilde{\mathrm{N}}_{\mathrm{M}},\widetilde{\mathrm{A}}_{\mathrm{M}}\right)$ as network representation. Cold area consists of nodes $\left(\widetilde{\mathrm{N}}_{\mathrm{C}}\right)$ which represent places where AAs are established and arcs $\left(\widetilde{\mathrm{A}}_{\mathrm{C}}\right)$ that represent roads which connect these places and are used by vehicles. This area is symbolized $\widetilde{\mathrm{G}}_{\mathrm{C}}=\left(\widetilde{\mathrm{N}}_{\mathrm{C}},\widetilde{\mathrm{A}}_{\mathrm{C}}\right)$ as network representation. Three networks and dashed arcs consist of network $\widetilde{\mathrm{G}}=(\widetilde{\mathrm{N}},\widetilde{\mathrm{A}})$ in Figure 3.

We revised the network $\widetilde{G} = (\widetilde{N}, \widetilde{A})$ with the intention of modeling. In the network, a DFAC is represented with three nodes, n_{D_1}, n_{D_2}, and n_{D_3}. n_{D_1} is a node for predecon staging area (contaminated vehicles use these nodes for parking as well) in the mild area. n_{D_2} is a node for DFACs. n_{D_3} is a node for postdecon AA. The set of all nodes of type $n_{D_1}, n_{D_2}, and\ n_{D_3}$ is denoted as N_{D_1}, N_{D_2}, and N_{D_3} respectively.

In addition to these, we add a super node n_{dummy} and directed arcs in the form of $(n_{dummy,} n_j)$ and $(n_{dummy,} n_j)$ for every n_j ($n_j \in N_C$). The super node is a virtual pool where all vehicles are assumed to gather in the beginning of evacuation and where all survivors are assumed to gather at the end of evacuation. The super node ensures that all the vehicles to be used are drawn from n_{dummy} via arc $(n_{dummy,} n_j)$. The resulting network is $G = (N, A)$ as in Figure 3.

The evacuees are classified into s types, namely, ambulants (a) and non-ambulants (n). How many of each type of evacuee to be moved from each node i, $Ssup_{is}$, is known priory. The available number of vehicles of each type v at node i, $Vsup_{iv}$, is also known. Evacuees must be coupled with vehicles of appropriate type, i.e., vehicles of type $v \in V_s$ that can carry evacuees of type s, to move between all nodes except decontamination nodes. Each vehicle type v has a capacity $VCap_v$ It takes $ttrv_{ijv}$ units of time for a vehicle type to traverse an arc (i,j).

There are two types of flows in the model. These are survivors and vehicles. Survivors cannot move between nodes without vehicles except among decontamination nodes. Therefore, survivors are coupled with vehicles while moving from one node to another. In the beginning, empty vehicles move from super node (n_{dummy}) to parking nodes ($j \in N_C$). After that, evacuation starts. Then, empty vehicles move to nodes where non-contaminated survivors wait to be evacuated. Empty vehicles which parked at nodes of N_{D_1} are considered as contaminated and they only carry contaminated survivors. Evacuation of contaminated survivors is out of scope of this study. After vehicles are coupled with survivors, they are considered as loaded and they carry non-contaminated survivors to nodes $j \in (N_{M_t} \cup N_{D_3} \cup N_C)$.



(a) (b) (c)

Figure 3. Phases After Chemical Agent Used.

To formulate the problem, a time-dynamic integer programming model is developed. The planning horizon consists of T time periods. A minimum amount of time, $tmin$ may be needed for the evacuation to start. $tchng_l$ represents lth changes of the state of the network. Accordingly, time related sets are defined as shown below.

$$T\underline{min} = \{t: t \in T \ and \ t < tmin\}$$

$$T\overline{min} = \{t: t \in T \ and \ t \geq tmin\}$$

$$T\underline{chng} = \{t: t \in T \ and \ tmin \leq t < tchng_l\} \quad l: 1$$

$$Tchng_l = \{t: t \in T \ \ and \ tchng_l \leq t < tchng_{l+1}\} \quad l: 1, \dots, m-1$$

$Tend = \{t: t \in T \ and \ t = tend\}$

$$t - ttrv_{jiv} \geq \begin{cases} tmin, & t < tchng_1 \\ tchng_l, & t \geq tchng_l \end{cases}$$

$tbef = t \quad \left(t \in T \ and \ tmin + ttrv_{jiv} \leq t < tchng_l + ttrv_{jiv}\right)$

$$tchng_0 = tmin$$

Evacuation planning model includes decisions such as (1) routing survivors from mild area to AAs and from AAs to super node, (2) determining the number of vehicles used for evacuation in different areas, (3) determining capacities of AAs, (4) choosing suitable nodes among candidate nodes to locate DFACs. Now, we give the formulation of the model.

Formulation of the Model

Decision Variables

SQ_{ist} The number of type *s* survivors presents at node *i* at time *t*.

DX_{ijsvt} The number of type *s* survivors start traveling from node *i* to node *j* at time *t* (it shows either contaminated survivors or decontaminated/non-contaminated survivors.).

VQ_{ivt} The number of type *v* vehicles presents at node *i* at time *t*. $i \in (N_{D_1} \cup N_C \cup n_{dummy})$

CVE_{ijvt} The number of contaminated empty type *v* vehicles starts traveling from node *i* to node *j* at time *t*.

DVE_{ijvt} The number of non-contaminated empty type *v* vehicles starts traveling from node *i* to node *j* at time *t*.

DVL_{ijvt} The number of non-contaminated loaded type *v* vehicles starts traveling from node *i* to node *j* at time *t*.

Y_i 1, if DFAC is located at node i; 0, otherwise.

U_{it} 0, if there are survivors in node i of mild area at time t, 1, otherwise.

Objective function:

$$Maks\ Z = \sum_{i \in N_C, j \in n_{dummy}, s \in S, v \in V_s, t \in T\overline{min}} DX_{ijsvt} \tag{1}$$

Objective function ensures that the number of the non-contaminated survivors who are evacuated from AAs to super node is maximized.

Constraints for flow balance of survivors:

$$SQ_{ist} = Ssup_{is} \qquad \forall i \in N_H, \forall s \in S, \forall t \in T\underline{min} \tag{2}$$

$$SQ_{ist} - SQ_{is,t-1} = 0 \qquad \forall i \in N_{H_{tchng_0}}, \forall s \in S, \forall t \in T\underline{chng} \tag{3}$$

$$SQ_{ist} - SQ_{is,t-1} = 0 \qquad \forall i \in N_{H_{tchng_{l-1}}}, \forall s \in S, \forall t \in Tchng_l \tag{4}$$

$$SQ_{ist} - \sum_{j \in N_{M_{tbef-ttrv_{jiv}}}, v \in V_s} DX_{jisv,tbef-ttrv_{jiv}} - SQ_{is,t-1} = 0$$

$$\forall i \in (N_{H_t} \cap N_{M_{tghng_{l-1}}}), j \neq i, \forall s \in S, \forall t \in Tchng_l \tag{5}$$

$$SQ_{ist} = Ssup_{is} \qquad \forall i \in N_{M_t}, \forall s \in S, \forall t \in T\underline{min} \tag{6}$$

$$SQ_{ist} + \sum_{j \in (N_{M_t} \cup N_{D_3} \cup N_C), v \in V_s} DX_{ijsvt} - \sum_{j \in \left(N_{M_{t-ttrv_{jiv}}} \cup N_{D_3}\right), v \in V_s} DX_{jisv,t-ttrv_{jiv}} - SQ_{is,t-1} = 0$$
$$\forall i \in N_{M_t}, j \neq i, \forall s \in S, \forall t \in T\underline{chng} \tag{7}$$

$$SQ_{ist} + \sum_{j \in (N_{M_t} \cup N_{D_3} \cup N_C), v \in V_s} DX_{ijsvt} - \sum_{j \in \left(N_{M_{t-ttrv_{jiv}}} \cup N_{D_3}\right), v \in V_s} DX_{jisv,t-ttrv_{jiv}} -$$
$$\sum_{j \in (N_{M_{tbef-ttrv_{jiv}}} \cup N_{D_3}), v \in V_s} DX_{jisv,tbef-ttrv_{jiv}} - SQ_{is,t-1} = 0 \quad \forall i \in N_{M_t}, j \neq i, \forall s \in S, \forall t \in Tchng_l \tag{8}$$

$$\sum_{j \in n_{dummy}, v \in V_s} DX_{ijsvt} - \sum_{j \in \left(N_{M_{t-ttrv_{jiv}}} \cup N_{D_3}\right), v \in V_s} DX_{jisv,t-ttrv_{jiv}} = 0 \quad \forall i \in N_C, \forall s \in S, \forall t \in T\underline{chng} \tag{9}$$

$$\sum_{j \in n_{dummy}, v \in V_s} DX_{ijsvt} - \sum_{j \in \left(N_{M_{t-ttrv_{jiv}}} \cup N_{D_3}\right), v \in V_s} DX_{jisv,t-ttrv_{jiv}} -$$
$$\sum_{j \in (N_{M_{tbef-ttrv_{jiv}}} \cup N_{D_3}), v \in V_s} DX_{jisv,tbef-ttrv_{jiv}} = 0 \qquad \forall i \in N_C, \forall s \in S, \forall t \in Tchng_l \tag{10}$$

$$SQ_{ist} = 0 \qquad \forall i \in N_{D_3}, \forall s \in S, \forall t \in T\underline{min} \tag{11}$$

$$SQ_{ist} + \sum_{j \in (N_{M_t} \cup N_C), v \in V_s} DX_{ijsvt} - \sum_{j \in N_{M_{t-ttrv_{jiv}}}, v \in V_s} DX_{jisv,t-ttrv_{jiv}} - SQ_{is,t-1} = 0$$
$$\forall i \in N_{D_3}, \forall s \in S, \forall t \in T\underline{chng} \tag{12}$$

$$SQ_{ist} + \sum_{j \in (N_{M_t} \cup N_C), v \in V_s} DX_{ijsvt} - \sum_{j \in N_{M_{t-ttrv_{jiv}}}, v \in V_s} DX_{jisv,t-ttrv_{jiv}} -$$
$$\sum_{j \in (N_{M_{tbef-ttrv_{jiv}}} \cup N_{D_3}), v \in V_s} DX_{jisv,tbef-ttrv_{jiv}} - SQ_{is,t-1} = 0 \qquad \forall i \in N_3, \forall s \in S, \forall t \in Tchng_l \tag{13}$$

$$SQ_{ist} = 0 \qquad \forall i \in n_{dummy}, \forall s \in S, \forall t \in T\underline{min} \tag{14}$$

$$SQ_{ist} - \sum_{j \in N_C, v \in V_s} DX_{jisv,t-ttrv_{jiv}} - SQ_{is,t-1} = 0 \qquad \forall i \in n_{dummy}, \forall s \in S, \forall t \in T\overline{min} \tag{15}$$

Constraints (2) – (15) are flow balance constraints for evacuees. Constraints (2), (6), (11), and (14) set the the number of evacuees at the nodes to their initial values. Constraints (3), (4) and (5) are flow balance constraints at the nodes that represent hot nodes at each time period. Constraints (7) and (8) are flow balance constraints at the nodes that represent mild nodes at each time period. Constraints (9) and (10) are flow balance constraints at the nodes that represent cold nodes at each time period. Constraints (12) and (13) are flow balance constraints at the nodes that represent postdecon nodes at each time period. Constraint (15) is flow balance constraint at the node that represents super node at each time period.

Constraints for flow balance of vehicles:

$$VQ_{ivt} = Vsup_{iv} \qquad \forall i \in n_{dummy}, \forall v \in V, \forall t \in T\underline{min} \tag{16}$$

$$VQ_{ivt} - \sum_{j \in N_C} DVE_{ijvt} - VQ_{iv,t-1} = 0 \qquad \forall i \in n_{dummy}, \forall v \in V, \forall t \in T\overline{min} \tag{15}$$

$$\sum_{j \in (N_{H_t} \cup N_{D_1} \cup N_{M_t})} CVE_{ijvt} - \sum_{j \in \left(N_{H_{t-ttrv_{jiv}}} \cup N_{M_{t-ttrv_{jiv}}}\right)} CVE_{jiv,t-ttrv_{jiv}} = 0$$
$$\forall i \in N_{H_{tchng_{l}-1}}, j \neq i, \forall v \in V, \forall t \in Tchng_l \tag{18}$$

$$\sum_{j \in \left(N_{H_t} \cup N_{D_1} \cup N_{M_t}\right)} CVE_{ijvt} - \sum_{j \in \left(N_{H_{t-ttrv_{jiv}}} \cup N_{M_{t-ttrv_{jiv}}}\right)} CVE_{jiv,t-ttrv_{jiv}} -$$
$$\sum_{j \in (N_{M_{tbef-ttrv_{jiv}}} \cup N_{D_3} \cup N_C)} DVE_{jiv,tbef-ttrv_{jiv}} - \sum_{j \in (N_{M_{tbef-ttrv_{jiv}}} \cup N_{D_3})} DVL_{jiv,tbef-ttrv_{jiv}} = 0$$

$$\forall i \in \left(N_{H_t} \cap N_{M_{tchng_l-1}}\right), j \neq i, \forall v \in V, \forall t \in Tchng_l \qquad (19)$$

$$\sum_{j\in(N_{M_t}\cup N_{D_3}\cup N_C)} DVE_{ijvt} + \sum_{j\in(N_{M_t}\cup N_{D_3}\cup N_C)} DVL_{ijvt} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\cup N_C\right)} DVE_{jiv,t-ttrv_{jiv}} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\right)} DVL_{jiv,t-ttrv_{jiv}} = 0 \qquad \forall i \in N_{M_t}, j \neq i, \forall v \in V, \forall t \in T\underline{chng} \qquad (20)$$

$$\sum_{j\in(N_{M_t}\cup N_{D_3}\cup N_C)} DVE_{ijvt} + \sum_{j\in(N_{M_t}\cup N_{D_3}\cup N_C)} DVL_{ijvt} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\cup N_C\right)} DVE_{jiv,t-ttrv_{jiv}} - \sum_{j\in(N_{M_{tbef-ttrv_{jiv}}}\cup N_{D_3}\cup N_C)} DVE_{jiv,tbef-ttrv_{jiv}} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\right)} DVL_{jiv,t-ttrv_{jiv}} - \sum_{j\in(N_{M_{tbef-ttrv_{jiv}}}\cup N_{D_3})} DVL_{jiv,tbef-ttrv_{jiv}} = 0 \qquad \forall i \in \left(N_{H_t} \cap N_{M_{tchng_l-1}}\right), j \neq i, \forall v \in V, \forall t \in Tchng_l \qquad (21)$$

$$\sum_{j\in(N_{H_t}\cup N_{D_1}\cup N_{M_t})} CVE_{ijvt} - \sum_{j\in\left(N_{H_{t-ttrv_{jiv}}}\cup N_{M_{t-ttrv_{jiv}}}\right)} CVE_{jiv,t-ttrv_{jiv}} = 0 \qquad \forall i \in N_{M_t}, j \neq i, \forall v \in V, \forall t \in Tchng_l \qquad (22)$$

$$\sum_{j\in\left(N_{H_{t-ttrv_{jiv}}}\cup N_{M_{t-ttrv_{jiv}}}\right), v\in V_S} CVE_{jiv,t-ttrv_{jiv}} \leq M * U_{it} \qquad \forall i \in N_{M_t}, j \neq i, \forall t \in Tchng_l \qquad (23)$$

$$\sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\cup N_C\right), v\in V_S} DVE_{jiv,t-ttrv_{jiv}} - \sum_{j\in(N_{M_{tbef-ttrv_{jiv}}}\cup N_{D_3}\cup N_C), v\in V_S} DVE_{jiv,tbef-ttrv_{jiv}} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\right), v\in V_S} DVL_{jiv,t-ttrv_{jiv}} - \sum_{j\in(N_{M_{tbef-ttrv_{jiv}}}\cup N_{D_3}), v\in V_S} DVL_{jiv,tbef-ttrv_{jiv}} \leq M * (1 - U_{it}) \qquad \forall i \in N_{M_t}, j \neq i, \forall t \in Tchng_l \qquad (24)$$

$$U_{i,t-1} \leq U_{it} \qquad \forall i \in N_{M_t}, \forall t \in Tchng_l \qquad (25)$$

$$\sum_{j\in(N_{M_t}\cup N_C)} DVE_{ijvt} + \sum_{j\in(N_{M_t}\cup N_C)} DVL_{ijvt} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_C\right)} DVE_{jiv,t-ttrv_{jiv}} - \sum_{j\in N_{M_{t-ttrv_{jiv}}}} DVL_{jiv,t-ttrv_{jiv}} = 0 \qquad \forall i \in N_{D_3}, \forall v \in V, \forall t \in T\underline{chng} \qquad (26)$$

$$\sum_{j\in(N_{M_t}\cup N_C)} DVE_{ijvt} + \sum_{j\in(N_{M_t}\cup N_C)} DVL_{ijvt} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_C\right)} DVE_{jiv,t-ttrv_{jiv}} - \sum_{j\in(N_{M_{tbef-ttrv_{jiv}}}\cup N_C)} DVE_{jiv,tbef-ttrv_{jiv}} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\right)} DVL_{jiv,t-ttrv_{jiv}} - \sum_{j\in(N_{M_{tbef-ttrv_{jiv}}})} DVL_{jiv,tbef-ttrv_{jiv}} = 0 \qquad \forall i \in \left(N_{D_3} \cap N_{M_{tchng_l-1}}\right), \forall v \in V, \forall t \in Tchng_l \qquad (27)$$

$$VQ_{ivt} = 0 \qquad \forall i \in N_{D_1}, \forall v \in V, \forall t \in T\underline{min} \qquad (28)$$

$$VQ_{ivt} - VQ_{iv,t-1} = 0 \qquad \forall i \in N_{D_1}, \forall v \in V, \forall t \in T\underline{chng} \qquad (29)$$

$$VQ_{ivt} - \sum_{j\in\left(N_{H_{t-ttrv_{jiv}}}\cup N_{M_{t-ttrv_{jiv}}}\right)} CVE_{jiv,t-ttrv_{jiv}} - VQ_{iv,t-1} = 0 \qquad \forall i \in N_{D_1}, \forall v \in V, \forall t \in Tchng_l \qquad (30)$$

$$VQ_{ivt} = 0 \qquad \forall i \in N_C, \forall v \in V, \forall t \in T\underline{min} \qquad (31)$$

$$VQ_{ivt} + \sum_{j\in(N_{M_t}\cup N_{D_3})} DVE_{ijvt} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\cup n_{dummy}\right)} DVE_{jiv,t-ttrv_{jiv}} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\right)} DVL_{jiv,t-ttrv_{jiv}} - VQ_{iv,t-1} = 0 \qquad \forall i \in N_C, \forall v \in V, \forall t \in T\underline{chng} \qquad (32)$$

$$VQ_{ivt} + \sum_{j\in(N_{M_t}\cup N_{D_3})} DVE_{ijvt} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\cup n_{dummy}\right)} DVE_{jiv,t-ttrv_{jiv}} - \sum_{j\in(N_{M_{tbef-ttrv_{jiv}}}\cup N_{D_3}\cup n_{dummy})} DVE_{jiv,tbef-ttrv_{jiv}} - \sum_{j\in\left(N_{M_{t-ttrv_{jiv}}}\cup N_{D_3}\right)} DVL_{jiv,t-ttrv_{jiv}} -$$

$$\sum_{j\in(N_{M_{tbef-ttrv_{jiv}}}\cup N_{D_3})} DVL_{jiv,tbef-ttrv_{jiv}} - VQ_{iv,t-1} = 0 \qquad \forall i \in N_C, \forall v \in V, \forall t \in Tchng_l \qquad (33)$$

$$\sum_{i\in(N_{D_1}\cup N_C)} VQ_{ivt} - \sum_{i\in n_{dummy}, j\in N_C, t_c\in \overline{Tmin}} DVE_{ijv,t_c} = 0 \qquad v \in V, t \in Tend \qquad (34)$$

Constraints (16) – (34) are flow balance constraints for vehicles. Constraints (16), (28), and (31) set the the number of vehicles at the nodes to their initial values. At the beginning of the evacuation, all vehicles are at the dummy node. Constraint (17) is flow balance constraint for vehicles at dummy node at each time period. Constraints (18) and (19) are flow balance constraints for vehicles at hot nodes, at each time period. Constraints (20) and (21) are flow balance constraints for non-contaminated vehicles at mild nodes, at each time period. Constraint (22) is flow balance constraint for contaminated vehicles at mild nodes, at each time period. Constraints (23), (24), and (25) prevent non-contaminated vehicles use mild nodes which are contaminated by contaminated vehicles. Constraints (26) and (27) are flow balance constraints for vehicles at postdecon nodes, at each time period. Constraints (29) and (30) are flow balance constraints for contaminated vehicles at predecon nodes, at each time period. Constraints (32) and (33) are flow balance constraints for vehicles at cold nodes, at each time period. Constraint (34) ensures that all vehicles drawn from the dummy node are at the predecon and cold nodes (parking places for vehicles) in the last period. Note that this set of constraints ensures that contaminated (non-contaminated) vehicles are used only in contaminated (non-contaminated) parts of the network.

Constraints for coupling vehicles and survivors:

$$\sum_{s\in S} DX_{ijsvt} \le VCap_v * DVL_{ijvt}$$
$$\forall i \in (N_{M_t} \cup N_{D_3}), \forall i \in (N_{M_t} \cup N_{D_3} \cup N_C), i \ne j, \forall v \in V_s, \forall t \in T\underline{chng} \qquad (35)$$

$$\sum_{s\in S} DX_{ijsvt} \le VCap_v * DVL_{ijvt}$$
$$\forall i \in (N_{M_t} \cup N_{D_3}), \forall i \in (N_{M_t} \cup N_{D_3} \cup N_C), i \ne j, \forall v \in V_s, \forall t \in Tchng_l \qquad (36)$$

$$\sum_{s\in S} DX_{ijsvt} + (VCap_v - 1) \le VCap_v * DVL_{ijvt}$$
$$\forall i \in (N_{M_t} \cup N_{D_3}), \forall i \in (N_{M_t} \cup N_{D_3} \cup N_C), i \ne j, \forall v \in V_s, \forall t \in T\underline{chng} \qquad (37)$$

$$\sum_{s\in S} DX_{ijsvt} + (VCap_v - 1) \le VCap_v * DVL_{ijvt}$$
$$\forall i \in (N_{M_t} \cup N_{D_3}), \forall i \in (N_{M_t} \cup N_{D_3} \cup N_C), i \ne j, \forall v \in V_s, \forall t \in Tchng_l \qquad (38)$$

Constraints (35) and (36) require that sufficient number of (loaded) vehicles be assigned to carry evacuees on the arcs when they move. Constraints (37) and (38) prevent loaded vehicles from moving when evacuees are not assigned. Moreover, this set of constraints ensures that minimum number of vehicles be assigned to carry evacuees on the move.

Location decisions for DFAC:

$$\sum_{i\in N_{D_1}} Y_i = k \qquad (39)$$

$$\sum_{j\in\left(N_{H_{t-ttrv_{jiv}}}\cup N_{M_{t-ttrv_{jiv}}}\right)} CVE_{jiv,t-ttrv_{jiv}} \le (Y_i * \sum_{j\in n_{dummy}} Vsup_{jv}) \quad \forall i \in N_{D_1}, \forall v \in V, \forall t \in Tchng_l \quad (40)$$

Constraint (39) sets the number of DFACs to be located to k. Constraint (40) allows the flows of empty vehicles to a predecon staging area only if a facility is located (DFAC is open) at the associated point.

Non-negativity constraints:

$SQ, DX, VQ, CVE, DVE, DVL$ are positive integer and Y, U are binary variables. (41)

Constraint (41) defines decision variables.

COMPUTATIONAL RESULTS

The tests are carried out on a PC with Intel® Core™ i5-2410M CPU and 4 GB RAM personal computer. The model is coded with GAMS 22.3 and solved by using CPLEX 10.1. Problems are constructed by changing the number of nodes in hot area and mild area. There are 520 survivors to be evacuated. Survivors can be carried by vehicles of capacity 5. Planning horizon includes 50 time periods. One DFAC is to be located among two candidate places. The characteristics of test problems are given in Table 1.

Results of the test problems are given in the last two columns of Table 1. Last two columns show the number of survivor who are rescued and the number of contaminated survivors. According to the number of contaminated survivors, we can determine the number of vehicles which are allocated to contaminated area in order to evacuate contaminated survivors to DFAC. We can understand how many vehicles are needed in order to evacuate all survivors before getting contaminated. On the other hand even we increase the number of vehicles, maybe vehicles cannot arrive in some nodes before they become contaminated because of the speed of dispersion.

Id.	t	tchng(0)	$H_{tchng(0)}$	tchng(1)	$H_{tchng(1)}$	tchng(2)	$H_{tchng(2)}$	# of Rescued Survivors	# of Contaminated Survivors
1.	50	2	1	5	1,2	10	1,2,3	380	140
2.	50	2	1	5	1,3	10	1,2,3	390	130
3.	50	2	1	5	1,2,3	10	1,2,3,4,5	300	220
4.	50	2	1	5	1,4,5	10	1,2,3,4,5	365	155
5.	50	2	1	5	1,2,3	10	1,2,3,5,6	300	220
6.	50	2	1	5	1,5,6	10	1,2,3,5,6	315	205

Table 1. Characteristics and Results of Test Problems

CONCLUSION

In this study, a MILP formulation of evacuating the units from military installations is proposed in order to save the units from the effects of chemical hazard. The proposed model presents how many vehicles are used for evacuation in different areas, what are the capacities of AAs, which node is suitable among candidate nodes to locate DFACs. The proposed model is tested using 6 generated problems solved with CPLEX-based branch-and-bound algorithm to understand the performance of the model. We built a model with the purpose of helping managers plan and execute disaster relief operations under the threat of chemical hazards. This model can be applied to evacuate people around chemical facilities/chemical spills from tanker accidents in rural areas.

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A MIXED INTEGER LINEAR PROGRAMMING MODEL TO A VARIANT OF HETEROGENEOUS VEHICLE ROUTING PROBLEM WITH FUEL STATIONS

Batuhan Eren Engin[1], İsmail Karaoglan, Turan Paksoy

Abstract *− As the global warming threatens the earth at unprecedented pace, retaining control on one of the major contributors to global warming, i.e. carbon emission through transportation, is of great importance today. By new regulations concerning the carbon emission, logistic firms are required to decrease their carbon footprint. One way to decrease the carbon emission for logistics firms is to employ alternative fuel vehicles on delivery. In this regard, it is intended to extend vehicle routing problem by allowing the companies to use alternative fuel vehicles alongside with the conventional vehicles, which have different fuel tank capacity, velocity and fuel consumption rate. The exact solution approach to the model developed is based on CPLEX ILOG Callable library.*

Keywords − Alternative fuel vehicles, Fuel stations, Heterogeneous fleet, Vehicle velocity and fuel consumption rate

INTRODUCTION

The classical vehicle routing problem (VRP) was first proposed by [1] in which each vehicle in the fleet is assigned a route to serve a set of customers under given customer demands. Since then, many variants of this optimization problem have been developed and added to the literature by researchers, such as VRP with pickup and delivery, or VRP with time windows in which the customers need to be served in a specified time interval, or Capacitated VRP in which a homogeneous fleet of vehicles with specified capacity is concerned.

More recently, growing concerns about global warming have driven the governments to put legislations into place about limiting carbon emission through transportation. Therefore, the logistic enterprises are required to employ some low-range alternative fuel vehicles to cut down on their carbon emission. Since it would require tremendous capital to re-new the fleet with AFVs, companies tend to operate different type of vehicles together. This practice in real world brought out the new variant of VRP to be investigated, i.e. Heterogeneous VRP (HVRP). In HVRP, vehicles in a fleet can have different characteristics such as capacity for goods, fuel tank capacity and velocity or fuel consumption rate per one unit of distance.

This paper deals with heterogeneous vehicle routing problem (HVRP) in which two different type of vehicle are used to serve the customers that differ in the ability to refuel at fueling stations, i.e. an alternative fuel vehicle (AFV) that can re-fuel en route and a conventional vehicle (CV) that cannot make use of fuel stations. A CV has a bigger fuel tank capacity, higher velocity and fuel consumption rate over an AFV. The problem is to determine the minimum required number of each type of vehicles and their routes so as to minimize the total transportation cost subject to the following assumptions:

- Depot cannot serve as fuel station.
- Each vehicle is used for at most one route.
- Each route starts and ends at the depot.
- Each customer is served by exactly one vehicle.
- The duration of a route by a vehicle cannot exceed T_{max}.
- A Fuel station can be visited by an AFV one more once.
- A conventional vehicle cannot use fuel stations.
- The number of available vehicles for each type is predetermined.

Related Work

Since our study allow the alternative fuel vehicles to refuel at fuel stations, investigating the literature on VRP with fuel station, electric VRP or Green VRP (G-VRP) is also needed. [2] formulated G-VRP as mixed integer

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linear program (MILP) to provide a framework for the organizations with AFVs with limited vehicle driving range and refueling infrastructure. G-VRP involves assigning a route to a set of vehicle starting from the depot and visiting a set of customers within a pre-specified time limit and assuring of returning to the depot without exceeding the vehicle's driving range that depends on fuel tank capacity. Each tour may include a visit to one or more AFSs for refueling en route. To the best of our knowledge, as they also claimed, [2] is the first to combine VRP with the possibility of refueling a vehicle at a station en route, which is referred as G-VRP. [3] considered Electric VRP with time windows and recharging stations in which the electric vehicles with limited freight capacity may visit available stations to recharge and customers need to be served in a given time windows. They presented a hybrid heuristic as a solution method on which the benchmark instances newly designed. [4] provided a different MILP formulation for the G-VRP with the same problem characteristics proposed by [2]. Some inequalities are strengthened through lifting and valid inequalities for the G-VRP are provided to be used in Branch and Cut (B&C) algorithm to increase the performance of algorithms significantly as reported in [4]. They incorporated a Simulated Annealing (SA) algorithm to improve the quality of the solutions. They compared the performance of their MIP formulation to the MILP proposed in [2] and reported that their formulation provides better results than [2] for all instances. And some other works addressing the locating the fuel stations for refueling infrastructure can be found in [5] and [6].

Regarding the heterogeneous fleet VRP; [7] proposed a heuristic column generation for the VRP with a heterogeneous fleet of vehicles, in which the vehicles have different capacity and cost, also the number of vehicles of any type vary. It is reported that the numerical result provide robust result particularly for medium and large size problem instances. [8] dealt with Fleet Size and Mix VRP with backhauls in which there are different type of vehicles with different fixed and running costs. In their study, pick-up task is considered after the delivery and no-route is allowed with only pick-up task. They proposed integer linear programming model for the problem in hand which provides optimal solution for small size instances, and Set Partitioning problem based heuristic for large size ones. [9] considered the fleet size and mixed VRP with time windows and split deliveries in which each customer can be served by more than one vehicle and must be served within a given time windows using a heterogeneous fleet. They proposed a heuristic to solve the benchmark instances.

To the best of our knowledge, it appears that the heterogeneous VRP in which only a type of vehicle among both types is allowed to refuel have not been studied yet. In this regard, it is intended to provide a mixed integer linear programming model to obtain optimal solutions to aid organizations using heterogeneous fleet as such. MILP model is tested on a real world data set and an example of a solution is also included.

Problem definition and formulation for the HVRP variant

Our variant of HVRP is defined as serving the customer, $N_C = \{n_1, n_2, .., n_c\}$ with a limited number of AFV and CV available at the depot with fuel tank capacity Q^{afv} and Q^{cv}, fuel consumption rate r^{afv} and r^{cv}, and velocity sp^{afv} and sp^{cv}, respectively. Each route must start and end at the depot, denoted as "0". Each pair of travel from vertex i to vertex j is associated with a nonnegative distance d_{ij} and travel times t_{ij}^{afv} and t_{ij}^{cv} calculated as follows:

$$t_{ij}^{afv} = p_i + d_{ij}/\, sp^{afv} \quad \forall i,j \in (0 \cup N_c);\ \ i \neq j \tag{1}$$

$$t_{ij}^{cv} = p_i + d_{ij}/\, sp^{cv} \quad \forall i,j \in (0 \cup N_c);\ \ i \neq j \tag{2}$$

where p_i denotes the service time at customer locations and fuel stations, which are taken constant as 30 minutes and 15 minutes respectively. Two parameters which are indirect distance d_{ijk} and indirect travel time t_{ijk}^{afv} are introduced as in [4], calculated as below:

$$d_{ijk} = d_{ik} + d_{kj} \quad \forall i,j \in (0 \cup N_c);\ \forall \mathrm{k} \in \mathrm{F};\ \ i \neq j \tag{3}$$

$$t_{ijk}^{afv} = p_i + p_k + \left(d_{ijk}/\, sp^{afv}\right) \quad \forall i,j \in (0 \cup N_c);\ \forall \mathrm{k} \in \mathrm{F};\ \ i \neq j \tag{4}$$

Since only AFVs can travel from one vertex to another through the fuel stations, the indirect travel time and indirect distance are only associated with AFVs. Based on these definitions, the decision variables and the formulation are presented below:

Decision variables:

X_{ij} Binary variable equal to 1 if a CV travels from node *i* to node *j* directly, otherwise 0, $\left(\forall i, j \in (0 \cup N_c)\right)$
Y_{ij} Binary variable equal to 1 if an AFV travels from node *i* to node *j* directly, otherwise 0, $\left(\forall i, j \in (0 \cup N_c)\right)$
Z_{ijk} Binary variable equal to 1 if an AFV travels from node *i* to node *j* through fuel station *k*, otherwise 0, $(\forall i, j \in (0 \cup N_c); \quad \forall k \in F)$
τ_i Arrival time of a vehicle at node *i*
f_i^{cv} Fuel level variable of a CV specifying the remaining tank fuel level upon arrival at node *i*,
f_i^{afs} Fuel level variable of an AFV specifying the remaining tank fuel level upon arrival at node *i*,

The mathematical formulation of our HVRP variant is as follows:

$$\min \sum_{i,j \in (0 \cup N_c)} d_{ij} X_{ij} + \sum_{i,j \in (0 \cup N_c)} d_{ij} Y_{ij} + \sum_{i,j \in (0 \cup N_c)} \sum_{k \in F} d_{ijk} Z_{ijk} \tag{5}$$

s.t:

$$\sum_{i \in (0 \cup N_c)} \left(X_{ij} + Y_{ij} + \sum_{k \in F} Z_{ijk} \right) = 1 \quad \forall j \in N_c \tag{6}$$

$$\sum_{j \in (0 \cup N_c)} \left(X_{ij} - X_{ji} \right) = 0 \quad \forall i \in (0 \cup N_c) \tag{7}$$

$$\sum_{j \in (0 \cup N_c)} \left(Y_{ij} - Y_{ji} + \sum_{k \in F} \left(Z_{ijk} - Z_{jik} \right) \right) = 0 \quad \forall i \in (0 \cup N_c) \tag{8}$$

$$\sum_{j \in N_c} X_{0j} \le m_{CV} \tag{9}$$

$$\sum_{j \in (0 \cup N_c)} \left(Y_{0j} + \sum_{k \in F} Z_{0jk} \right) \le m_{AFV} \tag{10}$$

$$\sum_{i \in N_c} X_{i0} \le m_{CV} \tag{11}$$

$$\sum_{i \in N_c} \left(Y_{i0} + \sum_{k \in F} Z_{i0k} \right) \le m_{AFV} \tag{12}$$

$$\tau_i - \tau_j + \left(T_{max} + t_{ij}^{cv}\right) X_{ij} + \left(T_{max} + t_{ij}^{afv}\right) Y_{ij} + \left(T_{max} + t_{ijk}^{afv}\right) Z_{ijk} \le T_{max} \quad \forall i, j \in N_c; \quad \forall k \in F \tag{13}$$

$$\tau_j \le T_{max} - \left(T_{max} - t_{0j}^{cv}\right) X_{0j} - \left(T_{max} - t_{0j}^{afv}\right) Y_{0j} - \sum_{k \in F} \left(T_{max} - t_{0jk}^{afv}\right) Z_{0jk} \quad \forall j \in N_c \tag{14}$$

$$\tau_i \leq T_{max} - t_{i0}^{cv} X_{i0} - t_{i0}^{afv} Y_{i0} - \sum_{k \in F} t_{i0k}^{afv} Z_{i0k} \quad \forall i \in N_c \tag{15}$$

$$f_j^{afv} - f_i^{afv} \leq Q^{afv}\left(1 - Y_{ij}\right) - r^{afv} d_{ij} Y_{ij} \quad \forall i, j \in N_c; \quad i \neq j \tag{16}$$

$$f_j^{afv} \leq Q^{afv} - r^{afv} d_{0j} Y_{0j} - \sum_{i \in (0 \cup N_c)} \sum_{k \in F} r^{afv} d_{kj} Z_{ijk} \quad \forall j \in N_c \tag{17}$$

$$f_i^{afv} \geq r^{afv} d_{i0} Y_{i0} + \sum_{j \in (0 \cup N_c)} \sum_{k \in F} r^{afv} d_{ik} Z_{ijk} \quad \forall i \in N_c \tag{18}$$

$$f_j^{cv} - f_i^{cv} \leq Q^{cv}\left(1 - X_{ij}\right) - r^{cv} d_{ij} X_{ij} \quad \forall i, j \in N_c; \quad i \neq j \tag{19}$$

$$f_j^{cv} \leq Q^{cv} - r^{cv} d_{0j} X_{0j} \quad \forall j \in N_c \tag{20}$$

$$f_i^{cv} \geq r^{cv} d_{i0} X_{i0} \quad \forall i \in N_c \tag{21}$$

$$\tau_i, f_i^{cv}, f_i^{afv} \geq 0 \tag{22}$$

$$X_{ij}, Y_{ij} \in \{0,1\} \quad \forall i, j \in (0 \cup N_c) \tag{23}$$

$$Z_{ijk} \in \{0,1\} \quad \forall i, j \in (0 \cup N_c); \ \forall k \in F \tag{24}$$

Objective function (5) seeks to minimize the total distance traveled by all vehicles. Equation (6) ensures that each customer is served exactly once and only by one vehicle. Equation (7) and (8) known as degree constraints and ensure that entering and leaving arcs to each node are equal. Equation (9) and (11) ensure that at most *m* conventional vehicles are routed out of the depot and return to the depot, while Equation (10) and (12) ensure that at most m alternative fuel vehicles are routed out the depot and return to the depot, respectively. Equation (13) along with Equations (16) and (19) eliminates the possibility of subtours. Equations (14) and (15) are used to bound the decision variable τ_i and therefore downsize the solution space. Equations (13), (14) and (15) ensure that each vehicle return to the depot before time T_{max}. Equation (16) determines the fuel level of an AFV upon arrival at a customer depending the fuel consumption between its predecessors. Equations (17) and (20) help to bound the fuel level variables for each vehicle type in order to reduce the solution space. Equation (18) ensures that the fuel level at each customer must be sufficient enough for an AFS to traverse to the depot or any Fuel stations. Equation (19) determines the fuel level of a CV upon arrival at a customer depending the fuel consumption between its predecessors. Equation (20) ensures that the fuel level at each customer must be sufficient enough for an AFS to traverse to the depot, as it is assumed that CVs cannot use fuel stations.

REAL WORLD CASE STUDY

The model is tested on real world data obtained from a logistic company based in Ankara, Turkey. The company owns a heterogeneous fleet, consisting of 2 AFVs and 3 CVs, to serve 20 customers located in nearby cities and towns. There are 3 fuel stations that AFVs can refuel at. 10 different cases are considered. An example to the geographic locations of each customer, fuel station and the depot from the instance S20c3U1 can be seen in Figure 1.

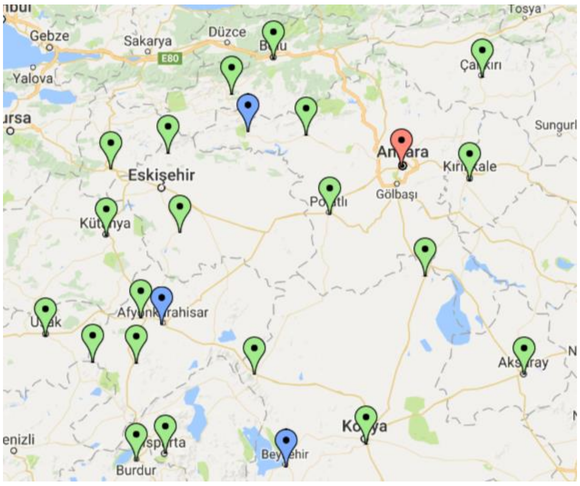

Figure 2. The geographic location of the depot (red), fuel stations (blue) and customers (green)

The exact approach is implemented using ILOG's Cplex Concert Technology (version 12.6) in Visual Studio environment in C# language. The optimal solutions for each case were found and the optimal solution to S1_20c3sU1 is visualized for instance as below:

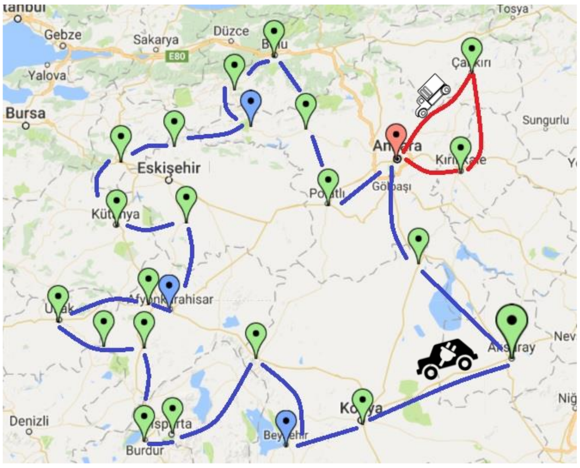

Figure 3. The visualization of an optimal solution to S1_20c3sU1 (blue lines traversed by an AFV, red lines by a CV)

Table 1 contains the total cost in miles and the number of used vehicles in optimal solutions to each given case.

Table 1. The optimal solutions to the cases

Instances	Exact Solution (in miles)	The number of used vehicles	Instances	Exact Solution (in miles)	The number of used vehicles
S1_20c3sU1	1741	CV=1; AFV=1	S1_20c3sU6	1587	AFV=2
S1_20c3sU2	1774	AFV=2	S1_20c3sU7	2157	AFV=2
S1_20c3sU3	2430	CV=1; AFV=1	S1_20c3sU8	2252	CV=1; AFV=1
S1_20c3sU4	1889	AFV=2	S1_20c3sU9	2098	AFV=2
S1_20c3sU5	1983	CV=1; AFV=1	S1_20c3sU10	1625	AFV=2

FUTURE WORK

In this paper, we have presented a mathematical formulation for a variant of HVRP that has never been studied in the literature, to the best of our knowledge. The problem is faced frequently in logistic industry in which agencies have heterogeneous fleet. Concerning the future work, a benchmark set can be generated and a B&C algorithm can be provided. For large size problem a heuristic can be developed and it can be incorporated into B&C algorithm to start the root search at a better lower bound.

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A TWO-PHASE SOLUTION APPROACH FOR ALLOCATION OF TEMPORARY DISASTER RESPONSE FACILITIES AND TRANSPORTATION PLANNING

Merve Kose-Kucuk[1], Fatih Cavdur [2], Asli Sebatli[3]

Abstract − *After the occurrence of a disaster, the first 72 hours is considered very crucial in general. It might not be possible for the governmental or central humanitarian organizations to reach the affected area in this time period due to various reasons, such as the potential damages to the infrastructures in the area. In this study, we consider the allocation of temporary-disaster-response (TDR) facilities which are planned to serve the disaster victims until the arrival of governmental or central humanitarian organizations as well as the transportation of relief supplies stored in these facilities. We propose a two-phase solution approach for the problems of facility allocation and transportation planning. In the first phase, allocation of TDR facilities is performed via a scenario-based integer programming model considering both the locations of the facilities and the distributions of the relief supplies stored in these facilities. In the second phase of our approach, we develop a transportation plan using an integer programming model to minimize the time (distance) to transport the required amounts of relief supplies. An earthquake case study is presented for the illustration of our approach where we represent the uncertainties about a possible earthquake via different disaster scenarios. The proposed approach involves two phases of disaster operations management as preparedness and response.*

Keywords − *disaster operations management, facility allocation, integer programming, relief supplies distribution, transportation planning*

INTRODUCTION

Increases in populations, infrastructure complexities combined with the fast and unplanned urbanizations, also increase the unwanted effects of disasters all around the world. The importance of Disaster Operations Management (DOM) studies is higher than ever recently since even a single disaster might cause loses of thousands of lives and billions of dollars of economic loses [6]. DOM is about the managerial activities performed before, during and after a disaster in order to reduce the unwanted effects of a disaster. It is noted that operations research/management science related studies represent an important part in DOM. A detailed classification of these can be found in [2] and [7].

Facility allocation is an important problem in DOM involving both pre- and post-disaster activities since it includes decisions about the locations of the facilities and the inventory levels of relief supplies in pre-disaster phase and the distributions of these relief supplies to disaster victims in post-disaster phase. There are many studies considering facility allocation in DOM literature, such as [27]-[19]-[3]-[29]-[14]-[20]-[24]-[8]-[12]-[21]-[22]-[15]-[17]-[23]-[11]. After the facility allocation decisions, another problem in post-disaster phase is planning the transportation of the relief supplies stored in these facilities to the neighborhoods in the affected area with minimum transportation time (distance) as in [4]-[18]-[28]-[1]-[25]-[16]-[26]. Consideration of uncertainties in facility allocation and transportation, makes it even harder to solve these problems involving uncertainties caused by various factors, such as the location and amount of demand, changes in link status and capacity of the transportation network, and damage level of supplies as in [20]-[16]-[21]-[26]-[17]-[13]. Studies considering uncertainties, such as [10]-[4]-[9]-[13], in general use methodologies of stochastic optimization via scenario analysis, simulation, fuzzy optimization, robust optimization, in some cases utilizing risk maps.

DOM activities are generally coordinated with some kind of governmental or central humanitarian organizations, such as the Federal Emergency Management Agency (FEMA) or the Red-Cross. In Turkey, we note that the corresponding organizations for such purposes are the Prime Ministry Disaster and Emergency Management Authority (AFAD) and the Turkish Red Crescent (TRC), respectively. On the other hand, it is noted that it might not always be possible for these organizations to reach the affected area right after the occurrence of a disaster (i.e., the first 72 hours) due to various reasons, such as the potential damages to the infrastructures in the area. It

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is therefore very important to provide the basic needs (i.e., relief supplies) of disaster victims in this critical time period using some temporary facilities. In this study, we consider the allocation of such facilities, so-called temporary-disaster-response (TDR) facilities, which are planned to serve the disaster victims until the arrival of governmental or central humanitarian organizations as well as the transportation of relief supplies stored in these facilities. Our solution approach includes two-phases. In the first phase, we propose a scenario-based integer programming model for TDR facility allocation and relief supplies distribution. In the second phase of our approach, we develop a transportation plan using an integer programming model to minimize the time (distance) to transport the required amounts of relief supplies.

METHODOLOGY

Solution Approach

In this study, we propose a two-phase solution approach for facility allocation and transportation planning. In the first phase, allocation of TDR facilities is performed via a scenario-based integer programming model considering the locations of the facilities as well as the distributions of the relief supplies stored in these facilities. In the second phase of our approach, we develop a transportation plan using an integer programming model to minimize the time (distance) to transport the required amounts of relief supplies. An earthquake case study is presented for the illustration of our approach where we represent the uncertainties about a possible earthquake via different disaster scenarios. The overall solution approach is shown in Figure 1.

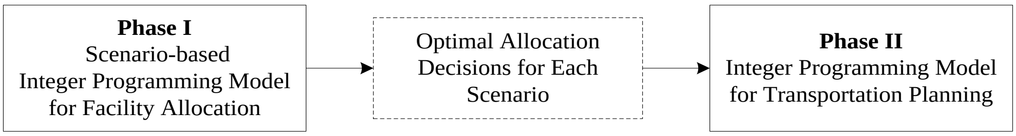

Figure 1. Overall Solution Approach

Scenario-Based Integer Programming Model for Facility Allocation and Relief-Supplies Distribution-Phase I

In the first phase, we minimize the total cost (distance) of distributing relief supplies and the total number of TDR facilities opened to ensure that the relief supplies demands of disaster victims are satisfied by the nearest neighborhoods in the distribution network with the minimum number of TDR facilities. We adapt the model from [6] with the following notation for a realization of disaster scenario s:

Indices:

i, j: neighborhood, $i, j = 1, \ldots, n_N$

k: relief supply type, $k = 1, \ldots, n_C$

Parameters:

$d_{jk}^{(s)}$: demand for relief supply of type k in neighborhood j for disaster scenario s

c_{ij}: cost (distance) between neighborhood i and j

v_k: unit volume of relief supply of type k

w_k: unit weight of relief supply of type k

V: volume capacity of a single TDR facility

W: weight capacity of single TDR facility

N_i: maximum number of TDR facilities for neighborhood i

N_T: total number of TDR facilities available

R_{pq}: supply-ratio between relief supplies of type p and q for a balanced distribution

S_i: safety level of neighborhood i

T: minimum required safety level (threshold) for a neighborhood

λ: scaling factor

Decision Variables

$z_i^{(s)}$: number of TDR facilities opened in neighborhood i for disaster scenario s

$x_{ijk}^{(s)}$: amount of relief supply of type k to be supplied by the facilities in neighborhood i for the disaster victims in the neighborhood j for disaster scenario s

$$y_{ij}^{(s)}: \begin{Bmatrix} 1, & \text{if neighborhood } i \text{ serves to neighborhood } j \text{ for disaster scenario } s \\ 0, & \text{otherwise} \end{Bmatrix}$$

Objective function:

$$\min \sum_{i=1}^{n_N} \sum_{j=1}^{n_N} \left(c_{ij} \left[\sum_{k=1}^{n_C} x_{ijk}{}^{(s)} \right] \right) + \lambda \left(\sum_{i=1}^{n_N} z_i{}^{(s)} \right) \tag{1}$$

Subject to:

$$\sum_{i=1}^{n_N} x_{ijk}{}^{(s)} \geq d_{jk}{}^{(s)}, \qquad \forall j, k \tag{2}$$

$$R_{pq} x_{ijp}{}^{(s)} = R_{pq} x_{ijq}{}^{(s)}, \qquad \forall i, j; \forall p, q \in k \tag{3}$$

$$\sum_{j=1}^{n_N} \sum_{k=1}^{n_C} v_k x_{ijk}{}^{(s)} \leq V z_i{}^{(s)}, \qquad \forall i \tag{4}$$

$$\sum_{j=1}^{n_N} \sum_{k=1}^{n_C} w_k x_{ijk}{}^{(s)} \leq W z_i{}^{(s)}, \qquad \forall i \tag{5}$$

$$z_i{}^{(s)} \leq N_i \left(\sum_{j=1}^{n_N} \sum_{k=1}^{n_C} w_k x_{ijk}{}^{(s)} \right), \qquad \forall i \tag{6}$$

$$\sum_{i=1}^{n_N} y_{ij}{}^{(s)} \leq \alpha, \qquad \forall j \tag{7}$$

$$\sum_{j=1}^{n_N} y_{ij}{}^{(s)} \leq \beta, \qquad \forall i \tag{8}$$

$$\sum_{k=1}^{n_C} x_{ijk}{}^{(s)} \leq M y_{ij}{}^{(s)}, \qquad \forall i, j \tag{9}$$

$$y_{ij}{}^{(s)} \leq \sum_{k=1}^{n_C} x_{ijk}{}^{(s)}, \qquad \forall i, j \tag{10}$$

$$z_i{}^{(s)} \leq N_i, \qquad \forall i \tag{11}$$

$$\sum_{i=1}^{n_N} z_i{}^{(s)} \leq N_T \tag{12}$$

$$z_i{}^{(s)} = 0, \qquad \exists i \in \{i: S_i \leq T\} \tag{13}$$

$$z_i{}^{(s)} \in \mathbb{Z}^+ \cup \{0\}, \qquad \forall i \tag{14}$$

$$x_{ijk}{}^{(s)} \in \mathbb{Z}^+ \cup \{0\}, \qquad \forall i, j, k \tag{15}$$

$$y_{ij}{}^{(s)} \in \{0,1\}, \qquad \forall i, j \tag{16}$$

Note that the model is solved for each realization of scenario index s deterministically. The objective function given in Equation (1) minimizes the total cost (distance) of distributing relief supplies and the total number of TDR facilities opened. Equation (2) ensures that the relief supplies demands are satisfied. Equation (3) defines the supply-ratios between different relief supply types to satisfy all relief supplies from the same neighborhood with a balanced supply distribution. Equation (4) and Equation (5) performs capacity checks in terms of volume and weight, respectively. By combining these with Equation (6), we also relate the corresponding decision variables. Equation (7) and Equation (8) are some kind of "humanitarian" constraints representing the maximum number of neighborhoods a neighborhood can serve and being served, respectively. Equation (9) and Equation (10) defines the logical relationships between the corresponding variables. Equation (11) and Equation (12) restricts the number of facilities per neighborhood and the total number of facilities whereas Equation (13) prevents allocating facilities in the neighborhoods whose safety conditions are below the required safety level. Constraints about the safety conditions simply identifies the neighborhoods in which it is allowed/not allowed to allocate facilities since it is also important to ensure that the minimum safety conditions are satisfied in a neighborhood for preventing the occurrences of unwanted situations before, during and after a disaster. Equation (14), Equation (15) and Equation (16) represent variable definitions.

Integer Programming Model for Transportation Planning- Phase II

In the second phase of our approach, we develop a transportation plan via an integer programming model corresponding to the optimal solution of the first phase for each scenario. This transportation plan is produced by solving a simple vehicle routing problem in which we determine the amounts of relief supplies transported in each vehicle as well as the shortest routes. The proposed integer programming model, using inputs such as possible routes between the neighborhoods (distances), number of vehicles available and vehicle capacities, produces a transportation plan which minimizes the total transportation time (distance) of relief supplies to the affected area.

We use the solution of the scenario-based integer programming model providing the optimal amounts of relief supplies to be distributed from the TDR facilities to the neighborhoods for each scenario (i.e., $x_{ijk}^{(s)}$) as the input parameters of the integer programming model of the second phase. These represent the total amounts of relief supplies transported from the corresponding TDR facilities with a minimum cost (shortest distance) transportation plan by dispatching vehicles. While planning the transportation via the integer programming model, neighborhoods in which at least one TDR facility is opened in the first phase are considered as the supply nodes whereas the neighborhoods which are served by these TDR facilities are defined as the demand nodes in the second phase. Corresponding integer programming model notation is defined as follows:

Indices:

i, j: neighborhood, $i, j = 1, \ldots, n_N$

v: vehicle, $v \in V$

r: route, $r \in R$

Parameters:

d_r: distance of route r

c_v: capacity of vehicle v

$p_{jr}: \begin{Bmatrix} 1, & \text{if node } j \text{ included in route } r \\ 0, & \text{otherwise} \end{Bmatrix}$

Decision variables:

$u_{vr}: \begin{Bmatrix} 1, & \text{if vehicle } v \text{ is assigned to route } r \\ 0, & \text{otherwise} \end{Bmatrix}$

t_{ijvr}: transportation amount of relief supplies along route r by vehicle v from neighborhood i to neighborhood j

Objective function:

$$\min \sum_{r \in R} d_r \left(\sum_{v \in V} u_{vr} \right) \tag{17}$$

Subject to:

$$\sum_{i=1}^{n_N} \sum_{j=1}^{n_N} t_{ijvr} \leq c_v u_{vr}, \qquad \forall v, r \tag{18}$$

$$\sum_{v \in V} \sum_{r \in R} t_{ijvr} = \sum_{k=1}^{n_C} x_{ijk}{}^{(s)}, \qquad \forall i, j \tag{19}$$

$$\sum_{r \in R} u_{vr} \leq 1, \qquad \forall v \tag{20}$$

$$t_{ijvr} \leq c_v p_{jr}, \qquad \forall i,j,v,r \tag{21}$$

$$u_{vr} \in \{0,1\}, \qquad \forall v,r \tag{22}$$

$$t_{ijvr} \in \mathbb{Z}^{+} \cup \{0\}, \qquad \forall i,j,v,r \tag{23}$$

The objective function in Equation (17) minimizes the total transportation distances of the assigned vehicles. The capacity of vehicles are taken into account by Equation (18). Equation (19) ensures that the distribution plan developed in the first phase (i.e., $x_{ijk}^{(s)}$) is attained for disaster scenario s. Assigning a vehicle to at most one route is guaranteed by Equation (20). Equation (21) prevents using vehicle v to transport relief supplies from neighborhood i to neighborhood j unless there is a route including them. Finally, Equation (22) and Equation (23) represent variable definitions.

CASE STUDY

We illustrate our solution approach with an earthquake case study in the Yildirim district of Bursa-Turkey with 64 neighborhoods. An earthquake case study developed by AFAD is used for determining the affected population in disaster area (Figure 2). We then use the affected population information to determine the relief supplies demands for different scenarios. As seen in Table 1, there are five different scenarios considered in our study where a 3-day and 8-hour demand occurs in the worst and best cases, respectively, meaning that the time for the TRC to reach the affected area are 3-days and 8-hours in the corresponding situations.

We obtain the distances between the neighborhoods using Google Maps (https://google.com/maps). Turkish Statistical Institute (TUIK)'s population statistics are used to determine the relief supply demands (http://www.tuik.gov.tr). There are three types of relief supplies considered in this study as water, meal-ready-to-eat (MRE) and medical kit with unit volumes (weights) of 1 liter (1 kilogram), 0.5 liters (0.25 kilograms) and 0.5 liters (0.25 kilograms), respectively. We assume that 1,000 TDR facilities are available totally each of which has a volume capacity of 34,560 liters and weight capacity of 30,480 kilograms and the maximum number of TDR facilities allowed per neighborhood is 100. We further assume that a neighborhood can serve and being served by 10 neighborhoods at most. The scenario-based integer programming model is solved for a safety level of 97.5%. To see the effects of different safety levels on the solution, the interested reader can refer to [5].

In the second phase, as a result of the first phase solution, we consider the sub-problem with a single supply node and several demand nodes represented by the neighborhood in which at least one TDR facility is opened and which are served by this supply node, respectively. We consider such a sub-problem for two different scenarios (best and worst cases) to illustrate our approach where we use a simplistic method for generating 24 possible routes each starts from the supply node and traverses at least one demand node, ensuring that the union of these routes covers all transportation network. It is assumed that there are 25 vehicles (trucks) each with a capacity of 90,000 liters.

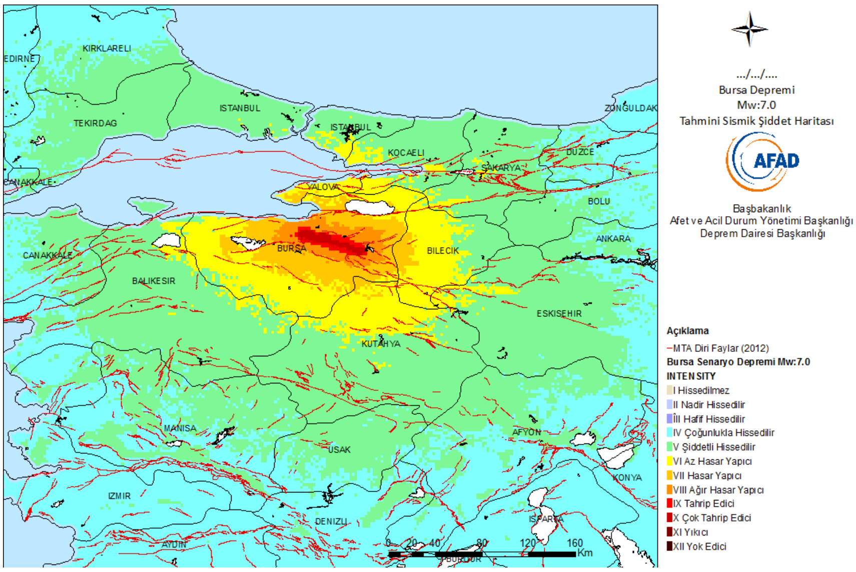

Figure 2. Earthquake Case Study Developed by AFAD

Table 2. Relief Supplies Demands for Different Earthquake Scenarios

Scenario	Relief Supplies Demands
Scenario-1	3-day demand
Scenario-2	2-day demand
Scenario-3	1-day demand
Scenario-4	16-hour demand
Scenario-5	8-hour demand

RESULTS

Results of Phase-I

We solve the first phase problem for each scenario to find the optimal TDR facility allocation and relief supplies distribution using the Mathematical Programming Language (MPL) with Gurobi. The results are shown in Table 2 where Objective-I corresponds to the first term in the objective function representing the total cost (distance) of distributing relief supplies and Objective-II given by the second term in the objective function shows the total number of TDR facilities opened. A measure of performance is also given in Table 2 as the average distance travelled per person to reach the corresponding TDR facility.

It is noted that TDR facilities are opened in the neighborhoods which are relatively closer to many others (i.e., hubs) with different number of facilities depending on the relief supplies demand in the corresponding scenario. We further note that, increasing the demand of relief supplies, also increases the total travel distance of distributing relief supplies (with an Objective-I value of 18,278,675) for disaster victims to reach the TDR facilities, representing a somewhat chaotic situation especially for the worst case scenario (Scenario-1). The total number of TDR facilities opened in Scenario-1 is 282 whereas in the most likely scenario (Scenario-3), most neighborhoods satisfy their own relief supplies demands (with an Objective-I value of 6,093,966) with 100 TDR facilities. In the best case, the total travel distance of distributing relief supplies decreases to 2,033,981 where the total number of TDR facilities is 38. It is also noted that the average distance travelled per person is approximately 1.91 kilometers and does not change significantly for different scenarios.

A network representation of Phase-I solution in the worst-case is shown in Figure 3 where the nodes of the network represent the neighborhoods with their approximate coordinates (also obtained using Google Maps) in the Yildirim district where the white (gray) nodes show the neighborhoods in which it is (not) allowed to open TDR facilities due to safety conditions (for a safety level of 97.5%).

Table 2. Summary of Results

Scenario	Objective	Objective-I	Objective-II	Average Travel Distance (per person)
1	18,560,675	18,287,675	282	1.91271
2	12,771,46	12,186,146	191	1.91264
3	6,193,966	6,093,966	100	1.91261
4	4,132,644	4,064,645	68	1.91320
5	2,071,981	2,033,981	38	1.91364

Figure 3. Network Representation of Phase-I Solution (worst-case) and Example Sub-Problem

Results of Phase-II

In the second phase, as a result of the first phase solution, we consider the sub-problems each with a single supply node and several demand nodes represented by the neighborhood in which at least one TDR facility is opened and which are served by this supply node, respectively. Example sub-problem is marked with the red circle in Figure 3 where neighborhood 4 is the supply node in which 73 TDR facilities are opened and it serves to neighborhoods 3, 8, 17, 19, 20, 23, 36, 47 and 59 which represent the demand nodes. We implement the integer programming model also using the Mathematical Programming Language (MPL) with Gurobi. The resulted transportation plan is summarized in Table 3 in which we present the minimum distance routes and the amount of relief supplies transported through these routes. It is noted that 25 vehicles are used to transport the required amount of relief supplies in Scenario-1 whereas the total number of vehicles used in Scenario-5 is 6. We also note that several vehicles are required to transport the relief supplies demands of some neighborhoods in Scenario-1. On the other hand, a single vehicle is sufficient to satisfy the demand of each neighborhood in Scenario-5.

CONCLUSIONS

In this study, we propose a two-phase solution approach for TDR facility allocation and transportation planning. In the first phase, allocation of TDR facilities is performed via a scenario-based integer programming model considering the locations of the facilities as well as the distributions of the relief supplies stored in these facilities. In the second phase of our approach, we develop a transportation plan using an integer programming model to minimize the time (distance) to transport the required amounts of relief supplies. We illustrate our solution approach with an earthquake case study in the Yildirim district of Bursa-Turkey. We represent the uncertainties about the earthquake using five different scenarios each representing the corresponding relief supplies demands until the TRC reaches the affected area. The first phase problem is solved for each scenario to find the optimal TDR facility allocation and relief supplies distribution by minimizing the total cost (distance) of distributing relief supplies and the total number of TDR facilities opened.

Table 3. Visited Routes and Transportation Amounts

Scenario	Demand nodes(s)	Minimum Distance Route	Transportation Amount to Demand Node(s)
S1	3	4-3-4	347814
S1	3,8	4-3-8-4	33972-56028
S1	3,8,17,19,20,23,36	4-3-8-17-19-20-23-36-4	38726-0-15942-23998-0-946-10388
S1	8	4-8-4	180000
S1	17	4-17-4	180000
S1	19	4-19-4	270000
S1	20	4-20-4	81260
S1	23	4-23-4	270000
S1	36	4-36-4	180000
S1	36,47,59	4-36-47-59-4	16400-68538-5062
S1	47	4-47-4	270000
S1	59	4-59-4	180000
S5	3,8	4-3-8-4	46750-26248
S5	17	4-17-4	22435
S5	19	4-19-4	33635
S5	20	4-20-4	9310
S5	23	4-23-4	31010
S5	36,47,59	4-36-47-59-4	22984-38745-9075

In the second phase, we develop a transportation plan via an integer programming model corresponding to the optimal solution of the first phase for each scenario. This transportation plan is produced by solving a simple vehicle routing problem in which we determine the amounts of relief supplies transported in each vehicle as well as the shortest routes. As a result of the first phase solution, we consider the sub-problems each with a single supply node and several demand nodes represented by the neighborhood in which at least one TDR facility is opened and which are served by this supply node, respectively. The proposed integer programming model produces a transportation plan which minimizes the total transportation time (distance) of relief supplies to the affected area. We determine the number of required vehicles to transport the relief supplies demanded by disaster victims.

In future studies, a complete solution approach combining the phases presented in this study for facility allocation and transportation planning problems can be considered. Consideration of the uncertainties in disaster situations can also yield new directions for future studies.

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COOPERATIVE INTERVAL GAME THEORY AND THE GREY SHAPLEY VALUE APPROACH FOR SOLVING THE MAXIMUM FLOW PROBLEM

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Abstract − During the last five decades, many efficient methods have been proposed for the solution of the maximum flow problem. The goal of the problem is to obtain maximum amount of flow between the origin and destination node of network. However, in real life problems arc capacities of the network can contain uncertain variables, which can be estimated as intervals. In this case, network is called uncertain and getting stable flow condition become vital as much as maintaining maximum unit flow through the network. In this paper, solution of the maximum flow problem in an uncertain network under the framework of interval analysis is discussed. We concentrate coalition in interval game theory of multiple-owner network under interval types of uncertainty. Based on this motivation, a new solution class of cooperative game method is used in logistics network where the set of players is restricted by a real number and the coalition values are interval numbers. Solutions are provided by the grey Shapley value procedure from interval cooperative game theory method. In order to provide practicality of the presented approach a numerical example is presented. The computational results support the possibility of getting more reliable solutions.

Keywords − Cooperative games, cost allocation, maximum flow problem

1. INTRODUCTION

In real-world problems, for a variety of reasons some of the input parameters (capacities, costs) exhibit different types of uncertainty [1]. Thus, it is important to find methods for coping with different types of uncertain data which can be probabilistic, possibilistic, and/or interval [2]. Grey theory is one of the most frequently employed approaches for modeling interval type of uncertainty. The concept of interval grey numbers was adopted for the first time in early 1980s by Julong Deng [3] as interdisciplinary scientific area and interval grey number's parameters may be specified as lying certain lower and upper bound limits. The theory can handle poor information systems which have partially unknown parameters and/or involving small samples. Grey models express unknown system's behavior by using small number of data. Having this property, it has many various application area and has become quite popular. For instance, social, economical, financial, technological, and industrial etc., systems are some of the systems in the real world that grey models are encountered. Herewith, new mathematical theories arose in the grey sets field. This theory, include five main parts namely grey prediction system, grey relational analysis (GRA) approach, grey decision making approach, grey-based programming, and grey control methods. During the last two decades solving interval linear programming problems attracted the attention of many researchers. Interval linear programming (ILP) or grey linear programming (GLP) model was applied to waste flow allocation planning problem within a municipal solid waste management system in 1992 [4]. In this method, ILP optimize model inputs with uncertainties in the optimization process, and solutions are derived by using simplex programs. The result showed that reasonable solutions can be achieved for grey objective function limits. In 1995, Huang et al. [5] was applied a grey integer programming (GIP) method to facility expansion planning problem under uncertainty circumstances. They developed new mixed integer linear programming optimization approach with combined interval grey number and grey mathematical programming into linear programming optimization approach. Huang et al. [6] used a GIP model to determine the optimal planning of waste-flow allocation for the regional municipality of Hamilton-Wentworth. The results, indicate that decision alternatives can be obtained by taking into consideration of uncertain system components.

Dating from 1960s to 1980s the topic of interval linear programming (ILP) is extensively studied. Hence, researchers working on ILP problems proposed several methods for solving ILP models. Shaocheng [7] provided the best and worst cases (BWC) method. He transformed the original interval LP into two specific LPs sub-models, the best and worst sub-models, which having particular characteristic: one LP has the largest possible

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feasible region which has the best objective function value and the other LP has the smallest possible region which has the worst objective function value. A given point is feasible for the ILP model if it satisfies the constraints of the best problem, and it is optimal for the ILP model if it is optimal for at least one characteristic model. However, Shaocheng's method is restricted to handle the general ILP problem in two important ways. Firstly, it is restricted to nonnegative variables only and secondly it deals only with inequality constraints which are finding optimum much easier than the interval equality constraints. Shaocheng's method has been extended by Chinneck and Ramadan [8] to ILP models with equality constraints. Allahdadi and Nehi [9] extended the method of solving ILP problems which was presented by Chinneck and Ramadan [8] to minimize and maximize functions with equality and inequality constraints.

The main concern of this paper is to illustrate how the maximum flow of a network in an uncertain environment can be modeled and solved. Realizing the design of real maximum flow problems in a network, due to the variety of reasons such as system failures, the arc capacities are uncertain in many situations. For these reasons, producing interval solutions will be more appropriate than the other methods to obtain better and more reliable services, in the real networks. The reasons are not only for economic reasons, but also for technical difficulties. For instance, if there exist lack of observed data for the arc capacities of a network, we often apply to consult experts or make a questionnaire who has knowledge about the related topics to evaluate event which will be accomplished. However, since human beings thoughts are subjective, this tends to misleading results. In this case, probability theory cannot reach successful results. Because, the subjective evaluation may have much larger variance than the real case. So, in this situation, grey theory can be applied in network research. We do not employ only optimization tools in uncertainty evaluation but also integrate game theory concept in this work. Cooperative games where all players are willing to achieve their overall benefits and are not very worried about their own personal benefits is the focus of the present study. The very well-known solution approach from the cooperative game theory which is known as Shapley value is utilized and extended under interval uncertainty domain. Network flow literature has hold game theory's competitive and cooperative advantages through players of the network. For example, Huang, et al. [10] was first introduced revised Shapley value idea. The proposed method has been applied to the problem of profit distribution in case of the strategic coalition of Chinese logistic companies. Solution ensured reasonable profit distribution among cooperation of members. Our paper is associated with the Reyes [11]'s work which is about the flow game model for the transshipment problem in the logistic network. He established Shapley value approach for the problem of collaborative game among the players (owners) of a network. The network's parameters and decision variables are crisp values and the effect of uncertainty in the multiple owner-networks was not the scope of his work. To the best of our knowledge, uncertainty in the network flow games is considered by a few researchers. Moreover, there exist researches about collaborative game methods which are used to handle the allocation of payoff value problem in case of coalition between the graph owners. However, interval type of uncertainties in the flow games with grey Shapley value collaboration method is not considered in the literature.

This paper is organized as follows. Basic notions and facts from the theory of grey calculus are shown in Section 2. In Section 3, the notion of the cooperative grey games as discussed in Palancı [12] is given. In Section 4, the cooperative maximum-flow problem is introduced. In Section 5, one example problem is illustrated. In Section 6, conclusions are presented.

2. DEFINITIONS AND PRELIMINARIES

In this section some definitions and preliminaries of the grey system, grey set and grey numbers from grey theory [13] are presented.

Definition 2.1

A grey system [14] is defined as a system containing uncertain information presented by grey number and grey variables.

Definition 2.2

Let X be the universal set. Then a grey set G of X is defined by its two mappings $\overline{\mu_G}(x)$ and $\underline{\mu_G}(x)$.

$$\begin{cases} \overline{\mu_G}(x): x \to [0,1] \\ \underline{\mu_G}(x): x \to [0,1] \end{cases} \quad (1)$$

Where $\overline{\mu_G}(x) \geq \underline{\mu_G}(x)$, x$\in X$, X=R , $\overline{\mu_G}(x)$ and $\underline{\mu_G}(x)$ are the upper and lower membership functions in G, respectively. When $\overline{\mu_G}(x) = \underline{\mu_G}(x)$, the grey set G becomes a fuzzy set. It shows that grey theory considers the condition of the fuzziness and can deal flexibly with the fuzziness situation.

Definition 2.3

A grey number is one of which the exact value is unknown, while the upper and/or the lower limits can be estimated. Generally, grey number is written as ⊗x.

$$\otimes x = x_{\underline{\mu}}^{\overline{\mu}} \quad (2)$$

Definition 2.4

If only the lower limit of x can be possibly estimated and x is defined as upper limit grey number.

$$\otimes x = [\underline{x}, \infty) \quad (3)$$

Definition 2.5

If only the upper limit of x can be possibly estimated and x is defined as lower limit grey number.

$$\otimes x = (-\infty, \overline{x}] \quad (4)$$

Definition 2.6

If the lower and upper limits of x can be estimated and x is defined as interval grey number;

$$\otimes x = [\underline{x}, \overline{x}] \quad (5)$$

Definition 2.7

The whitening value of grey number is given as

$$X = (1-a)\underline{x} + a\overline{x}, \; a \in [0,1] \quad (6)$$

Definition 2.8

Grey number operation is an operation which is defined on sets of intervals, rather than real numbers. The modern development of interval operation began with R.E. Moore’s work [15]. The basic operation laws of grey numbers $\otimes x_1 = [\underline{x_1}, \overline{x_1}]$, $\underline{x_1} < \overline{x_1}$ and $\otimes x_2 = [\underline{x_2}, \overline{x_2}]$, $\underline{x_2} < \overline{x_2}$ can be expressed as follows:

Addition operator:

$$\otimes x_1 + \otimes x_2 = [\underline{x_1} + \underline{x_2}, \overline{x_1} + \overline{x_2}] \quad (7)$$

Difference operator:

$$\otimes x_1 \ominus \otimes x_2 = \otimes x_1 + (-\otimes x_2) = [\underline{x_1} - \overline{x_2}, \overline{x_1} - \underline{x_2}] \quad (8)$$

Partial subtraction operator: if $|\overline{x_1} - \underline{x_1}| \geq |\overline{x_2} - \underline{x_2}|$ (9)

$$\otimes x_1 - \otimes x_2 = [\underline{x_1} - \underline{x_2}, \overline{x_1} - \overline{x_2}] \quad (10)$$

The scalar multiplication operator: Assume that k is positive real number

$k \otimes x_1 = [k\underline{x_1}, k\overline{x_1}]$ (11)

Multiplication operator:

$\otimes x_1 x \otimes x_2 = [min(\underline{x_1 x_2}, \underline{x_1}\overline{x_2}, \overline{x_1}\underline{x_2}, \overline{x_1 x_2}), max(\underline{x_1 x_2}, \underline{x_1}\overline{x_2}, \overline{x_1}\underline{x_2}, \overline{x_1 x_2})]$ (12)

Division operator:

$\otimes x_1 \div \otimes x_2 = [\underline{x_1}, \overline{x_1}] x [\frac{1}{\underline{x_2}}, \frac{1}{\overline{x_2}}]$ (13)

Definition 2.9

Length of grey number $\otimes x_1$ is defined by [7] as:

$|\otimes x_1| = [\overline{x_1} - \underline{x_1}]$ and $\underline{x_1} \in \mathbb{R}_+$ (14)

3. COOPERATIVE GREY GAMES

The n-person cooperative game can lead the maximum income by every coalition of players. A cooperative game consists of a finite set of players N who coordinately behave within the coalition strategies. There is a characteristic function V that map every non-empty subset S of N to a real number. It can be thought as the value which is obtained by dividing the total payoff value among the all of its members of the coalition S. Similar definitions are adopted and defined by [12] in cooperative interval games in the following way:

A cooperative interval game is an ordered pair $<N, w'>$ where N={1,…,n} is the set of players, and $w': 2^N \longrightarrow \mathcal{G}(\mathbb{R})$ is the characteristic function such that $w'(\emptyset) = \otimes_{\emptyset} \in [0,0]$, grey payoff function $w'(S) = \otimes_S \in [\underline{A_s}, \overline{A_s}]$ refers to the value of the grey expectation advantage belonging to a coalition S$\in 2^N$, where $\overline{A_s}$ is the maximal reward which coalition S could get and $\underline{A_s}$ the minimal reward which coalition S could receive on its own. Building blocks for grey solutions are grey payoff vectors, i.e. vectors whose components belong to $\mathcal{G}(\mathbb{R})$. $\mathcal{G}(\mathbb{R})^N$ denote the set of all such grey payoff vectors. So, a cooperative grey game can be considered as a classical cooperative game with grey profits $\otimes$ have played a key role . The length game $<N, |w'|>$,where $|w'$ (S)|=$\overline{w'}(S) - \underline{w'}(S)$ for each S$\in 2^N$. For further they denote by SM $\mathcal{G}G^N$ the class of grey size monotonic games with player set N. The grey marginal operators and the grey Shapley value are defined on SM $\mathcal{G}G^N$. Denote by $\prod$(N) the set of permutations : N⟶N of N. The grey marginal operator m^σ: SM $\mathcal{G}G^N \longrightarrow \mathcal{G}(\mathbb{R})^N$ corresponding to σ, associates with each $w' \in$ SM $\mathcal{G}G^N$ the grey marginal vector $m^\sigma(w')$ of w' with respect to σ defined by

$m_i^\sigma(w') := w'(P^\sigma(\mathrm{i}) \cup \{\mathrm{i}\}) - w'(P^\sigma(\mathrm{i})) \in [\underline{A_{P^\sigma(\mathrm{i}) \cup \{\mathrm{i}\}}} - \underline{A_{P^\sigma(\mathrm{i})}}, \overline{A_{P^\sigma(\mathrm{i}) \cup \{\mathrm{i}\}}} - \overline{A_{P^\sigma(\mathrm{i})}}], \forall \mathrm{i} \in N,$ (15)

Where P^σ(i)= { r$\in N$ | σ^{-1}(r) < σ^{-1}(i) },

σ^{-1}(i) denotes the entrance number of player i.

The grey Shapley value Φ' : SM $\mathcal{G}G^N \longrightarrow \mathcal{G}(\mathbb{R})^N$ is defined by

$\Phi'(w') := \frac{1}{n!} \sum_{\sigma \in \prod(\mathrm{N})} m^\sigma(w') \in [\frac{1}{n!} \sum_{\sigma \in \prod(\mathrm{N})} m^\sigma(\underline{A}), \frac{1}{n!} \sum_{\sigma \in \prod(\mathrm{N})} m^\sigma(\overline{A})].$ (16)

4. COOPERATIVE MAXIMUM FLOW PROBLEM

The network is presented as a graph which is frequently characterized by two sets of symbols and is denoted as G= (V, A). These are a set of V whose elements are called vertices or nodes, and a set of A of pairs of vertices called edges or arcs. A flow through the network is a way of sending objects from one point to another which obey the capacity constraints and conserves the flow at each node (except for the source and sink). The nodes from which units enter through a network are called source nodes, and the nodes to which the flow units are directed to are called sink nodes. Preserving the flow units mean that total flow entering a vertex must equal the total flow leaving the vertex. In real problems, the networks are often multiple owners so that several persons, companies or countries possess different parts of the network. In this case the cooperation of players should be considered due to cost reduction factors.

Kalai and Zemel [16] defined a family of games that are generated by problems of flows in a network which called flow games in multi-owner network. In the flow games, it is assumed that the owners are independent players. The set of coalition between a subset of the players is denoted by C. A n-person cooperation flow game is a function v from the set of coalitions to the set of real numbers. For a coalition S∈C, v(S) is defined as the maximum flow value for coalition S.

In the proposed model, there exist two assumptions as follows:

- The network problem mentioned in this study, has flow property such that transferred without any commodity loss when passing through each nodes in the network.
- The second assumption is the capacity of arcs is subject to interval type of uncertainties.

A set of symbols and notations are shown in Table 1 which are discussed through this paper.

Table 1. Model Notations

Notation	Definition
Indices	
N	Total number of nodes
M	Total number of different coalitions
i	Set of nodes $i \in \{1,\ldots, N\}$
s	Source node
t	Sink node
m	Set of coalitions, m $\in \{1,\ldots, M\}$
Interval Parmeters	
FN_k	The initial nodes for node k $(FN_k \subset V)$
TN_k	The terminal nodes for node k $(TN_k \subset V)$
$\otimes(c_{ij})$	Transferred flow units capacity of arc between the node i and node j

Interval Decision Variables

$\otimes(x_{ij})$	Amount of flow units Transferred through node i to node j ($i \neq j$)
$\otimes(x_{s,c_m})$	The total flow units entering from arcs to the sink node in case of coalition occurrences c_m
$\otimes(x_{t,c_m})$	The total flow units entering from arcs to the source node in case of coalition occurrences c_m

The maximum flow model by using the interval linear programming (ILP) method in case of coalition occurrences c_m between players can be developed as follows:

The objective of the problem is to maximize the total outflow units through the arcs from the source node s in case of coalition occurrences m.

Max flow(c_m)= $\sum_{j\in TN_s} \otimes(x_{sj})$, (17)

Alternatively, maximize the total inflow units from the sink node t through the arcs in case of coalition occurrences m.

Max flow(c_m)= $\sum_{i\in FN_t} \otimes(x_{it})$, (18)

The following constraint set satisfies that the capacity of flow units passing through the arcs is bounded from above by the $\otimes(c_{ij})$ of the arcs for each $\forall(i, j) \in A_{c_m}$.

$\otimes(x_{ij}) \leq \otimes(c_{ij}), \quad \forall(i, j) \in A_{c_m}$, (19)

The conservation of flow constraint set assures the balance equations. In other words, all of the nodes in the network except for the source and sink node are “transit” nodes. In other words, total flow units incoming each node is equal to the total outgoing flow units; therefore, there is no lost in the network while being transited through the nodes.

$\sum_{l\in FN_k} \otimes(x_{li}) = \sum_{j\in TN_k} \otimes(x_{ij})$, where $\forall$ (l, i)& $\forall$ $(i, j) \in A_{c_m}$, $i \neq s, t$ (20)

The following constraint set satisfies the non-negativity.

$\otimes(x_{ij}) \geq 0 \ \ \forall(i,j) \in A_{c_m}$. (21)

Mathematical model for the interval maximum flow problem is presented above in multiple-owner graph, and the collaboration mechanism between the owners is discussed subsequently in order to improve the graph efficiency.

5. EXAMPLE

Consider the logistics network that one desires to transfer maximum possible flow of products from source node s to sink node t in consisting of three distributors (a, b, c) as presented in Figure 1.

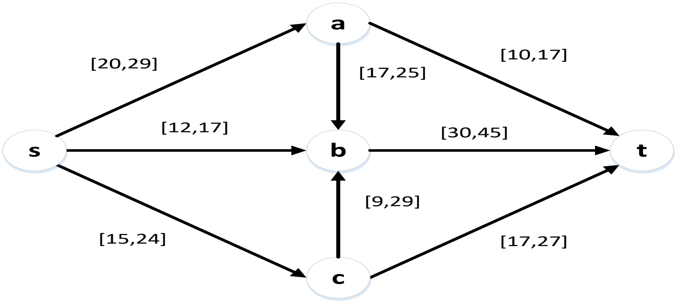

Figure 1. Logistics network

Now, suppose that this graph is of the multiple-owner type and three persons own the arcs (P_1,P_2, P_3). Precisely, the first player P_1 owns the upper arcs. The second one P_2 owns the middle arcs. The third one P_3 owns the bottom arcs.

The new concept of this paper is firstly to solve the interval maximum flow model with the method of solving ILP problems considering all of the possible coalitions of the graph owners. Afterwards, cooperative game theory, namely the grey Shapley value method is used to allocate the excess utility to the graph owners. In this problem, solution of the values is achieved by using the model of Allahdadi and Nehi [9] which is shown in Appendix 1. Solutions are obtained by making use of LINGO software. The result of the maximum flow from node s to node t in all coalitions cases is presented in Figure 2.

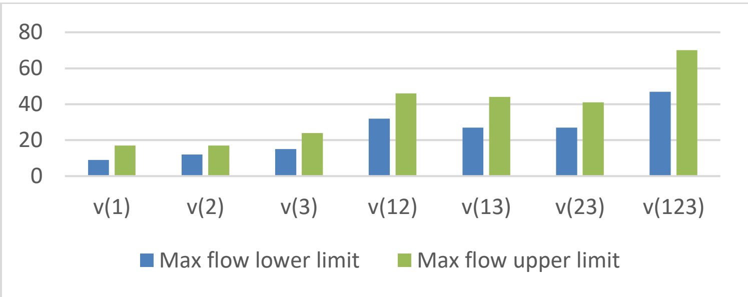

Figure 2. Maximum flow limits in all coalitions of the graph owners

Afterwards, the value of the game is found as [47,70] units and this value will be distributed fairly to each player. For this reason, the interval marginal vectors are calculated. Firstly, for order σ_1=(1,2,3), we calculate the interval marginal vectors by using formula (15). Then we get,

$m_1^{\sigma_1}(w')$ = [9,17],

$m_2^{\sigma_1}(w')$ = [23,29],

$m_3^{\sigma_1}(w')$ = [15,24].

The other results can be calculated similarly and then the average of the six grey marginal vectors gives the Shapley value. Finally, the Shapley value of the game is found as { $[15,\frac{47}{2}]$, $[\frac{33}{2},22]$, $[\frac{31}{2},\frac{49}{2}]$ }. Interval Shapley value means that the network should be distributed the flow units of the network in the following way: $[15,\frac{47}{2}]$ would be assigned to the player (1), $[\frac{33}{2},22]$ to the player (2) and $[\frac{31}{2},\frac{49}{2}]$ to the player (3). Amount of flow proportion allowable through the network for each player are shown in Figure 3.

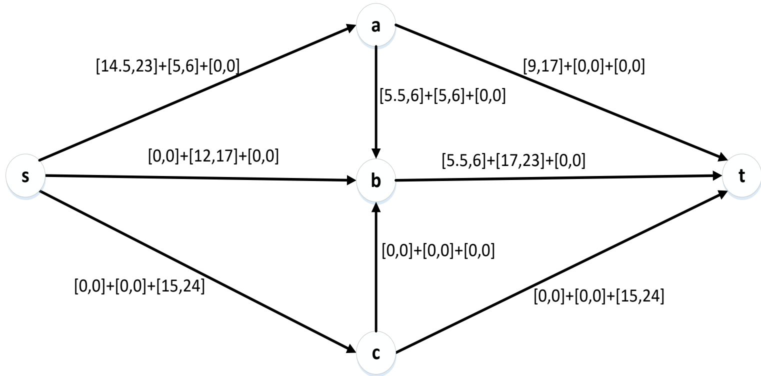

Figure 3. Logistics network with Shapley value.

In cooperative games, there exists another solution concept namely the core for distributing gains of the coalition between the players. Instead of Shapley value concept arranged according to fairness property, the core approach has based on stability. Core can be defined as a set of outcome allocations that are stable such that no coalition has an incentive to leave the grand coalition. Formally, as Kalai and Zemel [17, 18] pointed out, the core of the flow game is non-empty and defined core in the following way:

For a positive integer n let N={1, … ,n} denote a set of players, and 2^N={S⊆ N : S≠ $\emptyset$ } the set of coalitions of players. An n-person characteristic function game is a function V: $2^N \longrightarrow R_+$. The core of V is defined by:

CORE(V) = {x ∈ R^n : $\sum_{i\in N} x_i$ = V(N) and $\sum_{i\in S} x_i$ ≥V(S) for every S ∈ 2^N}.

We can check that the Shapley value we computed is in the core.

We have:

$\Phi_1'(w') = [15, \frac{47}{2}] = |\frac{17}{2}| > |8| = [9,17] = \nu(1)$,

$\Phi_2'(w') = [\frac{73}{6}, 20] = |\frac{36}{6}| = |6| > |5| = [12,17] = \nu(2)$,

$\Phi_3'(w') = [\frac{91}{6}, 22] = \left|\frac{54}{6}\right| = |9| \geq |9| = [15,24] = \nu(3)$,

$\Phi_1'(w') + \Phi_2'(w') = [15, \frac{47}{2}] + [\frac{33}{2}, 22] = [\frac{63}{2}, \frac{91}{2}] = |\frac{28}{2}| = |14| \geq |14| = [32,46] = \nu(12)$,

$\Phi_1'(w') + \Phi_3'(w') = [15, \frac{47}{2}] + [\frac{31}{2}, \frac{49}{2}] = [\frac{61}{2}, \frac{109}{3}] = |\frac{105}{6}| = |17.5| > |17| = [27,44] = \nu(13)$,

$\Phi_2'(w') + \Phi_3'(w') = [\frac{33}{2}, 22] + [\frac{31}{2}, \frac{49}{2}] = [32, \frac{93}{2}] = |\frac{87}{6}| > |14| = [27,41] = \nu(23)$,

$\Phi_1'(w') + \Phi_2'(w') + \Phi_3'(w') = [47,70] = \nu(123) = \nu(N)$.

6. CONCLUSIONS

Uncertainty theory lead to a new tool to deal with interval types of indeterminacy. Under the framework of uncertainty theory, we present an extension of maximum flow problem whose network capacities are interval variables instead of crisp values. Finally, we distribute flow in a fair way between players in case of coalitions by using the concept the grey Shapley value from the cooperative game theory. An example is derived to illustrate the theoretical considerations and the obtained results lead the efficiency of the method.

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APPENDIX 1.

From the mathematical point of view, the interval linear programming problem (ILP) is presented with $\{\geq, \leq$ and $=\}$constraints [9].

Definition 1. An ILP problem can be defined as

$$\text{Min } Z = \sum_{j=1}^{n} [\,\underline{c_j}\,, \overline{c_j}\,]x_j \tag{22}$$

s.t.$\sum_{j=1}^{n}[\underline{a_{ij}}, \overline{a_{ij}}]x_j \geq [\underline{b_i}, \overline{b_i}]$ i = 1, 2, …, m

$x_j \in (X^o \cup X^{si})$ j = 1, 2, …, n

Where X^o is variables set which are not associated with an interval coefficient anywhere in the ILP problem and can be sign-restricted or unrestricted, X^{si} is variables set which are sign-restricted and are associated with at least one interval coefficient in ILP problem. Problem (22) characteristic version can be state as:

$$\text{Min}Z = \sum_{j=1}^{n} c_j x_j \tag{23}$$

s.t.$\sum_{j=1}^{n} a_{ij} x_j \geq b_i$ i = 1, 2, …, m

$x_j \in (X^o \cup X^{si})$ where $c_j \in [\underline{c_j}, \overline{c_j}]$, $a_{ij} \in [\underline{a_{ij}}, \overline{a_{ij}}]$ and $b_i \in [\underline{b_i}, \overline{b_i}]$.

Solving ILP problems with ≥ constraints

Theorem 1. For ILP Problem (22) the best and worst optimum values obtain by solving the following problems respectively [9].

$$\text{min}\underline{Z} = \sum_{j=1}^{n} c_j' x_j \tag{24}$$

s.t.$\sum_{j=1}^{n} a_{ij}' x_j \geq \underline{b_i}$ i = 1, 2, …, m

$$\text{min}\overline{Z} = \sum_{j=1}^{n} c_j'' x_j \tag{25}$$

s.t.$\sum_{j=1}^{n} a_{ij}'' x_j \geq \overline{b_i}$ i = 1, 2, …, m where

$$a_{ij}' = \begin{cases} \overline{a_{ij}} x_j \geq 0 \\ \underline{a_{ij}} x_j \leq 0 \end{cases}, \; a_{ij}'' = \begin{cases} \underline{a_{ij}} x_j \geq 0 \\ \overline{a_{ij}} x_j \leq 0 \end{cases}, \; c_j' = \begin{cases} \underline{c_j} \quad x_j \geq 0 \\ \overline{c_j} x_j \leq 0 \end{cases}, \; c_j'' = \begin{cases} \overline{c_j} x_j \geq 0 \\ \underline{c_j} x_j \leq 0 \end{cases}$$

Solving ILP problems with ≤ constraints

Theorem 2. For ILP problem [9]:

$$\text{Min}Z = \sum_{j=1}^{n} [\underline{c_j}, \overline{c_j}]x_j \tag{26}$$

s.t.$\sum_{j=1}^{n}[\underline{a_{ij}}, \overline{a_{ij}}]x_j \leq [\underline{b_i}, \overline{b_i}]$ i = 1, 2, …, m

$x_j \in (X^o \cup X^{si})$

The best and worst optimum values obtain by solving the following problems respectively.

$$\text{min}\underline{Z} = \sum_{j=1}^{n} c_j' x_j \tag{27}$$

s.t.$\sum_{j=1}^{n} a_{ij}'' x_j \leq \overline{b_i}$ i = 1, 2, …, m

$$\text{min}\overline{Z} = \sum_{j=1}^{n} c_j'' x_j \tag{28}$$

s.t.$\sum_{j=1}^{n} a_{ij}' x_j \leq \underline{b_i}$ i = 1, 2, …, m where $a_{ij}', a_{ij}'', c_j', c_j''$ are as defined in Theorem 1.

Solving ILP problems with equality constraints

Theorem 3. The interval equality constraint [9]:

$$\sum_{j=1}^{n}[\underline{a_j}, \overline{a_j}]\, x_j = [\underline{b}, \overline{b}] \tag{29}$$

can be considered as the following two inequality constraints that they define a convex region.

$$\sum_{j=1}^{n} a_j' x_j \geq \underline{b}\ ,\ \sum_{j=1}^{n} a_j'' x_j \leq \overline{b} \tag{30}$$

Theorem 4. For ILP problem [9]:

$$\min Z = \sum_{j=1}^{n} [\underline{c_j}, \overline{c_j}] x_j \tag{31}$$

$$\text{s.t.} \sum_{j=1}^{n} [\underline{a_{ij}}, \overline{a_{ij}}] x_j = [\underline{b_i}, \overline{b_i}] \qquad i = 1, 2, \dots, m$$

$$x_j \in (X^o \cup X^{si})$$

the best optimum value obtains by solving the following problem [9]:

$$\min \underline{Z} = \sum_{j=1}^{n} c_j' x_j \tag{32}$$

$$\text{s.t.} \sum_{j=1}^{n} a_{ij}' x_j \geq \underline{b_i} \quad i = 1, 2, \dots, m$$

$$\sum_{j=1}^{n} a_{ij}'' x_j \leq \overline{b_i} \quad i = 1, 2, \dots, m$$

$$x_j \in X^{si}$$

and the worst value of objective function obtains by solving one of the following two linear programming problems [9].

$$\min \overline{Z_1} = \sum_{j=1}^{n} c_j'' x_j \tag{33}$$

$$\text{s.t.} \sum_{j=1}^{n} a_{ij}' x_j = \underline{b_i} \quad i = 1, 2, \dots, m$$

$$x_j \in X^{si}$$

$$\min \overline{Z_2} = \sum_{j=1}^{n} c_j'' x_j \tag{34}$$

$$\text{s.t.} \sum_{j=1}^{n} a_{ij}'' x_j = \overline{b_i} \quad i = 1, 2, \dots, m$$

$x_j \in X^{si}$ where a_{ij}', a_{ij}'', c_j' and c_j'' are as defined in Theorem 1.

MULTIPLE TRAVELING SALESMAN GAME FOR COST ALLOCATION: A CASE PROBLEM FOR SCHOOL BUS SERVICES

Adil Baykasoğlu[1], Burcu Kubur Özbel[1,2]

***Abstract** −This paper studies application of cost allocation method based on the cooperative game theory for the school bus services. The objective considered includes minimizing the total distance travelled between each bus stop for each bus services. The case study is first analyzed as a travelling salesman problem (TSP) to find the individual travel cost. Then, multiple travelling salesman problem (mTSP) is used for finding the travel cost of coalition of collaborating bus service companies. The mTSP can be defined simply as the determination of the set of routes for m salesman (bus services) who all start from and return to a single home city (depot). Then the travelling salesman game (TSG) is introduced, where the bus services are associated with the players of a cooperative game, thus allowing the study of possible allocations of the total cost among them. The Shapley value method is used to allocate the cost of the optimal route among the players.*

Keywords −Cooperative games, cost allocation, multiple travelling salesman problem

1.INTRODUCTION

In recent decades, transportation costs have gone up due to increased competition. Parallel with this increment cooperation among companies have also increased. The common ways of cooperation are vertical and horizontal cooperation. The cooperation can be vertical, i.e. different branches of business can cooperate or it can be horizontal, i.e. companies in the same business line can cooperate. The focus of this paper is horizontal cooperation among the school bus service companies. In the literature, the distribution of both costs and savings arising from horizontal cooperation is scarce. There are few papers reporting on horizontal cooperation studies within specific industries/contexts, such as grocery distribution [1], distribution in rural areas [2], furniture [3]-[4], freight carriers [5], forest [6], automotive industry [7], retail [8] and railway transportation [9].

The transportation cost allocation problem is a fundamental problem in logistics cost analytics. Tamir [10] defined a cost allocation game based on travelling salesman problem (TSP). In the present study, we are concerned with a school bus problem that arises in transporting the students of an elementary school that is located in Izmir, Turkey. The school has a three contractor firm which takes care of transportation of students. The contactor firm's objective is to minimize the total cost associated with transporting the students to and from the school to their homes. Bus service firms cooperate in order to realize economies of scale and collaboration is important in creating competitive advantages. We try to present the advantages of horizontal cooperation by solving a real life problem, especially in terms of reduction on transportation cost. First, school bus service companies' individual transportation costs are determined by solving TSP. After that, the coalitional costs are obtained by solving mTSP. To allocate coalitional costs, Shapley value approach is used. The Shapley value considers the marginal contribution of each participant in a collaborative system and provides a unique allocation solution.

The remainder of this paper is organized as follows. In Section 2, the proposed cost estimation models are presented. Section 3, discusses the cost savings allocation methods based on Cooperative Game Theory (CGT). Section 4, presents an illustration. In the last section, conclusions are drawn and further research is outlined.

2. COST ESTIMATION MODELS

In this study, individual bus service company is treated as Asymmetric TSP (ATSP). ATSP is defined on a directed graph G=(V, A), where V={1,…, n} is the vertex set, A={ (i,j): $i,j \in$ V} is the arc set, and a non-symmetric cost matrix (c_{ij}) is defined on A. The ATSP consists of determining at least cost Hamiltonian circuit or tour over G.

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The problem is commonly interpreted as that of determining an optimal salesman's tour over *n* cities. The ATSP is NP-hard even if the costs are Euclidean [11].

Different formulations of a given problem can be frequently stated in terms of different sets of variables, as is the case with some ATSP formulations that use an extended set of variables with respect to another formulation. Many ATSP formulations consist of an assignment problem with integrality and sub-tour elimination constraints. In order to mathematically formulate the ATSP, following notation is utilized.

N = The set of cities (nodes)
c_{ij}= The the distance between city i and j for $i, j \in N$
x_{ij}= Binary variables, equal to 1 if and only if arc $(i, j) \in L \subseteq N \times N$ is used where $i \neq j$.

The basic model ATSP is as follows:

$$\text{Minimize } \sum_{(i,j)\in L} c_{ij} x_{ij} \qquad (1)$$

Subject to

$$\sum_{j\in N:(i,j)\in L} x_{ij} + \sum_{j\in N:(j,i)\in L} x_{ji} = 2, \quad i \in N \qquad (2)$$

$$\sum_{(i,j)\in L:\{i,j\}\subseteq S} x_{ij} \leq |S| - 1, \qquad \forall S \subset N \qquad (3)$$

$$x_{ij} \in \{0,1\} \quad i, j \in N \qquad (4)$$

The objective function (1) is to minimize the distance of the tour. Constraints (2) satisfy that entering and leaving each city exactly once and constraint (3) says that no sub-tours are allowed.

A generalization of the well-known TSP is the mTSP. The mTSP can in general be defined as follows: Given a set of nodes, let there be *m* salesman located at a single depot node. The remaining nodes (cities) that are to be visited are called intermediate nodes. Then, the mTSP consists of finding tours for all *m* salesmen, who all start and end at the depot, such that each intermediate node is visited exactly once and the total cost of visiting all nodes is minimized. (The cost metric can be defined in terms of distance, time, etc.)

In this section an integer program (IP) is presented to estimate the travel cost of any coalition of collaborating companies. This estimation of the benefits of the collaboration will be necessary for the cost saving allocation model that is defined later. Various IP formulations for the mTSP have been proposed in the literature. We used Laporte and Nobert [12]'s modified formulation for asymmetrical cost structure. Let us assume that variations to the route throughout the day are ignored and each bus company's route is known. The cost of the trip between each pair of locations is also known.

Model Notations:

Data:
K: Total number of bus stops in bus company's routes
P: Total number of bus companies
S: Set of collaborating bus companies (the grand coalition is formed by all bus companies which are labeled as *N*)
BS: Set of bus stops in collaborating bus companies' routes (the grand coalition is formed by all bus companies which are labeled as *N*)
i, *j*, *k*: Index of bus stops in bus companies' routes
m: Total number of bus companies in the coalition S
c_{ij}: Travel cost between stop i and stop j
Decision variables:

$x_{ij} \in \{0,1\}$: Equals to 1 if a bus travels from stop *i* to stop *j* and 0 otherwise

Cost minimization model:

$$C(S) = \text{Min } Z = \sum_{i \in BS} \sum_{\substack{i \neq j, \\ j \in BS}} c_{ij} x_{ij} \tag{5}$$

Subject to

$$\sum_{j \in BS, j=2} (x_{1j} + x_{j1}) = 2\text{m} \tag{6}$$

$$\sum_{i \in BS, i \neq k} x_{ik} = 1, \; (k = 2, \dots, n \in BS) \tag{7}$$

$$\sum_{j \in BS, j \neq k} x_{kj} = 1, \; (k = 2, \dots, n \in BS) \tag{8}$$

$$\sum_{j \in BS} \sum_{\substack{i \neq j, \\ i \in BS}} x_{ij} \leq |S| - 1, \quad (2 \leq |S| \leq n - 2, S \subseteq \{2, \dots, n\}) \tag{9}$$

$$x_{ij} \in \{0,1\} \; i, j \in BS \tag{10}$$

$$m \geq 1 \text{ and integer.} \tag{11}$$

This formulation is a pure binary IP formulation where the objective is to minimize the total cost of the travel. Constraints (6) are degree constraints that is, each city is visited exactly once by one of the *m* salesmen, except city 1 which is visited by *m* salesmen. Note that (7) and (8) are the standard assignment constraints. Constraints (9) are known as the sub-tour elimination constraints.

3. COST SAVINGS ALLOCATION

In this section, we deal with the problem of how to share the benefits of that collaboration among the different partners. This is not an easy question, since it is not obvious what the contribution of each company to the total cost savings is. It may be first thought that some rule, such as sharing the cost savings proportional to the transported route points of each company, would do. However, in general, this type of simple proportional rule does not guarantee that a fair and equitable distribution of the benefits of the collaboration is attained [13]-[14]. Therefore, a more theoretically-grounded approach is needed and one of the most appropriate alternatives seems to be CGT. Game theory generally defined as the study of mathematical models of conflict and cooperation between intelligent rational decision-makers.

CGT provides a natural framework within which to study joint cost savings allocation problems. A cooperative game is the branch of game theory which has two elements. These are set of players N = {1,2, …, |N|} and a characteristic function c. In short, a game (Γ) is defined by the pair (N, c). Players are decision makers and we call every subset S ⊆ N cooperating players of a coalition. If two players are not cooperating, they belong to different coalitions; i.e., there is only one occurrence of cooperation. N is called the grand coalition. The number of coalition ($2^{|N|}$) rising exponentially with the increasing number of players. The set of players is assumed finite. The characteristic function:

$$c : 2^N \rightarrow \text{R} \tag{12}$$

assigns a cost or profit value (representing the total amount of transferable utility) to each coalition S ⊆ N which determines the best outcome for the coalition S if the players in S cooperate without the players in N\S. Empty set c(Ø)=0. The characteristic function can be interpreted as profits or costs. Although there are many CGT solution concepts, we will concentrate on the Shapley value method.

Shapley [15] aims to develop an allocation method that yields a unique solution for every game in coalitional form. The cost allocated to the company *j* is equal to

$$y_j = \sum_{S \subset N: j \in S} \frac{(|S|-1)!(|N|-|S|)!}{|N|!} \; [c(S) \; - c(S - \{j\})] \tag{13}$$

The Shapley value is based on four axioms formulated by Shapley. These axioms express that a cost allocation computed according to this solution concept satisfies the properties of efficiency, symmetry, dummy property and additivity. Symmetry means that if two arbitrary participants, *i* and *j*, have the same marginal cost with respect to all coalitions not containing *i* and *j*, the costs allocated to these two participants must be equal. The dummy property states that if participant is a dummy, in the sense that he neither helps nor harms any coalition he may join, then his allocated cost should be zero. Finally, additivity expresses that, given three different characteristic cost functions $c_1,$ c_2 and $c_1 + c_2$ for each participant, the allocated cost based on $c_1 + c_2$ must be equal to the sum of the allocated costs based on c_1 and c_2, respectively [6].

4. ILLUSTRATION

In this section we will use an example to illustrate the performance of the CGT approaches to the fair allocation of cost saving derived from horizontal cooperation. There are three bus service firms (A, B, C). Their business segment is same and power of negotiation is assumed to be same. These bus service firms are selected among others that based on their close business relationships which are willing to cooperate. Each bus must pick up students from bus stops and deliver them to their appropriate schools under their bus route. However, instead of completing their routes individually, they may share their route points which are located near in other bus service firm's route to obtain less travel cost. Bus service firms A, B, C have following individual route 1-2-8-4-1, 1-3-7-5-1, 1-6-10-9-1 respectively.

There are ten bus stops and the distances between bus stops are known. Google maps is used for obtaining the distance matrix. Each bus stop is represented by a number in the model. There exist one starting bus stop, namely bus stop 1 in the model. The objective is to minimize the transportation cost. The expectation from the cooperation is to reduce the transportation cost in accordance with non-cooperative situation. Table 1 gives the cost matrix of the distances between each pair of bus stops.

Model (1)-(4) must be solved 3 times for calculating individual costs: {A}, {B} and {C} and model (5)-(11) must be solved 4 times, so that for each possible coalition S: {AB}, {AC}, {BC}, {ABC} the minimum total cost C(S) can be computed. Results are depicted in Tables2 and 3which show the approximated Shapley values. In this case, the final allocation {33.666 TL, 22.1666 TL, 34.1666 TL} meaning that the total transportation cost should be allocated to each company in the following way: 33.666 TL would be assigned to the company A; 22.1666 TL to the company B and 34.1666 TL to the company C.

Table 1. Cost matrix (TL)

	1	2	3	4	5	6	7	8	9	10
1	0	10	20	15	8	7	30	35	5	12
2	8	0	17	19	6	12	8	20	11	9
3	7	6	0	13	18	7	6	3	14	23
4	5	4	3	0	10	5	12	17	9	30
5	10	20	10	15	0	40	50	7	11	14
6	30	40	12	30	19	0	16	18	26	28
7	8	50	10	20	8	7	0	8	10	12
8	7	25	17	26	14	19	6	0	9	11
9	18	11	4	28	6	13	11	5	0	7
10	22	25	27	28	30	40	10	3	4	0

Table 2. Corresponding optimal transportation cost C(S)for each of the possible coalitions

S	C(S)

{A}	61 TL
{B}	44 TL
{C}	58 TL
{AB}	61 TL
{AC}	71 TL
{BC}	65 TL
{ABC}	90 TL

Table 3. Approximated allocation costs according to Shapley Value Method

Company	Shapley Value
{A}	33.6666 TL
{B}	22.1666 TL
{C}	34.1666 TL

5. CONCLUSIONS

In this paper, a case study of the school bus routing problem which is an application of the mTSP is considered. The objective of the problem is to obtain minimum cost for all travelled bus companies. For this reason, a mathematical programming model is used to measure the benefits of merging the routes of different bus companies so that their joint transportation costs are reduced. Bus companies in the same business line is merged and the coalition cost arising from their horizontal cooperation is allocated among companies using cooperative game theory method. Although there are many cost savings allocation solution concepts, we will concentrate here on only one of them, namely the Shapley value based solution approach. To gain insight into the problem, a case problem has been carried out. In this case, we have a maximum three bus company in the coalition. Since in real life, there is a limit on the number of partners in the coalition due to the increasing transaction costs, complexity of managing the collaboration etc. Finally, results show that, in the collaboration significant cost reduction is obtained across the bus service firms.

The following future studies can be considered to further improve the present study. First of all, the school bus routing problem can be tackled for different objectives and constraints. Since there is no universal approach to cover all of the variations of the problem and majority of the proposed models seem to be problem dependent. Another issue is related to the negotiation power of bus firms which his assumed to be same for all firms. Relaxation of this assumption may be more realistic for some circumstances. Finally, this research can be extended by employing and comparing other solution concepts for cooperative games.

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ASSEMBLY LINE HIERARCHICAL WORKER ASSIGNMENT AND BALANCING PROBLEM WITH POSITIONAL CONSTRAINTS, TASK ASSIGNMENT RESTRICTIONS AND PARALLEL STATIONS

Şeyda Topaloğlu [1], *Raziye Okyay* [2]

Abstract – *This study considers the assembly line balancing problem with hierarchical worker assignment, positional constraints, and station paralleling. Three major constraints which can be observed in a typical real-world assembly line setting are also included in this study. The first constraint is related to the position of the workpieces during which an assembly task is performed. This constraint enables that only tasks performed in the same position of the workpiece can be assigned to the same workstation. The second constraint deals with the assignment of tasks that must be performed together in a workstation or in different workstations. Lastly, the third constraint enables opening a parallel station while incurring a station opening cost. The objective of this assembly line balancing problem is to find the optimal assignment of workers and tasks to the stations, and to decide on the optimal parallel stations such that total cost is minimized. A new integer linear programming model is proposed and the computational performance analysis of the model is done using the CPLEX solver on a number of generated problem instances.*

Keywords – *Assembly line balancing, hierarchical worker assignment, integer programming, parallel stations, positional constraints*

INTRODUCTION

Today, while standardized products are being manufactured in high quantities, assembly lines are used in almost all industries. (e.g. automobile, white appliances, electronic industries). Assembly line is a mass production system in which while a product travels along production line, transactions are made, such as adding, combining in a series of workstations.

Assembly line balancing (ALB) is to provide the assignment of tasks to work stations optimally under certain constraints. These constrains can be precedence relationship between these tasks, cycle time and number of workstations. According to Baybars [1] deterministic ALB problems are divided into two groups. The first is simple assembly line balancing (SALB) problem and the second is general assembly line balancing (GALB) problem. The SALB problem is also divided into two groups as SALB-1 and SALB-2 in terms of the objective function. Both problems include the precedence constraints between tasks and the objective function of SALB- 1 problem is to minimize the number of stations when cycle time is known and the objective function of SALB-2 problem is to minimize cycle time when the number of stations is known. Scholl and Becker [2] worked on the GALB problem and in addition to previous restrictions they dealt with a more flexible production system thanks to the conditions such as allowing opening parallel stations, indicating the mismatch between tasks (incompatibilities), modeling mixed-model production lines. In subsequent studies, more specific versions have been developed.

Miralles et al. [3] defined assembly line worker assignment and balancing (ALWAB) problem which is the extension of the SALB-2 problem. The aim of the problem is to minimize the cycle time, given certain available workers in the Sheltered Work Centres for Disabled. The ALWAB problem was solved with branch and bound procedures, a tabu search algorithm, hybrid metaheuristics, an iterated beam search algorithm and an iterative genetic algorithm in subsequent studies [4]-[8]. Borba and Ritt [9] developed a probabilistic beam search algorithm as well as a task-oriented branch-and-bound procedure. Vila and Pereira [10] proposed a branch, bound and remember algorithm which is reported for two different time limits (60 seconds and 600 seconds) and no time limit.

Emmons and Burns [11] for the first time defined the hierarchical workforce in the scheduling problem. The model is developed in an attempt to find the smallest number and most economical mix of workers. In this

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problem, main assumption is less qualified workers cost less. Hung [12] considered single-shift off-day scheduling of a hierarchical workforce and proposed a simple one-pass method that frequently gives the least cost labor mix. Billionnet [13] developed an integer programming formulation to solve the problem studied by Hung [12]. An optimal algorithm for the single shift scheduling of hierarchical workforce has been introduced by Narasimhan [14]. Pastor and Corominas [15] proposed a bi-criteria integer programming model for hierarchical optimization problem in which the first objective is to minimize the cost and the second is to maximize the suitability of task assignment. Sungur and Yavuz [16] introduced for the first time a formal definition and a mathematical model for the assembly line balancing problem with hierarchical worker assignment (ALBHW).

To approximate models to assembly lines in practice real life constraints have been developed. (e.g. parallel stations, positional constraints). Parallel station must be opened in order to increase productivity or to create a more balanced line as well. Buxey [17] presented the techniques of assembly line balancing with the parallel operation of identical stations for a reduction in idle time. The ALB problem for multiple objective problems is solved using simulated annealing by McMullen and Frazier [18] when paralleling of workstations is permitted. This study showed how simulated annealing can be used to find improved solutions for balancing a production line where task times are stochastic, multiple products were produced in a mixed-model fashion, parallel workstations are allowed, and cycle time performance as well as total labor and equipment cost are all important. Bukchin and Rubinovitz [19] took into consideration the choice of equipment with parallel stations. They intended to minimize the total cost and the number of stations with the integer linear programming model they proposed. In another work, Askin and Zhou [20] proposed a nonlinear integer programming model which allowed mixed-model production and the use of identical parallel workstations at each stage of the serial production system. A greedy heuristic approach is also developed to solve the problem.

There can be some constraints in accordance with the position of the product in the assembly line depending on products. Essafi [21] introduced the line balancing problem with positional constraints for the flexible transfer lines composed of identical CNCs. The constraint is related to the positioning of the part. Tuncel and Topaloğlu [22] formulated an integer linear programming model which assigns tasks to the stations taking into account the position of the workpiece in an electronics company.

While positional constraints, parallel stations, task assignment restrictions and cycle time constraint are considering individually in previous studies in the literature, we have developed a mathematical model that incorporates a combination of all of them for the ALBHW. The objective of this assembly line balancing problem is to find the optimal assignment of workers and tasks to the stations, and to decide on the optimal parallel stations such that the total cost is minimized.

PROBLEM DEFINITION AND PROPOSED MATHEMATICAL FORMULATION

In this section, we present the problem definition and the mathematical formulation for the ALBHW problem.

The assumptions of the model are listed as follows:

- A single model product is produced on the assembly line.
- The precedence relations between the tasks are known.
- Task times are deterministic and varies according to the types of workers.
- The workpiece must be placed in a specific position in order to perform a task. (e.g. front and back tasks)
- Some groups of tasks must be assigned to the same station.
- Some of the tasks must be assigned to a station alone.
- Parallel stations are allowed in each stage of the production line.

In this problem, tasks differ with respect to their qualification requirements and there is a hierarchical workforce structure in which a lower qualified worker can be substituted by higher qualified ones with a higher cost. The first worker type (type-1) is the most qualified worker type and the last worker type (type-H) is the least qualified worker type. Accordingly, the more skill levels of worker increase, the more processing time of the tasks decreases. This is why the cost of workers is increasing in this direction. The objective of this assembly line balancing problem is to find the optimal assignment of workers and tasks to the stations, and to decide on the optimal parallel stations such that total cost is minimized.

In the formulation the following notation is used:

i	tasks
s	stages
k	parallel station in each stage
l	part position
h	worker types
N	number of tasks
M	upper bound on the number of stages
K	maximum number of parallel stations in each stage
L	number of part positions
H	number of worker types
PT_l	set of tasks that can be performed when the part is situated in position *l*
TT_r	set of tasks that should be assigned together in a stage excluding all other tasks (it also includes sets with one task that should be assigned alone in a stage)
G	precedence graph
k_i	the least qualified worker type for task *i*
$Wcost_h$	cost of type-*h* worker
W_k	cost factor for paralleling *k* identical stations
T_{ih}	processing time of task *i* when it is performed by type-*h* worker
C	cycle time
UB	upper bound for the number of parallel stations in a stage
LB	lower bound for the number of parallel stations in a stage

Decision variables:

x_{ihs}	1, if task *i* is assigned to stage *s* equipped with type-*h* worker; 0, otherwise
z_{skl}	1, if stage *s* is opened with *k* stations in parallel for the part position *l*; 0, otherwise
y_{hs}	1, if type-*h* worker is assigned to stage *s*; 0, otherwise

a_s number of parallel stations in stage *s*

b_{hs} total number of type-*h* workers in stage *s*

The proposed mathematical model can be formulated as follows:

Objective function:

$$min \sum_s \sum_h Wcost_h . b_{hs} + \sum_s \sum_k \sum_l W_k . z_{skl} \qquad (1)$$

Subject to

$$\sum_{h \le k_i} \sum_s x_{ihs} = 1 \qquad \forall i \qquad (2)$$

$$\sum_i x_{ihs} \le N . y_{hs} \qquad \forall h \in H, \forall s \in S \qquad (3)$$

$$\sum_k \sum_l z_{skl} \le 1 \qquad \forall s \in S \qquad (4)$$

$$\sum_h y_{hs} = \sum_k \sum_l z_{skl} \qquad \forall s \in S \qquad (5)$$

$$\sum_{h \le k_j} \sum_s s . x_{jhs} \le \sum_{h \le k_i} \sum_s s . x_{ihs} \qquad \forall (j, i) \in A \qquad (6)$$

$$\sum_i \sum_{h \le k_i} t_{ih} . x_{ihs} \le C . \sum_k \sum_l k . z_{skl} \qquad \forall s \in S \qquad (7)$$

$$\sum_{i \in PT_l} \sum_h x_{ihs} \le |PT_l| . (1 - \sum_k \sum_{t | t \ne l} z_{skt}) \qquad \forall s \in S, \forall l \in L \qquad (8)$$

$$\sum_{i \notin TT_r} \sum_h x_{ihs} \le N . (|TT_r| - \sum_{i \in TT_r} \sum_h x_{ihs}) \qquad \forall s \in S, \forall r \in R \qquad (9)$$

$$x_{ihs} = x_{fhs} = \cdots = x_{dhs} \qquad \forall (i, f .. d) \in TT_r, \forall h, \forall s \qquad (10)$$

$$\sum_k \sum_l z_{skl} \ge \sum_k \sum_l z_{(s+1)kl} \qquad \forall s \in S \,|s < M \qquad (11)$$

$$\sum_k \sum_l z_{skl} . k = a_s \qquad \forall s \in S \qquad (12)$$

$$b_{hs} = y_{hs} . a_s \qquad \forall s \in S, \forall h \in H \qquad (13)$$

$$b_{hs} \le |UB| . y_{hs} \qquad \forall s \in S, \forall h \in H \qquad (14)$$

$$b_{hs} \geq |LB|.\, y_{hs} \qquad \forall s \in S, \forall h \in H \tag{15}$$

$$b_{hs} \leq a_s - |LB|.\, (1 - y_{hs}) \qquad \forall s \in S, \forall h \in H \tag{16}$$

$$b_{hs} \geq a_s - |UB|.\, (1 - y_{hs}) \qquad \forall s \in S, \forall h \in H \tag{17}$$

$$x_{ihs} \in \{0,1\} \qquad \forall i, \forall h \in H | h \leq k_i, \forall s \tag{18}$$

$$z_{skl} \in \{0,1\} \qquad \forall s \in S, \forall k \in K, \forall l \in L \tag{19}$$

$$y_{hs} \in \{0,1\} \qquad \forall h \in H, \forall s \in S \tag{20}$$

The objective function (1) of the proposed model minimizes the labor and equipment cost. Constraint (2) ensures that each task is assigned to exactly one stage equipped with one worker of type-*h*. Constraint (3) provides the relation between x_{ihs} and y_{hs} variables; that is, if type-h worker is not assigned to the stage s, then the values of all related x_{ihs} variables are forced to be equal zero as well. Constraint (4) provides that if a station is opened in stage *s*, the number of parallel stations in this stage and the part positions allowed for these stations are unique. Constraint (5) ensures that a single worker type, part position and number of parallel stations are assigned to each stage on the line. Constraint (6) guarantees the fulfillment of the precedence relationships between tasks; that is, no successor of task is assigned to earlier station than that task. Constraint (7) satisfies that the total workload time in a stage does not exceed the total capacity time in that stage. Constraint (8) enables that only tasks performed in the same position of the workpiece can be assigned to the same workstation. Constraints (9) and (10) deal with the assignment of tasks that must be performed together in a stage or in different stages, respectively. Constraint (11) ensures that stages are opened in ascending order. Constraint (12) calculates the number of parallel stations in stage *s*. Constraint (13) determines the total number of type-*h* workers in stage *s*. However, this constraint is in the quadratic form and linearized by Constraints (14)-(17). This situation includes two case. The first case $y_{hs} = 0$, which type-*h* worker is not assigned to stage *s*, so that $b_{hs} = y_{hs} * a_s$ should be 0. Constraints (14) and (15) indicate $0 \leq b_{hs} \leq 0$, thus b_{hs} is forced to be zero. Constraints (16) and (17) indicate $a_s - |UB(a_s)| \leq b_{hs} \leq a_s - |LB(a_s)|$, and b_{hs} equals to zero. The second case $y_{hs} = 1$, so that b_{hs} equals to a_s. Constraints (14) and (15) become $|LB(a_s)| \leq b_{hs} \leq |UB(a_s)|$, which is satisfied by $b_{hs} = a_s$. Constraints (16) and (17) imply that $a_s \leq b_{hs} \leq a_s$, forcing $b_{hs} = a_s$. Constraints (18)-(20) define the binary variables.

The weight factor W_k, represents the cost of a stage with *k* parallel stations, taking into consideration the additional equipment cost. When the only objective is to minimize the total number of stations, without preferring sequential stations to parallel stations the weight values are as follows [19]:

$$W_k = \frac{k * W_{k-1}}{k-1} \qquad k = 2, \ldots, K \tag{20}$$

When trying to minimize the total number of stations, while trying to minimize the number of parallel stations as a secondary objective, the weights should be adjusted as follows:

$$W_k = \frac{k * W_{k-1}}{k-1} + \varepsilon \qquad k = 2, \ldots, K \tag{21}$$

ε is a small fixed value and can be interpret as penalty cost for opening a new station.

In this study, the example of Jackson [23] with 11 tasks is selected and Figure 1 depicts the precedence diagram [16]. Furthermore, the figure indicates the type of each task i (k_i). For instance, $k_3 = 2$, it means that task 3 is performed by type-1 and type-2 workers. The processing times of task 3 when it is performed by type-1 and type-2 workers are 5 and 6, respectively. The number of worker types is three i.e. $H = 3$. The processing times of the original problem are assigned to the type-1. The processing times of type-2 and type-3 are arranged as in [16].

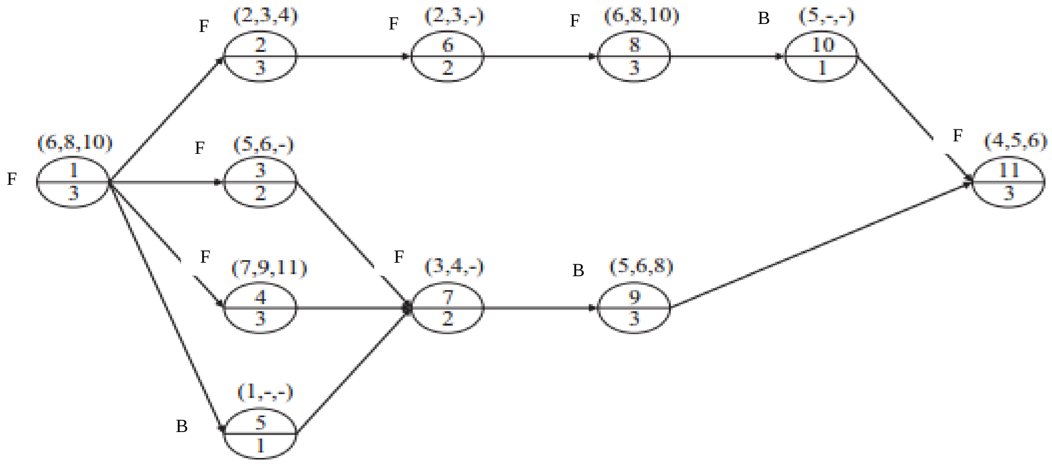

Figure 4. Precedence diagram

The tasks indicated as F in the Figure 1 are performed when the workpiece is turned to the frontside; the tasks indicated as B are carried out when the workpiece is turned to the backside. All the tasks assigned to a stage should consist of either all front or all back tasks.

Processing times of some tasks exceed the cycle time. In this case, a parallel station must be opened. In addition, to provide better fit of task assignment, parallel stations may be opened. The cycle time is equal to 6 units.

There are two task assignment restrictions in this problem. First one is that tasks 6 and 7 must be assigned to same station. The other one is that task 11 must be performed alone in a station. The number of part positions, the maximum number of parallel stations in each stage and the upper bound on the number of stages are equal to 2, 3 and the number of tasks, respectively i.e., L=2, K=3 and M=N.

The station opening and worker cost structures used for the ALBHW problem in [22] and [16] are adopted, respectively. Accordingly, these costs are as follows:

Table 3. Station and worker costs

Station Cost W_k	Worker Cost $Wcost_h$
10	100
22	70
35	49

The integer programming model is solved on the illustrative example. Table 2 shows optimal task assignments for the example.

Table 4. Optimal task assignment for the example problem

Stage	Parallel stations	Worker type	Tasks	Stage Time
1	1	1	1	6
2	1	1	5	1
3	2	2	2, 4	12
4	1	2	3	6
5	1	1	6, 7	5
6	1	1	8	6
7	1	1	10	5
8	1	2	9	6
9	1	3	11	6

Total Cost	931

COMPUTATIONAL RESULTS

This section consists of two parts. The first part describes the problem instances and the second part gives the computational results, respectively.

Problem Instances

The proposed mathematical model is applied to solve thirty test problems [24]. The test problems are taken from [16] and modified as follows:

- The “small (S)” and “medium (M)” data sets that include 20 and 50 tasks respectively are used.
- The “mixed” precedence graph, “low”, “medium” and “high” order strength and “peak at the bottom (PB)”, “peak in the middle (PM)” and “bimodal (BM)” task time distributions are considered.
- There are four types of trickiness categories which are “extremely tricky (ET) “, ”very tricky (VT)”, ”tricky (TR)” and ”less tricky (LT)”.
- The percentage of type-1, type-2 and type-3 tasks are determined as 20%, 30%, 50%, respectively.
- The processing times of the original problem are assumed for the type-1 worker. The processing times of type-2 and type-3 are arranged as [16] that $t_{i,h+1} = w_1 * t_{i,h}$ by rounding the resulting values to nearest integers. The cost of workers is determined as $Wcost_{h+1} = w_2 * Wcost_h$ where the cost of type-1 workers has been set to $Wcost_1$=100, $w_1 = 1.10,$ and $w_2 = 0.70$.
- The cost for paralleling k identical stations is determined as $W_k = \frac{k*W_{k-1}}{k-1} + \varepsilon$ where the cost of opening only one station is equal to 10 and $\varepsilon = 2$.
- The cycle time is equal to 1000 as in the original data set.
- Task 1 must be performed alone in a station.
- Tasks 19 and 20 must be assigned to the same station.
- Finally, we consider there are two types of part positions and three types of parallel stations in each stage.

Computational Results

The proposed mathematical model is solved using CPLEX 12.6.1. The computer system used is Intel® Core™ i7-5500U CPU with 12.0 GB RAM and 2.40 GHz speed. We limited the computation time as 7200 s.

In Table 3, the computational results of test problems are presented.

Table 5. The computational results of test problems

No'	Category	# of constraints	# of variables	# of stages	# of stages with 2 parallel stations	# of stages with 3 parallel stations	Total # of type-1 workers	Total # of type-2 workers	Total # of type-3 workers	Total cost	CPU time''	GAP%
291	S/0.2/PB/LT	616	1461	6	-	-	3	2	1	549	10	0
297	S/0.2/PB/TR	616	1461	6	-	-	3	1	2	528	15	0
313	S/0.2/PB/VT	616	1461	6	-	-	3	1	2	528	16	0
316	S/0.2/PM/TR	614	1461	10	3	-	3	3	7	989	7200	%2.14
318	S/0.2/PM/ET	614	1461	10	2	-	3	5	4	970	7200	%5.58
319	S/0.2/PM/VT	615	1461	12	1	1	4	3	8	1159	7200	%10.40
325	S/0.2/PM/LT	615	1461	11	3	-	5	4	5	1171	7200	%16.42

341	S/0.2/BM/LT	614	1461	8	-	-	3	2	3	667	38	0
348	S/0.2/BM/TR	615	1461	6	1	-	4	2	1	661	41	0
366	S/0.6/PB/LT	628	1461	6	-	-	3	1	2	528	12	0
368	S/0.6/PB/TR	628	1461	5	-	-	3	-	2	448	15	0
373	S/0.6/PB/VT	627	1461	7	-	-	3	2	2	608	18	0
392	S/0.6/PM/TR	624	1461	10	4	-	5	5	4	1194	7200	%14.37
406	S/0.6/PM/LT	624	1461	10	3	-	6	-	7	1079	7200	%4.41
416	S/0.6/BM/LT	624	1461	8	-	-	5	2	1	769	62	0
427	S/0.6/BM/TR	625	1461	9	-	-	3	2	4	726	255	0
443	S/0.9/PB/LT	634	1461	10	-	-	3	3	4	806	20	0
453	S/0.9/PB/VT	633	1461	8	-	-	3	1	4	646	15	0
469	S/0.9/PM/LT	628	1461	11	4	-	3	5	7	1151	4860	0
491	S/0.9/BM/VT	631	1461	10	-	-	3	3	4	806	46	0
492	S/0.9/BM/LT	632	1461	10	-	-	3	3	4	806	36	0
301	M/0.2/PB/LT	1557	8151	10	-	-	4	3	3	857	1800	0
325	M/0.2/PB/TR	1553	8151	11	-	-	4	4	3	937	2640	0
327	M/0.2/PM/ET	1548	8151	26	3	1	10	6	15	2476	7200	%45.08
352	M/0.2/BM/ET	1556	8151	13	1	-	4	3	7	1095	7200	%24.23
377	M/0.6/PB/TR	1593	8151	11	-	-	5	3	3	967	2640	0
384	M/0.6/PB/ET	1591	8151	13	-	-	3	5	5	1025	7200	%5.05
401	M/0.6/PM/ET	1595	8151	22	8	1	7	9	16	2455	7200	%50.73
426	M/0.6/BM/ET	1595	8151	14	2	-	4	7	5	1299	7200	%28.5
524	M/0.9/BM/ET	1616	8151	20	2	-	6	7	9	1755	7200	%23.07

' Back tasks are 2, 7, 10, 12, 13, 16 for small data sets (S) and 2, 5, 6, 9, 14, 16, 18, 22, 24, 30, 37, 41, 44, 46, 49 for medium data sets (M)
" CPU time unit is seconds.

As it can be seen from Table 3, CPU time extends when the number of tasks, trickiness levels and order strength increase. Due to the difficulty level of problems, optimum solution cannot be obtained within the time limit of 7200 seconds. More detailed explanation for related solution i.e. gaps, total costs, and CPU time are respectively in the 13th, 11th and 12th columns of Table 3.

CONCLUSIONS

The main goal of this study is to formulate a new mathematical model for the assembly line balancing problem with hierarchical worker assignment, positional constraints, and station paralleling and task assignment restrictions. The objective of this problem is to find the optimal assignment of workers and tasks to the stations, and to decide on the optimal parallel stations such that total cost is minimized for a given cycle time. In further studies, this study can be extended as u type assembly lines or adapted for multi-model product, mixed-model assembly lines.

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DEVELOPMENT OF A ROUTE SELECTION MODEL FOR DISRUPTED MULTIMODAL TRANSPORT NETWORKS

Yasanur Kayikci[1]

Abstract – Multimodal transport serves a more efficient, effective and sustainable freight transport network. This network must be designed to be as resilient as practicable and also it should provide transport service providers and carriers alternative feasible routes in case of a disruption. This paper presents a route selection model which supports transport planners to decide quickly on an optimal freight route for disrupted multimodal transport networks. An integrated Fuzzy Analytic Hierarchy Process and Fuzzy Goal Programming approach is used to develop this route selection model.

Keywords – decision support, fuzzy AHP, fuzzy GP, multimodal transport, stochastic programming

INTRODUCTION

A well-established transport system is very critical to the economic development and welfare. A competitive and sustainable multimodal transport network is therefore essential for companies to execute their supply chain processes successfully in both domestic and international operations. Multimodal transport offers an advanced platform for more efficient, effective and sustainable freight transport network [9] by enabling technical and economic advantages of long distance, high safety and speed, large transport capacity and low tariffs. Multimodal transport (also known as combined transport) is defined as a transport system which integrates at least two different transport modes in a transport chain. The association of transport modes within a multimodal transport network takes place across different combinations such as: rail-road, sea-road, sea-rail and so on. Any disruption within a transport network caused by natural disaster (hurricane, flood), traffic condition (construction work on highways, accident, traffic volumes), weather condition, technical problem, wear and tear, political issues (changing policies, customs issues) or human factor may affect the system reliability and efficiency and risk overheating [3]-[6]. Therefore, it is an important goal for decision makers (usually transport network planners), in case of a disruption, to offer cost effective, swift, time efficient alternative freight routes for transport users.

Based on this need, this study proposes a route selection model using an integrated Fuzzy Analytic Hierarchy Process (Fuzzy AHP) and Fuzzy Goal Programming (Fuzzy GP) approach. Fuzzy AHP is used to determine weights of each selection criteria, whereas Fuzzy GP is used to calculate the optimal route in terms of weights of each goal. Finally, a real-world case is presented in order to demonstrate the usefulness of the proposed method.

Multimodal transport refers to the transport of goods by using two or more different modes of transport (e.g. road, rail, air or inland waterway, and short or deep sea shipping) from one country to another based on one contract where the handling units (mostly containers or semi-trailers) do not change. Often a multimodal transport provider (MTP) or a consortium of MTPs (such as liner shipping provider and railway freight provider) is responsible for the performance of the entire haulage contract from origin to destination (O-D) [4].

RESEARCH FOCUS

There are various transport network forms in order to define routing between O-D seen in Figure 1: direct link, corridor, hub-and-spoke, connected hubs, static routes, and dynamic routes [10], where dotted lines show operationally related links in the network design and in dynamic routes, two alternative routes are shown. In all other designs, the routing is predefined. In the literature, consolidation systems are mostly configured as hub-and-spoke networks, with hub being a freight handling (consolidation) facility. Locations of hubs are determined and spoke nodes are allocated to the hubs [9]. The hub and spoke systems is a process whereby the main leg by carrier haulage between the ocean port and the hub is operated by rail or inland waterways, meanwhile the initial and final legs are usually operated by road [5] and these are often offered or arranged by MTP. This concept is a typical illustration of the multimodal transport networks.

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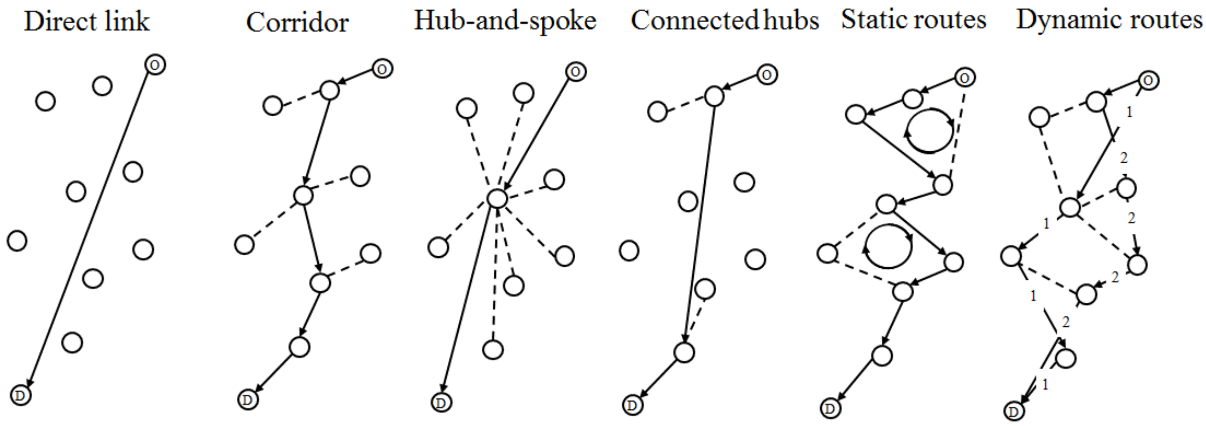

Figure 1. Six options for O-D transportation in a network of ten nodes

Because of its complex nature, multimodal transport networks are characterized by dynamically changing conditions and various modes of transport operating simultaneously on them. Goals of relevant interest such as the minimization of cost, time, risk or maximize service level, reliability, are conflict. Therefore, generally, there is no single optimal solution, but rather a set of optimal trade-off solutions, from which the decision maker must select the most preferred one, or the best compromise solution. It is usually assumed that the route selection in multimodal transport network is a multi-goal multi-criteria decision problem which needs to consider both qualitative and quantitative factors evaluating potential routes. Many experts solve this problem based on the mathematical programming models [2] where often the quantitative factors are taken into considerations. In this study, an integrated Fuzzy AHP and Fuzzy GP is proposed as a solution methodology, as this method is suitable to process both qualitative and quantitative factors in route selection problem, using Fuzzy AHP, decision makers can consistently integrate multi expert opinions and effectively determine appropriate weights. With the objective functions of Fuzzy GP, decision makers can effectively set the upper and lower limits to find the optimal route for each condition.

METHODOLOGY

Proposed procedure

This study is integrated Fuzzy AHP and Fuzzy GP to find the optimal route for multimodal transport. A procedure is given in Figure 2. First, Fuzzy AHP is used to obtain the relative weights of route selection criteria based on different freight conditions. It includes these steps: (1) determine the route selection problem, determine the possible routes (2) identify the selection criteria and construct the Fuzz AHP hierarchy, (3) perform the pairwise comparisons, decision makers are interviewed to obtain their opinions by using linguistic variables, (4) calculate weight for each criterion, (5) check consistency if it is not less than 0.10 then the expert is asked to revise his opinion until a consistency is met, (6) determine weights for main goals. Second, Fuzzy GP is utilized to process quantitative evaluation using weight numbers as coefficients of an objective function to determine the optimal route among given alternatives. It includes these steps: (1) Formulate the main goals of road selection with weight numbers that includes cost minimization, time minimization, risk minimization and service maximization. (2) solve Fuzzy GP and evaluate the potential routes, (3) filter potential routes. Finally, one of these potential routes can be selected as optimal route.

The AHP, first suggested by Saaty [8], is one of the most widely used multi criteria decision making (MCDM) methods. AHP can effectively handle both qualitative and quantitative data in order to decompose the problem hierarchically, such that, the problem is broken down thoroughly and its related sub criteria, with regards to hierarchical level, are listed in relation to the overall goal/objective to the sub-criteria. However, the conventional AHP method may not reflect the human judgment accurately. Hence AHP with its fuzzy extension, namely Fuzzy AHP approaches which use the concept of fuzzy set theory and hierarchical structure analysis are proposed in order to solve MCDM problems. The basic concept of Fuzzy AHP [1] is presented as follows:

Step 1: development of hierarchical structure for the decision making problem with an overall goal or objective at the top, criteria and sub-criteria at various levels and the decision alternatives at the bottom of the hierarchy.

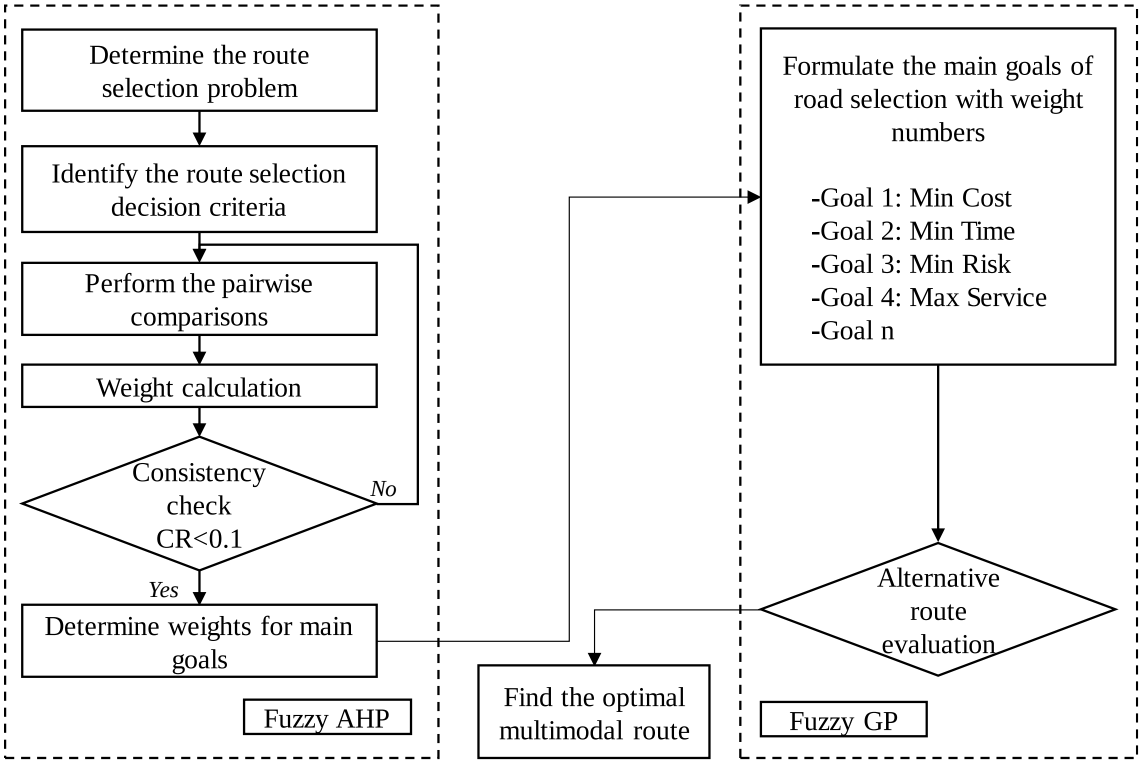

Figure 2. An Integrated Fuzzy AHP and Fuzzy GP Procedure for Optimal Multimodal Transport Route Selection

Step 2: construction of the fuzzy judgment matrix, $\widetilde{M}(a_{ij})$, by using triangular fuzzy numbers (TFNs) with pair-wise comparison as in Equation (1):

$$\widetilde{M}(a_{ij}) = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \ldots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \ldots & 1 \end{bmatrix} = \begin{bmatrix} (1,1,1) & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \frac{1}{\tilde{a}_{12}} & (1,1,1) & \ldots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{\tilde{a}_{1n}} & \frac{1}{\tilde{a}_{2n}} & \ldots & (1,1,1) \end{bmatrix} \quad (1)$$

The judgment matrix $\widetilde{M}$ is an $n\ x\ n$ fuzzy matrix containing fuzzy numbers $\tilde{a}_{ij}$(2):

$$\tilde{a}_{ij} = \begin{cases} 1,2,3,4,5,6,7\ ,\ or \\ 1^{-1},2^{-1},3^{-1},4^{-1},5^{-1},6^{-1},7^{-1}, if\ i \neq j \\ 1,\ if\ i = j \end{cases} \quad (2)$$

Where $\tilde{a}_{ij} = \tilde{a}_{ij}^{-1}$, and all $\tilde{a}_{ij}$are TFNs $\tilde{a}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right)$.

Let $X = \{\{x_1, x_2, \ldots., x_n\}$ be an *object set*, whereas $G = \{g_1, g_2, \ldots., g_m\}$ be a *goal set*. According to the fuzzy extent analysis model, each object is taken and extent analysis for each goal, g_i, is performed respectively. Resulting in m extent analysis values for each object can be obtained with $\widetilde{M}_{gi}^1, \widetilde{M}_{gi}^2, ., \widetilde{M}_{gi}^m,\ i = 1,2, \ldots., n$, where all the $\widetilde{M}_{gi}^j (j = 1,2, \ldots, m)$are TFNs representing the performance of the object x_i with regard to each goal g_i.

Step 3: The value of fuzzy synthetic extent of the ith object for m goals is defined as:

$$S_i = \sum_{j=1}^{m} \widetilde{M}_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} \widetilde{M}_{gi}^{j}\right]^{-1} \quad (3)$$

To obtain $\sum_{j=1}^{m} \tilde{M}_{gi}^{j}$ the fuzzy addition operation m extent analysis values for a particular matrix is performed such as

$$\sum_{j=1}^{m} \tilde{M}_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{4}$$

And to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{gi}^{j}\right]^{-1}$, the fuzzy addition operation of $M_{gi}^{j}(j = 1,2, \dots, m)$ values is performed such as

$$\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \tag{5}$$

And then the inverse of the vector above is computed, such as

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{6}$$

The degree of possibility of $\tilde{M}_1 \geq \tilde{M}_2$ is defined as:

$$V(\tilde{M}_1 \geq \tilde{M}_2) = \sup_{y \geq x}\left[min(\mu_{\tilde{M}_1}(x), \mu_{\tilde{M}_2}(y))\right] \tag{7}$$

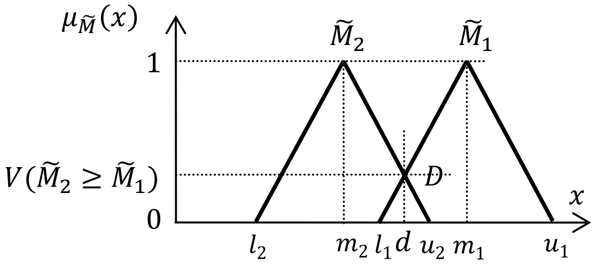

Figure 3. Intersection Point d between two TFNs, $\tilde{M}_1$ and $\tilde{M}_2$

When a pair (x, y)exist such that $x \geq y$ and $\mu_{\tilde{M}_1}(x) = \mu_{\tilde{M}_2}(y)$, the equality equation $V(\tilde{M}_1 \geq \tilde{M}_2) = 1$. Since $\tilde{M}_1 = (l_1, m_1, u_1)$ and $\tilde{M}_2 = (l_2, m_2, u_2)$ are convex fuzzy numbers and can be expressed like that:

$$V(\tilde{M}_1 \geq \tilde{M}_2) = 1 \; if \; m_1 \geq m_2 \tag{8}$$

$$V(\tilde{M}_1 \geq \tilde{M}_2) = hgt(\tilde{M}_1 \cap \tilde{M}_2) = \mu_{\tilde{M}_1}(d) \tag{9}$$

Where, d is the ordinate of the highest intersection point D between $\mu_{\tilde{M}_1}$ and $\mu_{\tilde{M}_2}$ (Figure 3). When $\tilde{M}_1$and $\tilde{M}_2$, the ordinate of D is given by the following equation:

$$V(\tilde{M}_2 \geq \tilde{M}_1) = hgt(\tilde{M}_1 \cap \tilde{M}_2) = \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \tag{10}$$

To compare $\tilde{M}_1$and $\tilde{M}_2$both values of $V(\tilde{M}_1 \geq \tilde{M}_2)$ and $V(\tilde{M}_2 \geq \tilde{M}_1)$ are required.

Step 4: The degree possibility of a convex fuzzy number to be greater than k convex fuzzy numbers $M_i(i = 1,2, \dots k)$ can be defined by

$$V(\tilde{M} \geq \tilde{M}_1, \tilde{M}_2, \dots, \tilde{M}_k) = V\left[(\tilde{M} \geq \tilde{M}_1) \text{ and} \left[\text{V}(\tilde{M} \geq \tilde{M}_2) \text{and } (\tilde{M} \geq \tilde{M}_k)\right] = \min V(\tilde{M} \geq \tilde{M}_i) \; i = 1,2 \dots k \right. \tag{11}$$

Assuming that

$$d'(A_i) = min\, V(S_i \geq S_k), k = 1,2, \dots, n; k \neq i \tag{12}$$

Then, the weight vector is obtained as follows:

$$w' = (d'(A_1), d'(A_2), \dots \dots, d'(A_n))^T \tag{13}$$

Where $A_i (i = 1,2, \dots, n)$ are n elements.

Step 5: After normalization, the normalized vectors are defined as:

$$w = (d(A_1), d(A_2), \dots \dots, d(A_n))^T \tag{14}$$

Where w is a non-fuzzy number.

The normalized weight vector is calculated as $Nw_i = w_i / \sum w_i$.

Fuzzy Goal Programming (Fuzzy GP)

Route selection problem with varied preferences is a typical decision-making problem involving multi criteria and objectives. Therefore, it often has some conflict sourcing goals such as cost, time and service quality. To maximize the utility function and fulfil the decision maker's aspiration levels Fuzzy GP [7]-[11] was implemented in solving this decision making problem. Further, these decision makers can define linguistic priorities in membership functions on goal values by considering fuzzy theory.

A Fuzzy GP can be formulated as follows:

Max λ

Subject to $\lambda - \mu_k(Z_k(X)) \leq 0, k = 1, 2, \dots, n$ (15)

$X \in F$, (F is a feasible set), $X \geq 0$.

Where λ is the *extra continuous variable*, $Z_k(X)$ is the *linear function* of the kth goal, X is $1 \times N$ vector of decision variables and $\mu_k(Z_k(X))$ is the fuzzy membership function of kth objective.

The preference-based membership functions are expressed as follows:

$$\mu_k(Z_k(X)) = \begin{cases} 1 & \text{if} \quad Z_k(X) \geq g_k \\ \frac{(Z_k(X) - l_k)}{g_k - l_k} & \text{if} \quad l_k < Z_k(X) < g_k \\ 0 & \text{if} \quad Z_k(X) \leq l_k \end{cases} \qquad \text{for } Z_k(X) \gtrsim g_k, k = 1,2, \dots, k_1, \tag{16}$$

$$\mu_k(Z_k(X)) = \begin{cases} 1 & \text{if} \quad Z_k(X) \leq g_k \\ \frac{(u_k - (Z_k(X))}{u_k - g_k} & \text{if} \quad g_k < Z_k(X) < u_k \\ 0 & \text{if} \quad Z_k(X) \geq u_k \end{cases} \text{for } Z_k(X) \lesssim g_k, k = k_1 + 1, \dots, K, \tag{17}$$

Where l_k and u_k are, respectively, the lower and upper tolerance limits for the kth fuzzy goal. $(g_k - l_k)$ as well as $(u_k - g_k)$ are the tolerances which are subjectively chosen. $\gtrsim$ and $\lesssim$ represent the fuzzified versions of $\geq$ and $\leq$. g_k is the aspiration level of the kth goal. $Z_k(X) \gtrsim g_k$ indicates the kth fuzzy goal approximately being essentially greater than or equal to the aspiration level g_k, whereas $Z_k(X) \lesssim g_k$ is to be understood as essentially less than or equal.

EMPIRICAL RESEARCH

Over the past decade freight transport volume between Turkey and the EU has grown rapidly and has generally been coupled with growth in GDP. A white goods producer company based in Turkey that produces refrigerators and washing machines wants to transport the products from its factory in Bursa to a customer in Austria. The company works with different MTPs for each possible multimodal route. Transport unit can be either semi-trailer or complete unit. The shipper wants to select an optimal multimodal route as the normal operation route is disrupted at this moment. The company established an expert group to decide on selection criteria and possible routes with using a variety of techniques including brainstorming, semi-structured surveys and interviews. According to expert suggestions, the final hierarchy of selection criteria and routes are listed in Figure 4. The criteria which are considered during the selection of the optimal multimodal route include freight cost, transport time, risk of multimodal route and service level of MTP.

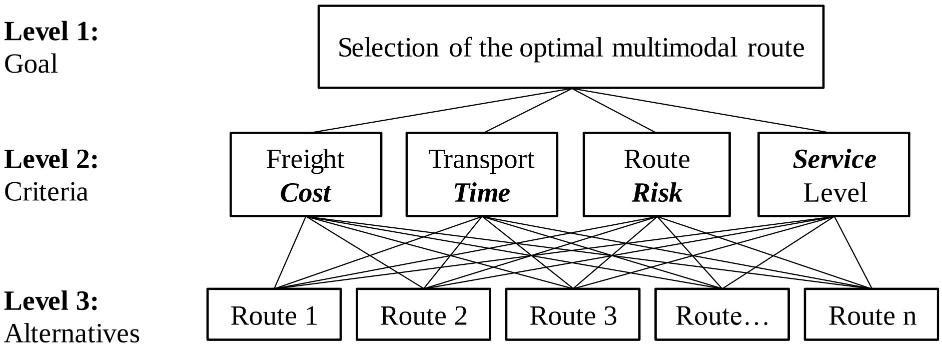

Figure 4. Hierarchy of Route Selection Problem

The expert group prioritized these criteria with three customers' freight conditions; respectively with slow (case1), normal (case2) and fast (case3) transport by using Fuzzy AHP method. By applying formulas from equations (1) to (14):

$$S_1 = (0.2031, 0.3008, 0{,}4716), S_2 = (0.1525, 0.2161, 0.2720),$$

$$S_3 = (0.1623, 0.2167, 0.2957), S_4 = (0.1875, 0.2665, 0.3786)$$

$$V(S_1 \geq S_2) = 1, V(S_2 \geq S_1) = 0.45, V(S_3 \geq S_1) = 0.52, V(S_4 \geq S_1) = 0.84,$$

$$V(S_1 \geq S_3) = 1, V(S_2 \geq S_3) = 0.99, (S_3 \geq S_2) = 1, V(S_4 \geq S_2) = 1,$$

$$V(S_1 \geq S_4) = 1, V(S_2 \geq S_4) = 0.63, V(S_3 \geq S_4) = 0.69, V(S_4 \geq S_3) = 1$$

$$d'(Cost) = 1, d'(Time) = 0.45, d'(Risk) = 0.52, d'(Service) = 0.84$$

$$w' = (1, 0.45, 0.52, 0.84)^T, w = (0.36, 0.16, 0.19, 0.30), CR = 0.095.$$

In this calculation, a set of linguistic values is used $I = \{very\ low = VL, low = L, medium\ low = ML, medium = M, medium\ high = MH, high = H, very\ high = VH\}$ in order to denote the importance weight of each criterion. TFNs corresponding to these linguistic values are: $VL = (0.0{,}0.0{,}0.1), L = (0.0{,}0.1{,}0.3), ML = (0.1{,}0.3{,}0.5), M = (0.3{,}0.5{,}0.7), MH = (0.5{,}0.7{,}0.9), H = (0.7{,}0.9{,}1.0), VH = (0.9{,}1.0{,}1.0)$. Table 1 shows the fuzzy expert evaluation of selection criteria for slow transport.

Table 1. The Fuzzy Evaluation of Criteria for Case1

	Cost	Time	Risk	Service	Weight
Cost	(1,1,1)	(1,1.11,1.43)	(1.43,2,3.34)	(0.7,0.9,1)	0.36
Time	(0.7,0.9,1)	(1,1,1)	(0.9,1,1)	(0.5,0.7,0.9)	0.16
Risk	(0.3,0.5,0.7)	(1,1,1.11)	(1,1,1)	(1,1.11,1.43)	0.19
Service	(1,1.11,1.43)	(1.11, 1.43,2)	(0.7,0.9,1)	(1,1,1)	0.30

The consistency ratio of expert judgments is checked. The ratio of consistency (CR) should not be greater than 0.10. Else, expert should re-enter the judgments. First of all, the consistency index should be calculated with equation (18), where λ_{max} is main value of comparison matrix, and n is number of columns.

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \tag{18}$$

Consistency ratio is calculated by using equation (19), where RI is the random index.

$$CR = CI/RI \tag{19}$$

After the consistency check the weight of criteria according to three cases are determined as seen in Table 2. For the case 1, cost is ranked as prior criterion, as the freight can be transported slowly therefore the route can be mainly cost efficient whereas for the case 2, the prior criterion is risk and for the case 3, cost and time are ranked as prior criteria.

Table 2. The Weight of Criteria according to Cases

Goals	Case1	Case2	Case3
Cost	0.36	0.25	0.31
Time	0.16	0.15	0.31
Risk	0.19	0.39	0.18
Service	0.30	0.21	0.21
CR	0.095	0.088	0.077

The expert group determined ten potential multimodal routes according to the existing rail, road and sea link within O-D shown in Figure 5, where the main legs are operated by RoLa and RoRo. RoLa (rolling road) services are specially designed wagons to carry wheeled cargo by rail link to/from the ports/terminals, whereas RoRo (roll-on/roll-off) vessels are specially types of ships designed to carry wheeled cargo by sea link to/from the ports. The initial and final legs are operated by road link. The values of cost and time frame of each route are offered directly by MTPs that provide the transport services for those paths. The transport unit cost of semi-trailer is Euro and the time shows the total traveling time per day. Risk and service values are generated according the expert consensus. The higher score of risk means the higher average risk for route. The higher score of service means that MTP can provide a better average service for selected route. Table 3 denotes the route table according to each route and selection criteria.

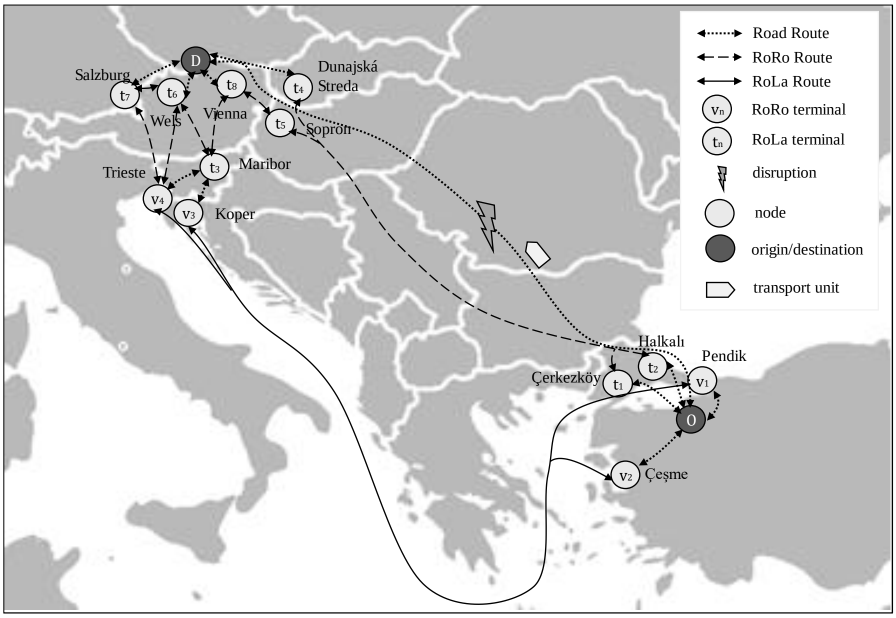

Figure 5. Alternative Multimodal Transport Routes between O-D in Case of a Disruption

Table 3. The Route Table for Multimodal Transport between O-D

#	Multimodal route	Transport modes	Cost	Time	Risk	Service
1	$O-t_2-t_4-D$	RoLa	2800	6.5	10	6
2	$O-v_1-v_4-t_7-D$	RoRo-RoLa	3800	7	6	8
3	$O-t_1-t_5-t_8-D$	RoLa-RoLa	3500	8.5	8	8
4	$O-t_2-t_8-D$	RoLa	3200	10.5	6	6
5	$O-v_1-v_4-t_7-t_6-D$	RoRo-RoLa-RoLa	2900	7	10	8
6	$O-v_1-v_3-t_3-t_6-D$	RoRo-Road-RoLa	3100	9	6	4
7	$O-v_1-v_4-t_3-t_6-D$	RoRo-Road-RoLa	3050	6	8	6
8	$O-v_2-v_4-t_7-D$	RoRo-RoLa	3000	8	4	6
9	$O-t_2-t_6-D$	RoLa	2900	9	6	8
10	$O-v_1-v_4-t_6-D$	RoRo-RoLa	2950	8.5	6	4

Table 4. The Goals for Route Selection

Constraints	Goals	Criteria	Lower bound	Upper bound	Difference
G_1	*Minimize*	Cost	0	3000	3000
G_2	*Minimize*	Time	0	10	10
G_3	*Minimize*	Risk	0	8	8
G_4	*Maximize*	Service	6	10	4

There are four goals for the route selection, including cost, time, risk and service. Table 4 summarizes the lower and upper bound of the goals for the route selection. To determine the optimal multimodal route, the goals are formulated with Fuzzy GP according to equations (15) to (17) as detailed in the appendix. This problem is solved by using LINGO 13.0 software package to obtain the solutions seen in Table 5.

The result gives a list of possible routes. According to result of case 1, slow transport, the prior route is the route 10 which uses RoRo and RoLa links. Transport cost is 2950 Euro, time period is 8.5 days, risk scale is 6 and service level is 4. The result of case 2 shows that the prior route is the route 8, which is composed of RoRo and Rola links. Transport cost is 3000, time period is 8 days, risk scale is 4 and service level is 6. The result of case 3 denotes the route 10 as prior route which is the combination of RoRo and RoLa links. Transport cost is 2950 Euro, time period is 8.5 days, risk scale is 6 and service level is 4.

Table 5. Result from Case1, Case2 and Case 3

	Route	Cost	Time	Risk	Service	Deviation
#	Target goal	3000	10	8	10	
Case1	Weight	0.36	0.16	0.19	0.30	
10	$O-v_1-v_4-t_6-D$	2950	8.5	6	4	8.83
6	$O-v_1-v_3-t_3-t_6-D$	3100	9	6	4	9.83
8	$O-v_2-v_4-t_7-D$	3000	8	4	6	11.50
4	$O-t_2-t_8-D$	3200	10.5	6	6	14.53
Case2	Weight	0.36	0.16	0.19	0.30	
8	$O-v_2-v_4-t_7-D$	3000	8	4	6	8.87
10	$O-v_1-v_4-t_6-D$	2950	8.5	6	4	13.25
6	$O-v_1-v_3-t_3-t_6-D$	3100	9	6	4	13.75
4	$O-t_2-t_8-D$	3200	10.5	6	6	16.53
Case3	Weight	0.31	0.31	0.18	0.21	
10	$O-v_1-v_4-t_6-D$	2950	8.5	6	4	10.58
6	$O-v_1-v_3-t_3-t_6-D$	3100	9	6	4	10.58
4	$O-t_2-t_8-D$	3200	10.5	6	6	11.06
8	$O-v_2-v_4-t_7-D$	3000	8	4	6	12.37

RESULTS AND CONCLUSION

The aim of this study is to develop a route selection method by applying Fuzzy AHP and Fuzzy GP techniques that can accommodate criteria in making decision and optimization on a multimodal transport route for shippers or MTPs in case of disruption. The main contribution of this study is to integrate pre-selected qualitative and quantitative criteria in order to solve a real world problem. The proposed method is accurate, flexible and efficient system, and supports the transport network planner to decide on an optimal route quickly if any disruption occurs within the transport network. According to customer needs or freight situation, decision maker can evaluate all other alternatives and find the optimal one. This proposed model can be used in many other transport applications.

APPENDIX

$$\mathrm{Max} = 0.36 * C1 + 0.16 * C2 + 0.19 * C3 + 0.30 * C4; \qquad (\mathrm{ForCase1})$$

$$C1 \le (3000 - (6.7 * X1 - 26.7 * X2 - 16.7 * X3 - 6.7 * X4 + 3.3 * X5 - 3.3 * X6 - 1.7 * X7 + 3.3 * X9 + 1.7 * X10))/3000; \qquad (\mathrm{ForG1: MinimizeCost})$$

$$C2 \le (10 - (65 * X1 + 70 * X2 + 85 * X3 + 105 * X4 + 70 * X5 + 90 * X6 + 60 * X7 + 80 * X8 + 90 * X9 + 85 * X10))/10; \qquad (\mathrm{ForG2MinimizeTime})$$

$$C3 \le (8 - (-25 * X1 + 25 * X2 + 25 * X4 - 25 * X5 + 25 * X6 + 50 * X8 + 25 * X9 + 25 * X10))/8; \qquad (\mathrm{ForG3: MinimizeRisk})$$

$$C4 \le ((40 * X1 + 20 * X2 + 20 * X3 + 40 * X4 + 20 * X5 + 60 * X6 + 40 * X7 + 40 * X8 + 20 * X9 + 60 * X10) - 10)/4; \qquad (\mathrm{ForG4: MaximizeService})$$

$$X_1 + X_2 + \cdots + X_{10} = 1, X_j = 0 \text{ or } 1: j = 1,2, \ldots,10.$$

ACKNOWLEDGMENT

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A COMPARATIVE STUDY OF SCALARIZATION TECHNIQUES ON THE BI-OBJECTIVE SET COVERING PROBLEM

Nurcan Deniz[1], *Tugba Sarac*[2]

Abstract − *Set covering models can be classified in covering based models in the discrete location selection models. The main objective is to open minimum new facilities (minimum cost) to cover all of the existent facilities. Set covering problems are NP-Hard problems in spite of there is only one constraint- about covering at least one time- in the model. Literature about bi-objective set covering problems is scarce and second objective function is defined as minimizing the total cost generally. Daskin (1995:107) showed a different version of bi-objective set-covering problem which have an objective function about maximizing the number of facilities covered more than once. In this study, we consider the bi-objective set covering problem. Its objectives are minimizing the number of new facilities to open and maximizing the number of facilities covered more than once. Weighted sum, epsilon constraint, hybrid, elastic constraint, Benson, Tchebycheff and conic scalarization techniques compared over this problem. As a result, epsilon constraint is the best method in producing different pareto optimal solutions and conic scalarization is the best in producing unique solutions among others.*

Keywords − *multi-objective problems, scalarization, set covering.*

INTRODUCTION

Multicriteria Decision Making (MCDM) is a developing area over the last fourty years in modelling real world decision problems dealing with conflicting more than one criteria [11]. Multiobjective optimization problems seek best trade-off among these criteria [2]. Finding Pareto optimal points on the Pareto frontier in multi-objective optimization problems (MOPs) is one of the oldest challenges in science and engineering [7]. Garfinkel and Nemhauser (1973), Roth (1969), Lemke et al. (1971), Bellmore and Ratliff (1971), Chavatal (1979) and Balas (1980) are the first researchers dealing with single objective Set Covering Problem (SCP) [1]. Prins et al (2006) proposed a two-phase heuristic using the primal-dual Lagrangian relaxation to solve single objective SCP.

Florios&Mavrotas (2014) stated there aren't many studies about bi-objective set covering problem (BOSCP) in the literature whether single objective SCPs are studied more. Daskin and Stren (1981) are the researchers who modelled lexicographic multiple objective set covering problem in placing emergency services. Liu (1993) and Jaszkiewicz (2001) are the other researchers solved BOSCP with heuristics [11]. Arora et al. (2011) developed an algorithm based on goal programming approach with non-linear objectives under pre-emptive priority structure to solve a multi-objective quadratic set-covering problem. Florios&Mavrotas (2014) studied on a BOSCP which has two different cost parameters and developed a method (AUGMECON) based on epsilon-constraint scalarization technique. Owais et al. (2016) formulated a SCP for the selection stage of multi- objective transit route network design problem.

There is a gap in comparing the scalarization techniques also. Palar et al (2015)'s study is one of the study that compares scalarization techniques. They implemented Tchebycheff and weighted sum scalarization functions inside a single surrogate assisted local search memetic algorithm and showed the advantages of Tchebycheff technique.

In the second section of the study there will be introductory information about set covering problems. Third section of the study consists of a summary about scalarization techniques. A numerical example about scalarization techniques on BOSCP is in fourth section. After the comparison of scalarization techniques in fifth section, the study ends with a conclusion and future studies part.

BI-OBJECTIVE SET COVERING PROBLEM

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Daskin (1995) classifies discrete location selection models in three section: median-based models, covering based models and other models. P-median and fixed-charge (capacitated/uncapacitated) location selection models are classified in median based models. Covering based models are including p-center, set covering and maximum covering models. P-dispersion model is classified in other models.

Set covering problem is located in covering based models in discrete location selection models. In this problem, it is aimed to open minimum new facilities to cover all facilities. This problem has only one constraint about covering all facilities at least one time and objective function is a minimization function. Despite its simplicity, it is NP-Hard problem. Single objective SCP model is shown below[4]:

$Min\ Z = \sum_{j \in N} C_j x_j$(minimum number new facility)

C_j = cost of opening a facility in j

s.t

$\sum_{j=1}^{n} a_{ij} X_j \geq 1\ \forall\ i \in I$ (all facilities should be covered at least one time)

$X_j \in \{0,1\}$

x_j : 1, if there will be open a new facility in j; 0, otherwise.

There is a different version of BOSCP in Daskin (1995:107)'s book about discrete location. In this version, first objective (minimizing the facility number) is the same as SCP. Maximizing the facilities covered by more than one facility is the second objective in this example. This is a multi-objective model, because of the conflicting objective functions. There need to add a new decision variable in the model about covering more than one in the new model. It is assumed that cost of opening new facilities are equal in the model. Second objective function was multiplied with (-) in to combine two objective functions in one.

$Min\ Z = \sum_{k \in N} y_k - \sum_{i \in N} s_i$(minimum number new facility and maximum number facility covered by more than one facility)

s.t

$\sum_{k=1}^{n} a_{ik} Y_{k} - s_i \ \geq 1\ \forall\ i \in I$ (all facilities should be covered at least one time)

$y_k \in \{0,1\}$, $s_i \in \{0,1\}$

y_k : 1, if there will be open a new facility which will give service to k. demand point; 0; otherwise

s_i : 1, if i. demand point will be covered by at least two facility; 0, otherwise

SCALARIZATION TECHNIQUES

Scalarization is the traditional approach in solving multicriteria optimization problems of the Pareto class [5]. Scalarization is defined as "*replacement of a multi-objective optimization problem by a suitable scalar optimization problem which is an optimization problem with a real valued objective functi*onal" [8]. Different scalarizing functions are used in multi-objective optimization methods. Some of them needs additional constraints in the model (Ɛ-constraint, Benson, Tchebycheff) and some of them (Weighted-sum, conic scalarization) are not. In this research, it is aimed to solve BOSCP model using different multi-objective scalarization techniques. BOSCP model was modelled in GAMS and solved with Cplex solver. Weighted-sum, epsilon (Ɛ)-constraint, hybrid, elastic constraint, Benson, Tchebycheff and conic scalarization methods are the scalarization techniques compared in this research context.

The Weighted-Sum Technique

The weighted-sum technique is the “simplest” method to solve multicriteria problems [5] and it is also known as “linear scalarization” [7]. In this technique, it is aimed to minimize a convex combination of the different objectives [10].

Let *wi* be the weight of the *i*th objective where *wi* >0 and $\sum_{i=1}^{r} w_i = 1$. It is aimed to minimize the sum of weighted objective functions in this technique.

$$\min_{x \in X} \sum_{k=1}^{p} w_k f_k(x)$$

The Epsilon (ε)-Constraint Technique

ε-constraint technique is probably “the best known” technique in multicriteria optimization problems introduced by Haimes et al. (1971). In this technique only one of the original objectives is minimized and the others are transformed to constraints [5].

$$\min_{x \in X} f_j(x)$$

s.t.

$$f_k(x) \leq \mathcal{E}_k, k = 1, \dots, p, j \neq k$$

The Hybrid Technique

Hybrid technique is the sum of weighted-sum and epsilon constraint techniques. The scalarized problem to be solved has a weighted sum objective and constraints on all objectives in this technique [5]. This technique can be modelled as below where x^0 is an arbitrary feasible point.

$$\min_{x \in X} \sum_{k=1}^{p} w_k f_k(x)$$

s.t.

$$f_k(x) \leq f_k(x^0), k = 1, \dots, p$$

The Elastic Constraint Technique

In ε-constraint technique, it is hard solve the scalarized problem due to the added constraints. Ehrgott and Ryan (2002) proposed elastic constraint scalarization to cope with this problem. In this technique, these constraints are relaxing by allowing them to be violated and penalizing (μ_k) any violation in the objective function [5].

$$\min_{x \in X} f_j(x) + \sum_{k \neq j} \mu_k s_k$$

s.t.

$$f_k(x) - s_k \leq \mathcal{E}_k, k = 1, \dots, p, j \neq k$$

$$s_k \geq 0, k = 1, \dots, p, j \neq k$$

The Benson’s Technique

The idea behind Benson’s (1978) technique is to choose some initial feasible solution $x_0 \in X$ and, if it is not itself efficient, produce a dominating solution that is. In this technique there need to define nonnegative deviation variables ($l_k = f_k(x^0) - f_k(x)$). The objective function is about minimizing the sum of these variables [5].

$$\min_{x \in X} \sum_k l_k$$

s.t.

$$f_k(x^0) - l_k - f_k(x) = 0, k = 1, \ldots\ldots, p,$$

$$l_k \geq 0, k = 1, \ldots., p$$

The Tchebycheff Technique

The Tchebycheff technique is based on a achievement type approach and reference point to improve the current solution. The reference point is the objective values of the individual models to be improved for each local search step [10]. The augmented weighted model can be expressed as below, where y_k^* represents the ideal point for *k.* objective function, *p* represents objective number and ρ represents adequately small positive number [5];

$$\min \alpha + \rho \sum_{k=1}^{p} \left(f_k(x) - y_k^*\right)$$

s.t.

$$\alpha \geq w_k(f_k(x) - y_k^*), k = 1, \ldots\ldots, p,$$

$$x \in X$$

The Conic Scalarization Technique

Conic Scalarization technique's foundations are Gasimov (2001)'s paper. Choosing the preference parameters which consist of weights of objective functions and a reference point for these objectives and solving the scalar optimization problem is the idea behind this technique [8]. B1 and B2 values determination according to weighted-sum technique solutions is the first step of this technique. Alpha value determination is the second step and alpha value need to be smaller than the smallest weight. The objective function in this technique is;

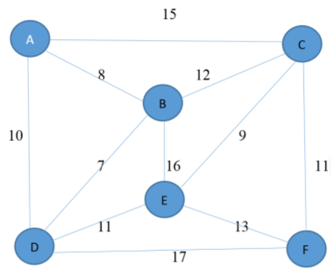
$$\min_{x \in X} \alpha \sum_{k}^{p} \left|f_k(x) - a_k\right| + \sum_{k \neq j} w_k(f_k(x) - a_k)$$

COMPUTATIONAL RESULTS

In this section firstly, a numerical example is given, then the results obtained by all of the scalarization methods explained in previous section are presented, finally performance of these scalarization methods are compared.

Numerical Example

It is considered to use a numerical example from Daskin (1995:95)'s book to make a comparison between multi-objective scalarization techniques on BOSCP. There are nodes (demand points) and distances in the network diagram in Figure 1.a. Distances in the network diagram were transferred to distance matrix in Figure 1.b. and this matrix was transformed to 0-1 matrix for maximum service distance (D_{max}) is 15 in Figure 1.c. d_{ik} values in Figure 1.b. represents whether *i*. Facility give service to *k*. demand point. For example A can give service to B (d_{ik} =1) because of the distance between A and B is 8<15. By the way A can't give service to E (d_{ik} =0) because of the distance between A and E is 21>15.



	A	B	C	D	E	F
A	-	8	15	10	21	26
B		-	12	7	16	23
C			-	19	9	11
D				-	11	17
E					-	13
F						-

D_{max}=15	A	B	C	D	E	F
A	1	1	1	1	0	0
B	1	1	1	1	0	0
C	1	1	1	0	1	1
D	1	1	0	1	1	0
E	0	0	1	1	1	1
F	0	0	1	0	1	1

Figure 5. a. Network Diagram b. Distance Matrix c. 0-1 Matrix(d_{ik})

Weighted Sum Technique

In this research weights are determined between [0-20]. Summary of solutions produced with 21 different weights are shown in Table 1. In this table, there are first (f_1) and second (f_2) objective function values in first and second columns. In the third column, there are new facility points according to the f_1 value. Facilities covered by more than one facility are placed in fourth column based on f_2 value. It can be seen that there are two alternative solution for the feasible solution of (2,3). The last columns is about the each unique solution's frequency. 14 solutions in 21 solutions is (3,6).

Table 1. Solution Summary with Weighted Sum Technique

f_1	f_2	New Facility Points	Facilities Covered by More Than One Facility	Frequency
6	6	1,2,3,4,5,6	1,2,3,4,5,6	1
3	6	3,4,5	1,2,3,4,5,6	14
2	3	3,5	3,5,6	4
2	3	3,4	1,2,5	1
2	0	1,3		1

Epsilon Constraint (Ɛ-Constraint) Technique

The maximum value of f_1 and f_2 are 6. Ɛ values are determined between [3, 6] interval because of the small dimension of the problem. In Table 2, there are results achieved by epsilon-constraint technique. Ɛ values are in the first column. The second and third column is about first (f_1) and second (f_2) objective function values respectively. The fourth columns is about the solution time. In the fifth column, there are new facility points according to the f_1 value. Facilities covered by more than one facility are placed in sixth column based on f_2 value.

Table 2. Solution with Ɛ-Constraint Technique

Ɛ	f_1	f_2	Time (s)	New Facility Points	Facilities Covered by More Than One Facility
3	2	3	0.05	1,3	1,2,3
4	3	4	0.11	1,3,5	1,2,3,5
5	3	5	0.13	3,4,5	1,2,3,4,5
6	3	6	0.11	3,4,5	1,2,3,4,5,6

Hybrid Technique

Solutions produced by hybrid technique can be seen in Table 3. In this table, there are first (f_1) and second (f_2) objective function values in first and second columns. In the third column, there are new facility points according to the f_1 value. Facilities covered by more than one facility are placed in fourth column based on f_2 value. The last columns is about the each unique solution's frequency. 14 solutions in 21 solutions is (3,6). The results are very similar with weighted-sum technique except one feasible point (6,6). By the way there is one more alternative solution about (2,3) point in hybrid solution and this solution's frequency is 4.

Table 3. Solution Summary with Hybrid Technique

f_1	f_2	New Facility Points	Facilities Covered by More Than One Facility	Frequency
3	6	3,4,5	1,2,3,4,5,6	14
3	6	1,3,5	1,2,3,4,5,6	1
2	3	3,5	3,5,6	1
2	3	3,4	1,2,5	4
2	0	1,3		1

Elastic Constraint Technique

Solutions produced by elastic constraint technique can be seen in Table 4. In the first column, there are punishment values. It can be seen from second and third column objective function values, there aren't any change in solutions with different punishment values (1, 10, 100 and 1000). The fourth column is about time and the fifth column is about points where the new facilities will be open. The last column is about the deviation values. It can be seen that there is only one solution (2,0) produced by elastic constraint technique.

Table 4. Solution with Elastic-Constraint Technique

μ	f_1	f_2	Time (s)	New Facility Points	Deviation Values
1	2	0	0.121	1,3	0
10	2	0	0.12	1,3	0
100	2	0	0.11	1,3	0
1000	2	0	0.097	1,3	0

Benson Technique

Definition of l_1 and l_2 is the first step in this technique. First of all, solution is produced according to (3,6) feasible point. Solution is repeated with (2,5) point to investigate two different feasible point effect. As it can be seen in Table 5, the first column is about solutions. The second and third columns are about l_1 and l_2 values respectively. The fourth and fifth columns are about objective values. Columns about time, new facility points and facilities covered by more than one facility are the next columns. It can be seen that there isn't any result corresponds second objective functions. That means there isn't any facility covered by more than one facility.

Table 5. Solution with Benson Technique

Solution	l1	l2	f_1	f_2	Time (s)	New Facility Points	Facilities Covered by More Than One Facility
3,6	0	6	3	0	0.0325	1,2,6	
2,5	0	5	2	0	0.05	1,3	

Tchebycheff Technique

In the first step of this technique, model solved as single objective. Objective function value is 2 for first objective function and 6 for second objective function. These values are used for alpha constraints. Table 8 shows the summary of the solution produced by two different δ values. It is concluded that there isn't a δ value differentiation effect on optimal solution. Table 6 columns are about objective function values, points about new facilities, facilities covered by more than one facility respectively. The last column is about frequency as this table is a summary table. It can be concluded that the most frequent solution is (2,3). There are alternative solutions that 2 new facilities can be open in (2,3) points or (1,3) points. Either (2,3) or (1,3) points, facilities covered by more than one facility don't change.

Table 6. Solution Summary with Tchebycheff Technique

f_1	f_2	New Facility Points	Facilities Covered by More Than One Facility	Frequency
3	6	3,4,5	1,2,3,4,5,6	1
2	3	2,3	1,2,3	7
2	3	1,3	1,2,3	13

Conic Scalarization

B1 and B2 values determination according to weighted-sum technique solutions is the first step of this technique. (2,5) point is determined as B1 and B2 values according to (3,6) and (2,3) points. Alpha value determination is the second step of this technique. Alpha value need to be smaller than the smallest weight. Because of the [0,20] range in weighted-sum technique, 10 is the alpha's maximum value. According to this values, 121 different cycle is produced with different alpha, w1 and w2 parameter. Table 7 shows the summary of paramater determination phase and Table 10 shows the summary of the solution with conic scalarization technique.

Table 7. Summary of Parameter Determination

w_1	w_2	f_1	f_2
0	20	6	6
1_14	19_6	3	6
15_19	5_1	2	3
20	0	2	0

In Table 7, the first and second columns are about weights and the next columns are about objective function values. It can be seen that, four solutions are produced with conic scalarization. In Table 8, there are alternative solutions about these four solution. In this table, there are first (f_1) and second (f_2) objective function values in first and second columns. In the third column, there are new facility points according to the f_1 value. Facilities covered by more than one facility are placed in fourth column based on f_2 value. The last columns is about the each unique solution's frequency. 53 solutions among 121 solutions is (3,6). The second most frequent solution is again (3,6) but new facility points are change from (3,4,5) to (2,3,5). By the way facilities covered by more than one facility don't change. This results show that, conic scalarization technique gives a flexibility to decision maker with producing richer unique solutions.

Table 8. Solution Summary with Conic Scalarization Technique

f_1	f_2	New Facility Points	Facilities Covered by More Than One Facility	Frequency
6	6	1,2,3,4,5,6	1,2,3,4,5,6	1
3	6	3,4,5	1,2,3,4,5,6	53
3	6	1,3,5	1,2,3,4,5,6	2
3	6	2,3,5	1,2,3,4,5,6	31
2	3	3,5	3,5,6	13
2	3	2,3	1,2,3	14
2	3	3,4	1,2,5	6
2	0	2,5		1

COMPARISON OF SCALARIZATION TECHNIQUES

In this section the performance of weighted-sum, epsilon (Ɛ)-constraint, hybrid, elastic constraint, Benson, Tchebycheff and conic scalarization techniques are compared. Table 11 shows a comparison between techniques according to speed, step by step solution and different solution number performance criterias. Speed is an important performance criteria. Conic scalarization is the slowest technique. Hybrid and Thychebychev are the other slow techniques. The fastest techniques are the elastic constraint technique. Weighted sum and Benson are the other fast techniques. Step by step solution is another performance criteria related by easiness of the solution. Epsilon constraint, hybrid, Tchebycheff and conic scalarization techniques are difficult techniques use, because they need a preperation before the solution phase. Especially in conic scalarization, determining alpha values depending on the weights is a time consuming phase. The weighted sum, elastic constraint and Benson techniques are easy to apply. The last performance criteria in Table 9 is unique solution number. Conic scalarization gives the richest alternatives. Weighted-sum and hybrid techniques are following conic scalarization about unique solution numbers.

Table 9. Comparison of Scalarization Techniques

Scalarization Techniques	Speed (s)	Step by Step Solution	Unique Solution* Number
Weighted-sum	0,109		5
Epsilon (Ɛ)-constraint	0.1	√	4
Hybrid	3.641	√	5
Elastic constraint	0.012		1
Benson	0.113		2
Tchebycheff	3.647	√	4
Conic	26.602	√	8

*Unique solutions in the same pareto efficient set, assessed as different solutions. For example, in (2,0) set alternative solutions in different techniques are {1,6}, {1,3} and {2,5}.

Tablo 10 shows different solutions depending on scalarization techniques. Four different {(2,3), (3,4), (3,5), (3,6)} pareto optimal solution are produced by epsilon-constraint technique. Also, (3,4) and (3,5) solutions aren't produced by the other techniques. The other important point is the applicability of solutions. All solutions produced by epsilon-constraint are applicable despite one of the solution produced by conic scalarization (2,0) may not be be applicable. Because in the second objective function, there isn't any facility covered by one more than one facility. Conic scalarization is the second technique which gives richer solution alternatives despite its high solution time, also. It is important that conic scalarization gives alternative solutions that can be used to assess different criterias. For example in (2,3) set new facilities can be open in (1,3) and (2,3). This also gives flexibility for decision maker.

RESULTS AND FUTURE STUDIES

The scalarization techniques (weighted sum, epsilon constraint, hybrid, elastic constraint, Benson, Tchebycheff and conic scalarization) are employed on BOSCP in this paper and compared. The first objective function is the same as SCP and the second is about maximizing the facilities covered by more than one facility. As a result, epsilon constraint is determined as the best method in producing different pareto optimal solutions and conic scalarization is the best in producing alternative unique solutions among others. Also epsilon-constraint is faster than conic scalarization. The decision maker may prefer the conic scalarization in the direction of flexibility despite its hardness to imply and slowness.

Dandurand&Wiecek (2016), Ghane-Kanafi&Khorram (2015) and Burachik et al. (2014) are some of the researchers proposed new scalarization techniques. As a further research, these new techniques may be covered. Considered BOSCP can be used in some context in real life problems. Ambulance location problem in healthcare sector can be one of the implementation area so more instances with different features or a real-life data set may be used to compare the scalarization techniques. Also one more conflicting objective function can be added in the model.

Table 10. Technique Based Assessment of Different Solutions

					Scalarization Techniques						
	f1	*f2*	New Facility Points	Facilities Covered by More Than One Facility	Weighted-sum	Epsilon-constraint	Hybrid	Elastic Constraint	Benson	Tchebycheff	Conic
1	2	0	1,6								

2	2	0	1,3		√		√	√	√		
3	2	0	2,5								√
4	2	3	3,5	3,5,6	√		√				√
5	2	3	3,4	1,2,5	√		√				√
6	2	3	1,3	1,2,3		√				√	
7	2	3	2,3	1,2,3						√	√
8	3	0	1,2,6						√		
9	3	3	2,3,4	1,4,5							
10	3	4	1,3,5	1,2,3,5		√					
11	3	5	3,4,5	1,2,3,4,5		√					
12	3	6	1,3,5	1,2,3,4,5,6			√				√
13	3	6	2,3,5	1,2,3,4,5,6						√	√
14	3	6	3,4,5	1,2,3,4,5,6	√	√	√			√	√
15	6	6	1,2,3,4,5,6	1,2,3,4,5,6	√						√

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OBSOLESCENCE MANAGEMENT IN THE FRAMEWORK OF PRODUCT LIFE CYCLE MANAGEMENT AND ITS SIGNIFICANCE FOR DEFENSE INDUSTRY

Hüseyin Şen[1], F.Furkan Bakar[2]

Abstract - Rapid technological changes and developments has made obsolescence inevitable. Obsolescence has been one of the most significant issues especially for military systems having approximately 10-40 years life cycle. Because parts and components of military systems have considerably shorter life cycle than their systems' life cycle. In this study, the literature related to obsolescence management and product life cycle management in defense industry is reviewed. Furthermore, definition of obsolescence, types of obsolescence, causes of obsolescence, characteristics of military systems and strategies to mitigate obsolescence risk in defense industry are also presented. The main purpose of the study is to point out the significance of obsolescence management for defense industry and create situational awareness in obsolescence management. Results of the study indicate that elaborate planning, forecasting, monitoring and taking necessary measures throughout military systems' life cycles are essential in order to provide their supportability, enhance their availability and mitigate their obsolescence risk and life cycle cost.

Keywords - Defense Industry, Obsolescence Risk, Obsolescence Management, Product Life Cycle Management.

INTRODUCTION

Defense industry has gained considerable attention of both researchers and states following the end of the Cold War. This dynamic sector has experienced constant transformations since the increased need for dual use technologies in the development of modern weapons systems, interdependence among nations and shrinking of product life cycle.

The existing literature on the defense industry uses the phrase and the concept of defense industry interchangeably, with it also applying to both arms industry and military industry [40]. Defense industry can not be isolated from the other industries, for it includes various sub-sectors such as automotive, electronics, apparel, metal and machine industry [1]. Defense industry is viewed as a 'technology locomotive' spurring the growth of new industries and new technologies, particularly in the area of aerospace, electronics, and information technologies sectors [8]. However, defense industry is differed from other sectors since it necessitate indigenous product and market characteristics, special quality standards, superior skilled manpower, high research and development activities, reliability, security and supply chain structure and design [44].

Defense industry have more risk than the other sectors because of these specialties of defense industry. Actors and managers in defense supply chain should find to mitigate these risks. Defense industry, including various products that ranges from weapon systems to basic components at different level, has the total product life cycle approximately 30-40 years in addition to long technology and product development process. Defense product life cycles exceed those for commercial/consumer products. Many of the electronic parts that compose a product have a life cycle that is significantly shorter than the life cycle of the product. Both process availability and product obsolescence become a major concern [29].

Therefore, elaborate planning is needed to manage the military systems/products, which have high technology and complex structure, from the design phase to operation and support phase and disposal phase. Obsolescence of electronic components and parts emerged as one of the most significant challenges in the operation and support phase due to the long periods that the military systems are required to be in service.

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This study presents the principles and measures of a life cycle approach to obsolescence management. The purpose of the study is to point out the significance of obsolescence management for defense industry that is of utmost importance for national security and create situational awareness in obsolescence management.

The rest of this study is organized as follows. In section 2, we review the literature on product life cycle management. Section 3 explains definition of obsolescence, types of obsolescence, causes of obsolescence, characteristics of military systems and strategies to mitigate obsolescence risk in defense industry. Section 4 draws attention to the significance of obsolescence management for defense industry. Final section expresses the conclusion and suggests implications future research.

PRODUCT LIFE CYCLE MANAGEMENT

Since the introduction of the idea of a product life cycle (PLC) almost 65 years ago, a great deal has been written on the subject and several empirical studies have appeared. Numerous managerial-oriented articles and books have discussed the PLC [22]. Life cycle theory has been used since the 1970s to describe the behavior of a product or service from design to obsolescence. The typical pattern of a product is represented by a curve divided into four distinct phases: introduction, growth, maturity, and decline [26].

In the literature, numerous researchers defined product life cycle management (PLM), yet any common acknowledged definition has not been existed. Especially, definition of PLM varies according to the industry and product features. The general used definition of PLM is the business activity of managing, in the most effective way, a company's products all the way across their lifecycles; from the very first idea for a product all the way through until it is retired and disposed of. At the highest level, the objective of PLM is to increase product revenues, reduce product-related costs, maximize the value of the product portfolio, and maximize the value of current and future products for both customers and shareholders [34]. According to NATO, the management of a system, applied throughout its life that bases all decisions on the anticipated mission-related, political, social and economic aspects of the system Life Cycle [21].

The concept of PLM appeared in the 1990's with the aim of moving beyond engineering aspects of a product and providing a shared platform for the creation, organization and dissemination of product related information (cradle to the grave) across the extended enterprise. PLM seeks to extend the reach of Product Data Management (PDM) beyond design and manufacturing into other areas like marketing, sale and after sale service, and at the same time addresses all the stakeholders of the product throughout its life cycle [2].

Life cycle management organizes the interaction of the life cycle partners to achieve the maximum benefit from each technical product. The three main fields influencing the activities of the partners are environment, regulations and standards, as well as the constraints of economy. To achieve the best practice, the partners have to cooperate and tap into the know-how of all parties at all life cycle stages. To minimize the risks and to secure the maximum result, all of them should be part of the value adding processes depending on the extent of the value they contribute [41].

Applying the life cycle concept to man-made artifacts such as material products gives rise to the question as to what should be the starting point of the product life and what should be the end of the life. The most important stages of the product life cycle are manufacturing, service stage and recycling stage. To maximize the products performance, the life cycle has to be managed by use of rational methodologies [41].

The product life cycle (PLC) represents the unit sales trend of a narrowly defined product from the time it is introduced into the marketplace until it is later withdrawn. Product life cycle phases are broken into phases in different quantity regarding its features. For example, defense products and commercial / consumer products are similar, but they are also differences in terms of the acquisition and logistic processes. Schematically, the PLC may be approximated by a bell shaped curve that is divided into four stages[15].; Introduction, Growth, Maturity, and Decline. Figure 1. presents a PLC curve. We will summarize the characteristics of each stages below.

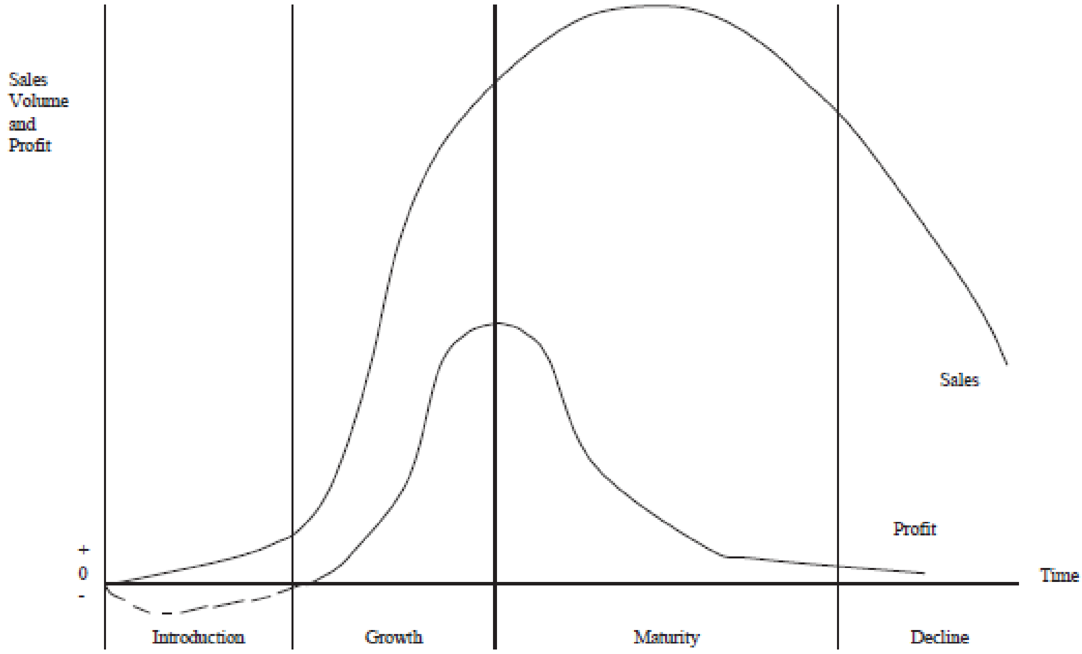

Figure 1. Product Life Cycle Curve [23].

The firm develops a new product, which requires a variety of materials in small quantities at the beginning of the **Introduction Phase**. The purchasing manager seeks flexibility, because of the innovation's uncertain future. Tentative or reversible procurement decisions are desired. Even with full-scale marketing of the new product, unit sales tend to be low and net losses occur. Purchasing policy seeks to balance the high likelihood of the innovation's failure with the urgency of adequate resources if it succeeds. This phase ends when top management decides to either withdraw the new product from the market or support it.

When the product's unit sales increase rapidly, it has entered the **Growth Stage**. Production increases to meet this demand. Profits ramp up dramatically. Procurement pleads with vendors for quicker and larger deliveries while trying to enforce quality standards. **The Maturity Stage** occurs when the product's unit sales level off and decrease slightly. With many aggressive competitors, the company is forced to reduce the price, increase advertising, and develop new models, if it wishes to continue selling the product. This cost-price squeeze causes profits to fall significantly. Purchasing joins other functions within the firm in a company-wide quest for efficiency. Procurement also stabilizes the organization's materials commitments.

When unit sales shrink rapidly, the product is in the **Decline Stage**. Customers forsake the firm's product for newer ones. Retrenchment is mandatory. Purchasing seeks true cost eliminations, not cost reassignments (e.g., selling manufacturing equipment). It is only a matter of time until top management withdraws this product from the market [23].

Defense products or weapon systems used worldwide include longer life cycles than the commercial ones. Therefore, definition of life cycle management of defense products are different from the commercial / consumer products'. Furthermore, a defense product has usage life cycle varying from 30 years to 50 years. The nature of the defense sector differs from other sectors in a number of ways. One of them is in the fewer number of players, for example the UK Ministry of Defense (MoD) is the main defense customer within the UK, surrounded by many contractors. Another difference is the lifecycle of the contracts that typically runs through the Concept, Assessment, Demonstration, Manufacture, In-service and Disposal (CADMID) cycle of large complex systems and equipment for a duration which could be between 5 and 40 years or more. Different contracting approaches are employed within the defense industry such as traditional, spares and repairs, availability and capability contracts. The move towards availability contracts with the duration described above, necessitates the implementation of robust cost estimating techniques to assess the through life cost (whole life cost) of the contract [5].

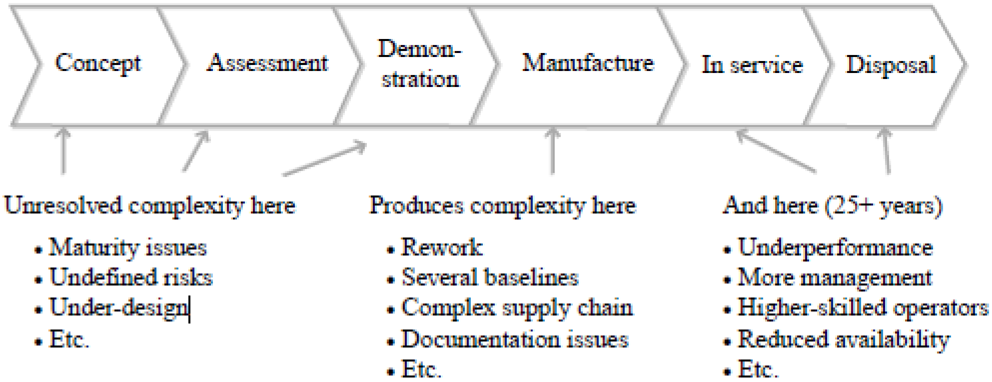

Figure 2. The CADMID Lifecycle from the UK MoD [17].

Total Life Cycle System Management (TLCSM), “life cycle management is the implementation, management, and oversight by the program manager of all activities associated with the acquisition, development, production, fielding, sustaining, and disposal of a DOD system”. In addition, the tenets of life cycle management emphasize sustainment planning early in the capability solution's life cycle, to include requirement generation activities [13].

Life Cycle Management is the implementation, management, and oversight, by the designated PM, of all activities associated with the acquisition, development, production, fielding, sustainment, and disposal of a DoD system across its life-cycle. In LCM, the PM, with responsibility delegated to the PSM for product support activities, is responsible for the development and documentation of an Acquisition Strategy to guide program execution from program initiation through re-procurement of systems, subsystems, components, spares, and services beyond the initial production contract award, post-production support, and through retirement or disposal [9].

Application of life cycle management concept is twofold: traditional and technology insertion. However, applications can generally be developed into mixed if they are appropriate for the system’s needs. In the former philosophy, Traditional: Freezing the design at the end of the engineering manufacturing design (EMD) phase is the traditional strategy for dealing with continuity of design and obsolescence. This offers many advantages with respect to control and total interchangeability throughout the program but has serious disadvantages in today’s environment [43]. Advantages can be enumerated as achievement of total design control, fully interchangeable modules of a like kind and predictable performance of the system. On the other hand, fixed and inflexible design, obsolescence risk and systematic failure of one single system can be listed as the disadvantages of traditional one.

Traditional long term program support requires a Supplier Program Management infrastructure to handle parts control, redesign as required (either device substitution, replacement with ASIC or total product redesign) and long term inventory management. Tailored lifetime sustainment programs need to be created to meet the ongoing needs of specific programs. Despite the care placed upon component management, too many programs are getting trapped into maintenance philosophies that are at the mercy of single-sourced components, many of which are already obsolete. O&M budgets can be used for program sustainment through the redesign of assemblies using newer parts to mitigate against obsolescence, but the wheel will inevitably turn again and no advantage is achieved in terms of either enhanced capability or performance. This is spending just to stand still – no improvement in the performance or functionality of the equipment will be gained unless a major redesign is undertaken, which may even exceed the cost of the original procurement.

The latter strategy is technology insertion, an alternate approach that is developing into an industry standard is Open Architecture, Functional Partitioning and Technology Insertion. This three-cornered strategy can be used to define the future lifecycle requirements of a system. First of them is Open Architecture, which provides vendor and technology independence plus a long-life backbone architecture that continues to evolve while maintaining backward compatibility. Secondly, functional partitioning involves the designer’s use of the modularity afforded by the chosen open architecture to functionally partition the system into a) platform-specifics with long life span and b) technologies with rapid evolution (i.e. SBCs, graphics, DSP and others). Finally yet importantly, technology insertion means planning to insert improved technology in batches through the production and support life of the program. This method has some advantages, despite its drawbacks. Future-proofed of the system backbone and upgradeability of the system are the benefits of technology insertion. As for the disadvantages, additional logistics cost and recertification of safety-critical functions stand out. This is the model that many of today’s integrators are adopting to protect against future obsolescence. One example is Boeing/GDIS (General Dynamics Information Systems) and the OSCAR (Open Systems Core Avionics Requirement) program which is planning regular insertions of increasingly powerful Single Board Computers (SBCs) into their systems for deployment on AV-8B, F-15 and F/A-18E/F [20].

The duration or extent of the life cycle depends upon fulfilling the intended need, the complexity of the system, the environment in which it operates, and its life cycle cost. LCM is a holistic approach used to describe all the strategic, organizational and technological tasks that should assist in correcting the flaws of our current logistics systems. The focus on LCM will provide an optimal adjustment of organizations, business processes and information systems to the demands of the war fighters and all other stakeholders.

Managing the total life cycle means the integration of the acquisition and logistic processes [21]. The generic and “classical” product life cycle model can help in analyzing product, industry, and technology maturity stages from all perspectives. Businesses are constantly seeking ways to grow cash flows by maximizing revenue stream from the sale of products and services. In mature businesses (rather than start-ups using venture investment) it is the cash flow that allows a company to invest in new product development and business development, in an effort to acquire additional market share and become a leader in its industry. It is logical and obvious that in order to ensure long-term value creation and good balance in business, any company must have a portfolio of products that contain both high-growth low-volume products in need of cash inputs and low-growth high-volume products that generate large amounts of cash. In addition to classical product life cycle models, there are a number of different variations of such models usually specific to a particular branch of the industry as well as to the industry’s special characteristics. The best-known variations of the model are in cyclic industries such as pulp and paper, where the growth and maturity phase can be undulating and in high technology industries where the balance of introduction, growth, and maturity phases differs somewhat from the classical model [3].

Given the obsolescence challenges, total PLM is the only way to effectively bridge the widening gap between customers’ and end-users’ needs and industry’s ability to deliver effective and maintainable solutions. LCM starts from inception of a new product idea and doesn’t end until the last customer has sent his last product back for repair. The first step starts with new product design by implementing a component selection procedure. This means understanding your suppliers and their market dynamics, and working with them to ensure acceptable parts longevity. The ideal situation is to only deal with suppliers who offer a reasonable promise of longevity. Unfortunately, this is not always practical especially when it comes to the leading-edge technologies that evolve very rapidly[18].

OBSOLOSCENCE MANAGEMENT

Obsolescence is generally defined as “the loss or impending loss of original manufacturers of items or suppliers of items or raw materials” [28]. Due to the length of the system’s manufacturing and planned support life, and unforeseen life extensions to support the system longer than its planned end of support date, the parts and other resources necessary to support the system become unavailable before the system’s demand for them ends [27].

Rapid changes in item or material technology, uneconomical production requirements, and extended product life cycles are major causes of component obsolescence. The rapid change in electronics and microcircuit technology continues to advance in accordance with Moore’s Law, which states that the density of semiconductors (e.g., fabrication process minimum feature size measured in micrometers) doubles about every 18 months. The electronic and microcircuit industries are increasingly more sensitive to rapidly improving consumer products rather than DoD and other industries (such as the airlines) that have to retain their equipment for much longer than 18 months due to economical considerations. As a result, the DoD continues to see the availability of military grade microcircuits decreasing and the number of DMSMS situations increasing [39].

The main aim of the obsolescence management in the literature is to determine the means of anticipating and reacting to occurrences of obsolescence and mitigating the risks of future obsolescence [12]. Collaboration within the industry, standardization of designs and modularization [39] that may promote the interchangeability of components; and the implementation of proactive actions to determine accurately the cost and impact of obsolescence are the major means of minimizing obsolescence risks [16].

There are many possible reasons for obsolescence. Some of the causes of obsolescence include the following [6].: (1) Rapid technological development makes a product or part unusable for technical, economical, or legal reasons [10], (2) The original component manufacturer (OCM) or original equipment manufacturer (OEM) disappears from the market for various reasons, The OCM or OEM is not willing to continue producing a part for economic reasons (usually precipitated by a drop in demand for the part) [4], (4) Chemical or physical aging processes of parts placed in storage can destroy parts or make it impossible to use existing part inventories in products [6].

In the literature, types of obsolescence can be categorized into three groups [10]:

- **Logistical:** Loss of the ability to procure the parts, materials, manufacturing, or software necessary to manufacture and/or support a product.
- **Functional:** The product or subsystem still operates as intended and can still be manufactured and supported, but the specific requirements for the product have changed; as a result the product's current function, performance, or reliability (level of qualification) become obsolete. For consumer products, functional obsolescence is the customer's problem; for more complex systems (such as avionics) it is both the manufacturer's and customer's problem. For complex systems, the functional obsolescence of a subsystem is often caused by changes made to other portions of the system.
- **Technological:** More technologically advanced components have become available. This may mean that inventory still exists or can be obtained for older parts that are used to manufacture and support the product, but it becomes a technological obsolescence problem when suppliers of older parts no longer support them.
- **Functionality Improvement Dominated Obsolescence (FIDO):** Manufacturers cannot maintain market share unless they evolve their products in order to keep up with competition and customer expectations (manufacturers are forced to change their products by the market). Note that this differs from functional obsolescence in that for commercial products FIDO obsolescence is forced upon the manufacturers and functional obsolescence is forced upon the customers.

Effective management of obsolescence in systems requires three different management levels: reactive, pro-active and strategic. **Reactive** management determines the immediate resolution to the problem of an obsolete part, executes the resolution process, and tracks the action(s) taken. **Pro-active** management of obsolescence requires the identification of critical parts that: a) are at risk of becoming obsolete, b) will have an insufficient quantity available after obsolescence to satisfy expected demand, and c) will represent a problem to manage if/when they become obsolete. Once critical parts are identified they are managed prior to their actual obsolescence event. Pro-active management requires an ability to forecast the obsolescence risk for parts. **Strategic** management of obsolescence means using obsolescence data, logistics data, technology forecasting, and business trending (demand forecasting) to enable strategic planning, life-cycle optimization, and long-term business case development for system support. The most common approach to strategic management of obsolescence is design refresh planning (DRP), i.e., determining the set of refreshes that maximizes future cost avoidance [27].

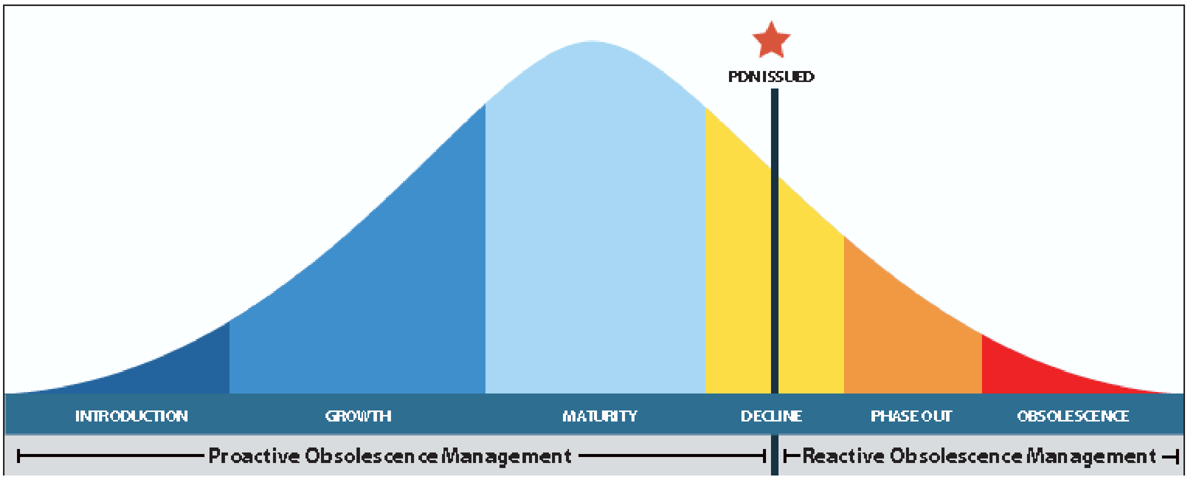

Figure 3. Proactive vs. Reactive Obsolescence Management at the Component Level [30]

The overall budget for proactive mitigations is established as a system-level trade-off between the level of assured availability desired by the customer and the price the customer is prepared to pay. Reactive mitigations are used where the likelihood of obsolescence is believed to be low and / or the cost of proactive mitigation is not economically viable. The benefit of this approach is that costs are only incurred if obsolescence problems materialize. The disadvantages are that it is not possible to achieve an assured level of availability, and the customer and supplier must agree how the mitigation costs are covered if obsolescence does materialize. Reactive mitigation generally involves a degree of redesign at component, assembly, sub-system, or system level [24].

When parts become obsolete there are various mitigation approaches that can be employed [35]. Replacement of obsolete parts with non-obsolete substitute or alternative parts is common for simple parts where the requirement for requalification of the system is not unreasonable. Lifetime buys of parts are also commonly used, i.e., buying and storing enough parts to last through a system's remaining manufacturing and sustainment life. There are also a many aftermarket electronic part sources that range from original manufacturer authorized aftermarket sources that fulfill part orders with a mixture of finished parts (manufactured by the original manufacturer) and new fabrication in original manufacturer qualified facilities (e.g., Rochester Electronics), to brokers and eBay [27].

Obsolescence management is essential to achieve optimum cost effectiveness throughout the whole product life cycle. Obsolescence forecasting is important in both the design phase of the product and the manufacturing life-cycle of the product. It is estimated that 80-85% of cost during a product's life cycle are caused by decisions made in the design phase. Additionally, obsolescence forecasting can be used throughout a product's life cycle to analyze predicted component obsolescence dates and find the optimal time to administer a product redesign that will remove the maximum number of obsolete or high obsolescence risk parts [37].

SIGNIFICANCE OF OBSOLESCENCE MANAGEMENT FOR DEFENSE INDUSTRY

The problem of electronics obsolescence has become especially problematic in the context of designing and supporting niche products with a high degree of technological content and long life cycles. An illustrative example of this environment is found in defense products [11]. The total product life cycle for technology in a military application could therefore be in the region of about 30 years [29]. This should be contrasted with the life cycle of commercial and consumer products, which could be as little as one year. It certainly exceeds the expected life of state-of-the-art commercial fabrication facilities and processes, which may require major update or renewal every 5 years. This marked difference between the military and commercial product life cycles and the corresponding life cycle of the associated fabrication processes and equipment raises the question of process availability and product obsolescence.

Obsolescence is inevitable and affects all systems, especially military systems which are designed for a long product life. Military systems typically outlive most of their internal components, giving rise to parts obsolescence. In the past 10 years, parts obsolescence is accelerated by the wave of progress in electronics and material innovations. Thus, it has become a greater challenge for military agencies to sustain their systems.

Obsolescence affects system supportability, safety and mission readiness. In order to overcome obsolescence, high costs and significant efforts may be incurred. A new approach is required to maximize the value of the military system throughout its life cycle. This article presents the principle, framework and measures to address obsolescence issues in military systems [42].

Obsolescence is increasingly affecting military systems at an early stage of their life cycles. Availability of replacement parts is critical for operational readiness, but the wave of progress in electronics and material innovations in the past 10 years has accelerated parts obsolescence. Traditional support options are no longer effective in minimizing the risk of obsolescence and impact to the system's cost and availability. It has become evident that a more comprehensive approach is needed, where obsolescence management is carried out from the planning to retirement phase. During front-end planning, measures can be taken to pre-empt obsolescence issues and delay their onset in the life cycle of the system. Proactive measures can also be put in place through contracting mechanisms [42].

Electronic part obsolescence began to emerge as a problem in the 1980s when the end of the Cold War accelerated pressure to reduce military outlays [32]. There is a general lack of standard procedures in the defense industry for the cost estimation of obsolescence [24]. Obsolescence issue has become one of the main costs in the life cycle of long-field life systems [31]. By the early 1990s, manufacturers migrated away from the low volume military market and focused their efforts on the more profitable commercial market. The consequence is that from the 1980s onwards, technology obsolescence has become a major issue for the military and the aerospace industry. The obsolescence issues can arise not only during the in-service phase but also at any stage of the whole life cycle. Obsolescence needs to be managed since early stages of the project, especially at the design stage where several strategies to mitigate the obsolescence risk should be considered [14].

DMSMS (diminishing manufacturing sources and material shortages) is the term used by the American defense industry to refer to electronic part obsolescence (and technology obsolescence in a general manner). Mechanical components and materials, processes and procedures, software and media, skills and knowledge, manufacturing tooling, test equipment are the sustainment-dominated system that can be obsolete [25].

Technological change is the most important source of supply chain risk in Turkish defense industry [36]. It indicates that obsolescence risk is the main reason of technology change risk. With the increased use of commercial parts in defense systems, it has become essential to include obsolescence management within the program plans from the earliest stages. Furthermore, the increase in environmental legislation has the potential to affect the use of some materials and substances and this issue must also be considered at the outset of equipment projects.

The management of obsolescence is essential to achieve optimum cost effectiveness throughout the whole product life cycle. The importance of obsolescence management is to provide contract requirements and guidance in planning a cost effective obsolescence management process, which takes into account the essential factors to ensure that the Product's life cycle costs are considered and applied [38].

Obsolescence affects system supportability, safety and mission readiness. In order to overcome obsolescence, high costs and significant efforts may be incurred. Existing methods of obsolescence management are inadequate to ensure cost-effective continuity of support for the system. Obsolescence management is essential to achieve optimum cost effectiveness throughout the whole product life cycle [42].

CONCLUSION

The obsolescence problem cannot be avoided [33]. The only way to minimize the impact of obsolescence and mitigate the risk is by planning and managing responses in a strategic and pro-active manner. Study concludes that elaborate planning, forecasting, monitoring and taking necessary measures throughout military systems' life cycles are essential in order to provide their supportability, enhance their availability and mitigate their obsolescence risk and life cycle cost.

A new approach is required to maximize the value of the military system throughout its life cycle. This study presents the principle, framework and measures to address obsolescence issues in defense systems. Little attention has been given to obsolescence management in Turkish defense industry. Indeed, very few organizations in Turkish defense industry are managing obsolescence in the framework of product life cycle management. Both researchers and practitioners from the early stage of the projects to the disposal phase should investigate comprehensive obsolescence mitigation strategies. In this context, obsolescence management practices are required to be studied empirically in a case study approach.

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INTEGRATED SUPPLY CHAIN AND COMPETITIVE FACILITY LOCATION MODELS

Canser Bilir[1], *Sule Onsel Ekici*[2]

Abstract - The optimization of supply chain networks plays a key role in determining the competitiveness of the whole supply chain. Therefore, during the last two decades, an increasing number of studies have focused on the optimization of the overall supply chain network. However, in most of these optimization studies, the structure of the network is considerably simplified and there is still a need for more comprehensive models that simultaneously capture many aspects that are relevant to real-world problems such as demand dynamics on the market. Facility location decisions—more specifically, decisions on the physical network structure of a supply chain network—are important factors affecting chain's competitiveness, especially for the supply chains serving retail markets. However, supply chain network optimization models in the current literature ignore the impacts of network decisions on customer demand. Nevertheless, competitive facility location problems model only the distribution part of the supply chain, even though they have certain characteristics of supply chain networks and analyze the rival chains existing on the market. In this study, an integrated supply chain network optimization model based on the joint supply chain network optimization and competitive facility location models is proposed to analyze the results of ignoring the impacts of network decisions on customer demand. The unique unknown variable within the model is the demand. The demand at each customer zone is assumed to be determined by price and the utility function. The utility function is defined as the availability of same-day transportation from the distribution center to the customer zone.

I. INTRODUCTION

The optimization of SC networks plays a key role in determining the competitiveness of the whole SC. Therefore, during the last two decades, an increasing number of studies have focused on the optimization of the overall SC network. However, in most of these optimization studies, the structure of the SC network is considerably simplified (e.g., a single product and a single location layer are usually assumed), and there is still a need for more comprehensive models that simultaneously capture many aspects that are relevant to real-world problems such as demand dynamics on the market.

Facility location decisions—more specifically, decisions on the physical network structure of a SC network—are important factors affecting chain's competitiveness, especially for the SCs serving retail markets. However, SC network optimization models in the current literature ignore the impacts of SC network decisions on customer demand. Nevertheless, competitive facility location problems model only the distribution part of the SC, even though they have certain characteristics of SC networks and analyse the rival chains existing on the market (Bilir et al., 2015).

In this study, a new model has been proposed in which the concept of SC network optimization modelling is incorporated with competitive facility location factors (e.g., changing demands that are dependent not only on price but also on customer service related functions). The aim of this model is to include the impact of a SC's physical network structure on customer demand.

The remainder of the paper is organized as follows: the next section provides a brief literature review. Section 3 defines a real-world problem to which the proposed model is applied. Section 4 focuses on the proposed model and its objectives, variables, and parameters. The paper ends with final conclusions of the study and provides further research suggestions.

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II. LITERATURE REVIEW

In order to identify different characteristics of the various models and common trends, we conducted a comprehensive literature review of recently developed (from 2009 to 2013) SC network optimization models. In this review, our focus was on identifying studies that included a strategic-level SCN model. Models that considered the reconfiguration or relocation of the SCN nodes and arcs (0-1 decisions) are considered as strategic-level models.

Supply chains are dynamic networks consisting of multiple transaction points with complex transportation, information transactions and financial transactions between entities. Therefore, SC modelling involves several conflicting objectives, at both the individual entity and SC levels. Our survey on SC network model objectives showed that the majority of SC network optimization models are solely based on cost minimization (e.g., Nagurney & Nagurney, 2012; Lundin, 2012; Melo et al., 2012) or profit maximization objectives (e.g., Kabak & Ulengin, 2011; Rezapour & Farahani, 2010; Yamada et al., 2011), even though the number of multi-objective models is increasing and there appears to have been a major shift from cost minimization to profit maximization objectives (Bilir et al., 2015).

Indeed, 24 % of studies in the SC literature from 2009 to 2014 feature multi-objective functions. When compared to 9 % of the articles reviewed by Melo et al. (2009), it can be concluded that multi-objective models are becoming increasingly popular. Multi-objective models typically include a cost minimization or profit maximization function, together with customer service, environmental effects or risk mitigation related objectives (e.g., Olivares-Benitez et al., 2013; Shankar et al. 2013; Akgul et al., 2012; Prakash et al., 2012).

The existence of competition within the market (both among firms and via other SCs providing the same or substitutable goods) is an important factor that must be considered when designing a SC network.

The literature survey that we have conducted regarding competition modelling for SCs identified only seven papers (Nagurney, 2010a; Nagurney & Yu, 2012; Masoumi et al., 2012; Yu & Nagurney, 2013; Zamarripa et al., 2012; Rezapour & Farahani, 2010; Rezapour et al., 2011) explicitly modelling competition within the market. Among these papers, the demand is simultaneously modelled as a function of both the retailer's and the competitor's price (oligopolistic competition). These authors developed an equilibrium model to design a centralized SC network operating in markets under deterministic price-dependent demands and with a rival SC present. The competing chains provide products, either identical or highly substitutable, that compete for participating retailer markets. Using this approach, the authors were able to model the joint optimizing behaviour of these chains, derive the equilibrium conditions, and establish and solve the finite-dimensional variational inequality formulation. In six other models (Yamada et al., 2011; Cruz et al., 2011; Cruz, 2009; Amaro & Barbosa—Póvoa, 2009; Meng et al., 2009; Yang et al., 2009), demand is modelled as a function of only the retailer's price. Only one study modelled demand as a function of selected marketing policy (e.g., inventory-based replenishment policy, made-to-order policy or vendor managed inventory policy) (Carle et al., 2012). None of the reviewed papers included customer service related factors—or, more specifically, the location or number of SC network points—in their demand models. However, the physical network structure of a SC clearly influences its performance and is an important factor that affects a chain's competitiveness, especially for retail markets.

SC risk management is also an important part of SC network configuration and optimization. SC risk management involves designing a robust SC network structure and managing the product flow throughout the configured network in a manner that enables the SC to predict and address disruptions (Baghalian et al., 2013). The uncertainties associated with disruptive events such as heavy rain, excessive wind, accidents, strikes and fires may dramatically interrupt normal operations in SCs. Hendricks and Singhal (2005) quantified the negative effect of

SC disruptions on long-term financial performance (e.g., profitability, operating income, sales, assets and inventories).

In the literature survey, nine models (Cruz et al., 2011; Baghalian et al., 2013; Lundin, 2012; Yu and Nagurney, 2013; Cruz, 2009; Masoumi et al., 2012; Bassett and Gardner, 2010; Pan and Nagi, 2010; Kumar and Tiwari, 2013) explicitly included SC risk modelling (defined as SC robustness or SC risk models). In those models, the robustness of the models is quantified in SC risk equations to identify how it changes through the changes in the SC network.

A careful analysis of the SC network modelling literature finds that almost all SC network models assume that customer demands (either deterministic or stochastic) are not substantially influenced by the configuration of the SC network itself. However, the physical network structure of a SC clearly influences its performance and is one of the most important factors affecting a SC's competitiveness, especially for SCs serving retail markets. This disconnect between models and reality represents a gap in the literature and an opportunity for future research.

In this paper, the main objective is the integration of competitive facility location factors (e.g., changing demands dependent not only on price but also on customer service related functions) into SC network optimization model. As SC networks are multi-objective in nature, we define our model as multi-objective. Such multiple objectives might include profit maximization, sales maximization and SC risk minimization. Cost minimization and profit maximization are traditional objectives in SC network optimization problems. Sales maximization may also be utilized within the competitive facility location modelling framework as companies aim to increase (or at least maintain) their sales by reconfiguration of their SC network and possibly by adding new SC network point(s) (Plastria, 2001). The third objective proposed in the multi-objective framework is a risk minimization function. As SC risks have significant effects on the long- and short-term operational and financial performance of the SC (Hendricks and Singhal 2005), strategic-level SC network decisions should be modelled with a risk metric to help understand how network decisions influence SC risks.

The principal contribution of the proposed direction for future SC network optimization model research is the improved modelling of demands, which are affected by the price and service characteristics of SCs. The price and service, in turn, are substantially influenced by strategic-level SC network model decisions. As a second contribution of the proposed framework, SC risk will be included in modelling strategic-level SC decisions. Among the many published multi-objective SC network optimization models, only a few include SC risks as an objective.

III. MODEL DEFINITION

In this research, the model is built as deterministic MILP with three echelon SC networks, with multiple products and a single period. The objectives of the model are to optimize SC configuration and to analyse how the location and number of DCs will influence SC performance metrics. The demand at each customer zone is assumed to be determined by the price and the utility function defined as DC-one day transportation coverage availability. The SC structure consists of three echelons: (1) Suppliers, (2) Distribution Centres (DC), and (3) Customer Zones. Figure 1 summarizes our methodology on the definition and the analysis of the proposed model.

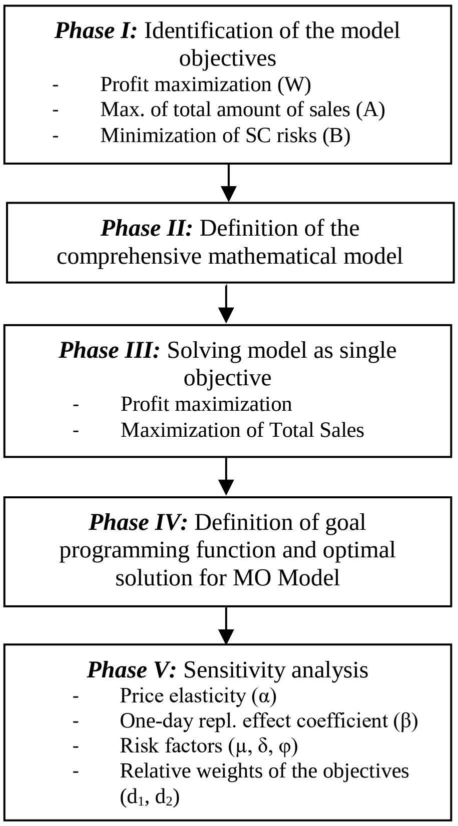

Figure 1. Methodology on the definition and analysis of the

In Phase I, three objectives of the model are identified; profit maximization, maximization of total sales (Plastria, 2001) and SC risk minimization (Hendricks and Singhal 2005). Phase II defines the mathematical model which integrates the concept of the competitive facility location model into SC Network optimization models. The details of the proposed model may be found under "model overview" section. Phase III provides the results of the models defined as single objective separately for profit maximization, sales maximization, and risk minimization. Meanwhile, phase IV involves a multi-objective optimization model which is constructed and solved to compare with the results of single objective models. In that phase, goal programming algorithm is utilized to solve the multi-objectivity. In the last phase, a sensitivity analysis has been conducted to test the applicability of the model with respect to various parameter coefficients; price elasticity, one–day replenishment coverage impact, risk factors (disruption probabilities), relative weights of the objectives.

3.1. Model Overview

Model Objectives: The proposed model has three objectives. The first objective is the maximization of the total profits. The second objective is the maximization of the total amount of sales, which are dependent on the price and the distance between the DC and the customer zone. Sales volume is not calculated as the sum of the total products distributed to customer zones, as the model may choose not to fill some of the demand when it is not profitable. The third objective of the proposed model is the minimization of SC risks.

Decision Variables: There several decision variables that need to be determined:

- Number of DCs and their locations
- Capacity of each DC
- The inbound and outbound traffic network
- DC – customer zone allocation
- Demand fill rate

Demand Function: In the SC network modelling literature, demand is generally either defined as deterministic or defined as a product of price. As the main purpose of the present study is to prove that adding a utility (attraction) function, which is also affected by strategic level SC decisions, to the demand model may have substantial influence on SC network optimization decisions, the demand model is built to include both price elasticity and utility function. Demand is defined as the product of both the sales price and the responsiveness of the SC network in terms of the distance between the DC and customer zones. In this study, the demand function includes two independent variables:

- Demand to Price elasticity coefficient (α);
- Availability of the one–day replenishment coverage affect (β); it is assumed that if the distance between the DC and retail outlet is less than a specified distance, the right product will be provided from the DC in one day. Therefore, this availability will have a positive impact on the sales of the products by a predefined coefficient (β).

Risk Function: To formulate SC risks, a path-based formulation, as proposed by Baghalian et al. (2013), is utilized. In path-based formulation, possible disruptions in DCs (DC operations), inbound and outbound connecting links (transportation links) are considered and formulated as the probability of disruption occurrence in SC network nodes and links. Path-based formulation helps the analyser to visualize the effects of partial disruption cases.

Predetermined probabilities of disruptions at DCs (DC operations), inbound and outbound connecting links (transportation links) are formulated in risk value calculations. According to path-based supply side risk calculation, the SC risk value of one DC network (current network) is calculated as follows:

$$\text{SC risk value} = (1-\mu)*(1-\delta)*(1-\varphi) = 0{,}995*0{,}99*0{,}98=0{,}965 \qquad (1)$$

The first term in the formulation (μ) is the probability of transporting the required goods to the DC without any disruptions from suppliers. μ assumed to be 0.5 % in the base scenario. The second term in the formulation (δ) is the probability of handling goods at the DC without any disruptions. δ is assumed to be 1 % in the base scenario. The third term in the formulation (φ) is the probability of transporting the required goods from the current DC to customer zones without any disruptions. φ is assumed to be 2 % in the base scenario. If more than one DC is utilized within the SC network, the probability of disruption occurrences at each node and link is assumed to be same. However, the disruption occurs at the SC network only if all alternatives at any single node or echelon are disrupted.

Disruption costs: When the SC network does not operate due to disruptions, there will also be a loss of sales. Therefore, shortage costs for each product type are also defined in the model. Shortage costs are defined as the net difference between the sales price and the unit cost of the product. Disruption costs are calculated as the total sales times the disruption probability of the whole SC network multiplied by shortage costs.

3.2. Notations and Formulation for the Model

Indices

i	Products, *i=1,……….I*
j	Product suppliers, *j=1,……….J*
k	Distribution centres, *k=1,……….K*
z	Customer zones, *z=1,………Z*
m	Number of DCs, *m=1,………M*
n	Alternative cities, *n=1,…….N*

Inputs

F_k Fixed costs for DC k
C_k Capacity for DC k
TI_{ijk} Inbound transportation costs for product (i) from supplier (j) to DC (k)
TO_{ikz} Outbound transportation costs for product (i) from DC (k) to customer zone (z)
IC_{mi} Inventory costs per item in case of m DC(s)
U_i Unit purchasing cost of the product (i)
S_i Shortage cost of the product (i)
SR_{ij} Supply rate for the product i from supplier j
α Price elasticity coefficient
β One-day replenishment coverage area elasticity coefficient
μ Probability of disruption at the transportation link from suppliers to DC(s).
δ Probability of disruption at handling goods at DC(s).
ϕ Probability of disruption at the transportation link from DC(s) to customer zones
P_{0i} Base (current) price of product (i)
DCK_{kz} "1" if the distance between DC k and customer zone z is less than 600 km; otherwise, "0"
D_{0iz} Current demand of product (i) at customer zone (z)
DC_{nk} "1" if DC k is at city n; otherwise, "0"

Outputs - Decision Variables

X_{ikz} Total amount of product i distributed from DC k to customer zone z
Y_{ijk} Total amount of product i distributed from supplier j to DC k
D_{iz} Demand of product i at customer zone z
TIC Total cost of inventory (changes depending on the total amount of sales and the number of DCs within the SC network)
LS Total lost sales
LSC Total lost sales costs
W Total profit
A Total amount of sales
B SC risk value

Binary Variables

DC_k "1" if DC i is open; otherwise, "0"
DCS_{kz} "1" if DC k serves customer zone z; otherwise, "0"
O_m "1" if only m number of DC(s) is / are open; otherwise, "0"

Objective 1: Maximization of total profit

$$W = [(\sum_i P_i * \sum_{kz}(X_{ikz}) - LSC]] - [\sum_i (\sum_{kz}(X_{ikz}) * U_i)] + [\sum_{ijk}(Y_{ijk}) * (TI_{ijk})] + [\sum_{ikz}(X_{ikz}) * (TO_{ikz})] + [\sum_k (F_k) * (DC_k)] + [TIC] \quad (2)$$

Objective 2: Maximization of total amount of sales

$$A = \sum_{ikz}(X_{ikz}) - LS \quad (3)$$

Objective 3: Maximization of SC risk value

$$B = \sum_m (1 - \mu^m) * (1 - \delta^m) * (1 - \varphi^m) * S_m \quad (4)$$

Subject to:

$$D_{iz} = D0_{iz} + \alpha * [(P_i - P0_i) * \frac{D0_{iz}}{P0_i} + \beta * \sum_k DCS_{kz} * DCK_{kz} * D0_{iz} \quad \forall i, z \quad (5)$$

$$\sum_j Y_{ijk} \leq \sum_z X_{ikz} \quad \forall i, k \quad (6)$$

$$\sum_k X_{ikz} * DCS_{kz} \leq D_{iz} \quad \forall i, z \quad (7)$$

$$\sum_k Y_{ijk} = \sum_{kz} X_{ikz} * SR_{ij} \quad \forall i, j \quad (8)$$

$$\sum_{ij} Y_{ijk} \leq DC_k * C_k \quad \forall k \quad (9)$$

$$\sum_k DCS_{kz} = 1 \quad \forall z \quad (10)$$

$$X_{ikz} \leq DCS_{kz} * 100000000 \; \forall i, k, z \quad (11)$$

$$\sum_k DC_k = \sum_m O_m * m \quad (12)$$

$$\sum_m O_m = 1 \quad (13)$$

$$\sum_i (\sum_{kz} X_{ikz} * IC_{mi}) - TIC \leq 1000000000 * (1 - S_m) \quad \forall m \quad (14)$$

$$[(\sum_i S_i \sum_{kz} X_{ikz}) * (1 - \mu^m) * (1 - \delta^m) * (1 - \varphi^m)] - LSC \leq 1000000000 * (1 - S_m) \; \forall m \quad (15)$$

$$[\sum_{ikz} X_{ikz} * (1 - \mu^m) * (1 - \delta^m) * (1 - \varphi^m)] - LS \leq 1000000000 * (1 - S_m) \quad \forall m \quad (16)$$

$$\sum_k DC_{nk} * DC_k \leq 1 \quad \forall n \quad (17)$$

$$X_{ikz}, Y_{ijk}, D_{iz} \geq 0 \; \forall i, j, k, z \quad (18)$$

$$DC_k, DCS_{kz}, O_m = 0 \; or \; 1 \; \forall k, z, m \quad (19)$$

The first objective function (W) (equation 3) maximizes total profit and is divided into five components: (1) Total revenue excluding lost sales, (2) Total purchasing costs, (3) Total inbound transportation costs from suppliers to DCs, (4) Total outbound transportation costs from DCs to customer zones, (4) Fixed costs associated with DC operations, and (5) Total inventory costs.

The second objective function (A) (equation 4) maximizes total amount of sales excluding total lost sales due to disruptions. The third objective function (B) (equation 5) maximizes SC risk value, which is a function of disruption probabilities at SC nodes and links.

Equations 6 – 18 of the model represent the following:

- Eq. 6 specifies the demand for each customer zone for each product.
- Eq. 7 ensures that any product transferred to a customer zone goes through a DC .
- Eq. 8 ensures that the total amount of products sold at each customer zone is less than the demand at that point for a specific product.
- Eq. 9 matches products sold at customer zones to supplied products.
- Eq. 10 ensures that the total amount of products handled at each DC is within DC capacity.

- Eq. 11 and 12 ensures that each customer zone is served by only one DC.
- Eq. 13 and 14 specify the number of DCs utilized within the model.
- Eq. 15 calculates “Total inventory costs” based on the number of DCs utilized within the model. In the calculation, the required Customer Service Level is assumed to be 99 %.
- Eq. 16 calculates “Lost sales costs” based on disruption probabilities and the number of DCs utilized within the model.
- Eq. 17 calculates “Lost sales” based on disruption probabilities and the number of DCs utilized within the model.
- Eq. 18 ensures that a maximum of one DC is utilized at each city.
- Eq. 19 ensures non-negativity for all variables.
- Eq. 20 restricts the binary variables.

IV. PROBLEM DEFINITION FOR A REAL–WORLD SCENARIO

XYZ Group Company is one of the leading ready-to-wear clothing companies primarily based in Turkey. The company has approximately 150 retail stores throughout Turkey, including 3 multi-storey mega stores and over 500 sales points. The firm is one of Turkey's first 500 Big Industrial Organizations in terms of sales volume, number of employees, and other factors.

The company currently has only one DC in Istanbul. That DC supports all sales points throughout Turkey. However, the number of sales points and the company's total amount of sales increased sharply in recent years. It is considered that the firm needs to reconfigure its SC network and to decide whether to open additional DC(s) in alternative locations, such as İzmir or Ankara. In the case of opening a new DC, the firm also needs to decide on the capacity of the new DC.

The company's current SC structure is composed of three echelons. Figure 2 depicts the current network of the company:

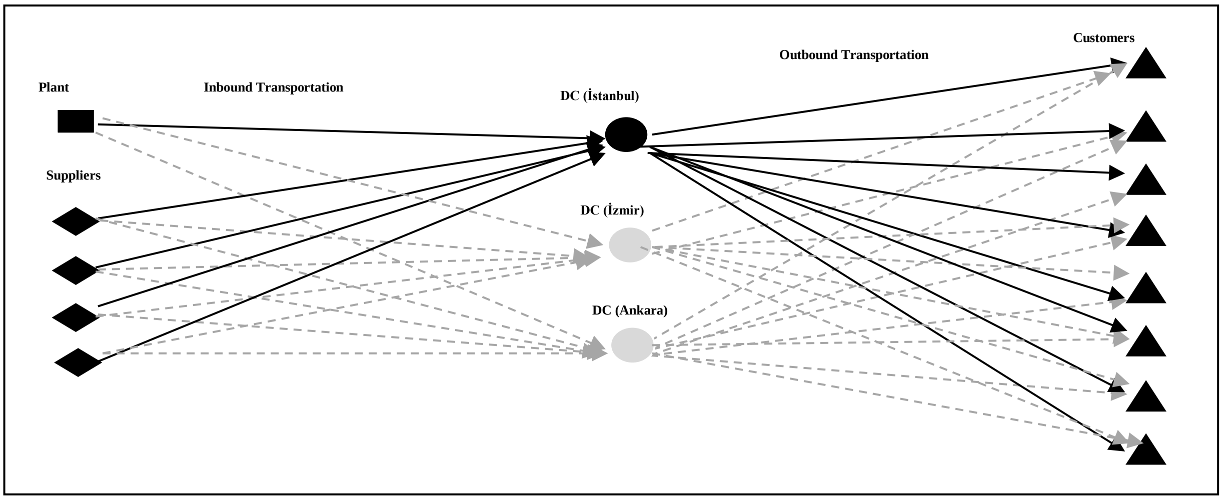

Figure 2. Current SC Network of XYZ Company

Customer zones are spread throughout Turkey. The company has 209 retail outlets. The demand for the retail outlets is aggregated to 39 city locations. The company has an enormous number of SKU to provide to the customer zones. To simplify the model, SKU are aggregated to represent the company's entire product composition. In the current SC network, only some of the stores are provided the right product within one day. If the distance between the DC and the retail outlet is less than 600 kilometres the right product will be provided from the DC in one day.

V. CONCLUSIONS AND FURTHER RESEARCH SUGGESTIONS

This study aims to analyse and explore how strategic level SC network decisions, such as number, location, and capacity of SC nodes affect sales volume and, ultimately, strategic level SC network decisions. The developed model is the first SC network optimization model to incorporate the changes in demand, which is defined as being subject to both the price change and distance from the end-customers and which is substantially influenced by strategic level SC network optimization model decisions. The results prove that including a utility function (based on the number and the location of DCs) in demand substantially changes the value of all three performance objectives of the model. When the model proposes opening an additional DC, it generates approximately 5 % more sales volume due to the defined utility function. However, the model generates less profit due to the fixed DC costs, slightly increased inventory holding costs, and slightly increased transportation costs.

The model also proves that single objective models may not generate acceptable results and that SC network optimization models need to be defined as multi-objective, as SCs are multi-objective in nature.

The model results also show that the model’s performance objectives are substantially influenced by strategic level SC network decisions such as the number and location of DCs, price change level, and other factors, which have a substantial influence on all performance objectives. However, decisions such as SC network traffic decisions, DC – customer zone allocation, and demand fill rate have either minor or no influence on performance of the SC.

The model is also utilized to model SC disruption risks. The risk factor sensitivity analysis shows that controlling and lowering disruption probabilities as much as possible through SC nodes and links is crucial for the company’s success, as lower disruption probabilities may lead to lower risks, higher sales volume, and higher profitability, all of which are very important to serving customers without interruption.

To enhance the developed model, other utility (attraction) functions that are also influenced by SC network configuration decisions—such as customer service level, availability of the stores at the demand point, distance between the store and the customers—may be defined to explore how demand and, ultimately, network configurations are influenced by those decisions.

A major limitation of the study concerns the lack of research on several major parameters of the model, such as the price elasticity coefficient and the DC – customer zone one-day replenishment coverage effect coefficient. After a more deliberate study of price elasticity in the market and after implementing the one-day replenishment program, the study may be rerun with the real data gathered from the market on those coefficients.

To explore the usefulness of the model, it may also be applied to real-world scenarios from other highly competitive sectors such as food products, electronic products. The SC network of the model firm only consisted of three echelons. Defining a more complex SC network with more than three echelons and possibly including recycling centres, globalization issues, and other factors may also enhance the usefulness of the model.

In the proposed model, a simple, linear demand model that includes price elasticity and utility function is defined for the sake of simplicity. A more complex demand model may be defined to analyse how SC network optimization decisions and model objectives change. Again, to simplify the model, only supply side path-based risk formulation is utilized. The model may be defined with a more comprehensive SC risk modelling. To avoid non-linearity in revenue function, different price change values are defined as alternative scenarios, and each scenario is solved separately instead of defining sales price as a decision variable. In a future study, a non-linear model that defines sales price as a decision variable may be defined and solved by non-linear solution algorithms.

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AN INVESTIGATION OF FACTORS AFFECTING PRICE MECHANISM IN FRESH PRODUCE SUPPLY CHAINS: A DISTRIBUTION CHANNEL PERSPECTIVE

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Abstract - Fresh produce supply chains differ from many supply chains due to their perishability nature of product, short shelf life, seasonability, long production process, physical specialities etc. as well as embodied large number of intermediaries within itself. Stated specifications of fresh produce supply chain are also interrelated with the factors that have an impact on price levels directly. Involvement of many actors within these supply chains as well as their changing needs and expectations may result in the emergence of possible conflict and issues related to power. Although there is an increasing interest in fresh produce supply chains in recent literature, studies that focus on changing price mechanisms from the perspectives of various actors especially in Turkey are limited. Hence, this study aims to review the basic price changing mechanisms and identify main problems experienced by various actors involved in fresh produce supply chains through the application of distribution channel theory and power-conflict theory. Interviews are conducted with various members of fresh produce supply chains in Izmir, Turkey and a qualitative analysis software (Nvivo) is used for content analysis and interviews have been interpreted. A conceptual framework is also suggested in order to reveal the main links between the actors and related dimensions in fresh produce supply chains. Findings of the study are discussed and future research suggestions are provided within the study.

Keywords - Conflict, Distribution Channel, Fresh Produce Supply Chain, Interview, Power, Turkey.

INTRODUCTION

Fresh produce and fresh produce supply chains have its own specifications that directly incline to problems in price fluctuations. Even though farmers don't get remunerative prices, high level of fresh produce prices paid by customers lead to main problem in many countries [1]-[2]-[3]-[4]. There are many reasons of those problems which have been discussed in the literature. Apart from specifications of fresh produces [5]-[7]-[8]-[9]-[10]-[11]-[12]-[13]-[14], supply chain structure contributes to such problems[1]-[2]-[3]-[4]-[5]-[8]- [9]-[11]-[13]-[14]-[15]-[16]-[17]-[18]-[19]. Besides, general characteristics of the fresh produce market are specified by presence of large number of middle men who distribute products from farmer to retailer [3]. Therefore intermediaries play an important role in price fluctuation**s** and lead to inefficiency in supply chain [2]-[8]-[11]-[16]-[17]. Accordingly power and conflict dimensions in fresh produce supply chain have not been determined on the basis of factors which affect price mechanism. Thus, there is a gap in the literature so that this study attempts to fill the gap by presenting the current situation through the interviews with parties of fresh produce supply chain. NVivo has been used for analyzing the interview data. The study is organized as follows: Theoretical framework consists of two different sections that explain (i) fresh produce supply chain characteristics and price mechanism, (ii) distribution channel theory: power and conflict dimensions. Methodology provides information about research process and data interpretation. Lastly, conclusion and recommendation for future research are discussed.

THEORETICAL FRAMEWORK

Fresh Produce Supply Chain Characteristics and Price Mechanisms

Particular specifications of fresh produce effect supply chain management and performance of fresh produces [5]. Characteristics of fresh produces which distinguish from other supply chains have been studied by many researchers. While general specifications of fresh produces are identified as having limited shelf life [5]-[6], being perishable [5]-[6]-[8]-[9]-[10]-[11]-[12]-[20], delicate [8], being seasonal and need for long production process [6]-[8] product quality and physical specialties are important i.e. color, size, image, taste, appearance, odor etc. [6]-[12], fresh produce supply chain specifications can be mentioned as; need for transportation and storage activities [6]-[8]-[13]-[14]; being effected by natural conditions in terms of quality and quantity of fresh produces and product safety [6].

There are several reasons which are associated with the fresh produce price fluctuations. Report on "Global Food Crisis" pointed out high energy prices that cause more expensive productions of food due to cost of production

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such as seeds, irrigation, transport and fertilizers. Additionally the report stated that supply and demand imbalances, low food stocks, climate change, droughts, population, income growth, changing dietary patterns in urban centers and urbanization, speculation in food market, food security, biofuel issues, constraints on agricultural production in developing countries, investments, trade rules, market conditions (fair competition) are also giving rise to price increases [21]. Furthermore many studies have also addressed the main reasons for price changes in fresh produce supply chain literature which are; are transaction costs [1]-[4]-[15]-[16], transportation process and cost [11]-[14]-[16]-[17], wastages [2]-[4]-[5]-[16]-[17], large number of intermediaries [3]-[8]-[11]-[16]-[17], supply and demand misalignment ([1]-[4]-[8]-[18]-[17], improper production policies [17]-[18], geographical conditions and transport routes [19], weather conditions [19]-[1], information systems and data processing [5]-[9]-[17]-[18], market structures and marketing [3]-[11]-[13]-[15], e-commerce selling [15].

Along with that these factors can be eliminated by efficient supply chain management because inefficiency in fresh produce supply chain induces wastage and losses which farmers get less prices while customers get low quality products [2]. According to [8] issues which enhance supply chain efficiency are listed as; availability of cold storage, government policies, connectivity, sorting and grading technology, handling and packaging, skilled labor, linkage in marketing channel. Moreover demand forecasting, vertical coordination of farmers by favor of cooperatives, customized logistics activities information systems, PPP (public-private partnership) solutions increase supply chain efficiency. Correspondingly price levels decrease. Furthermore smart pricing which is compatible with operations based on lead time, capacity and inventory decisions [9]-[10]-[22] emphasized dynamic pricing due to setting exact fresh food prices that provides optimal ordering and decreases unsold wastage or low-priced products and maximizes return on products. [12] highlighted cost and quality optimization in order to minimize costs. Besides [23] implied that coordination of supply chain members may decrease wastages and increases farmers' income. With regard to coordination and cooperation, [24] found out the role of power in managing supply chain networks, especially with effects on coordination and cooperation so as to develop strategy which provides effective mix power mechanism to supply chain managers. In the light of this, the following section focuses on the power and conflict dimensions within a distribution channel by considering the supply chain issues.

Distribution Channel Theory: Power and Conflict Dimensions

In the distribution channel literature power is identified as "A *has power over B to the extent that he can get B to do something that B would not otherwise do"* [25]. In addition to this definition [26] implied that one channel member has control over another channel member. The scope of the control includes alternatives, environment, information etc. Additionally, control could be comprehensive and effective that means a significant sources of power. Sources of power are represented under the six title as: Informational, reward, coercion, legitimate, expertise and referent. Many of researches have also explained these terms in detail [27]. Despite [28], following researches omitted "Informational Power", [27] included the source of power by explaining the reasons.

Reward power infers that influencer has the ability to reduce or diminish unfavorable consequences and to mediate favorable results over influencee [28]. Giving economical rewards for increased sales and profits are simple examples of reward form in the channel [30]. *Legitimate* power source represents that influencer has legitimate right to prescribe influencee then influencee has to yield less conflicts with influencer [31]. "Obliged", "obligated", "ought to", "required to" terms may be seen as signal of usage of legitimate power [27]. *Referent power* comes from influencee's opinions when defining influencer that influencee considers influencer as a model which influencee wants to achieve [27]. Hence, influencee does not want to be in conflict with influencer [28]. *Coercive power* refers that if influencee does not comply with influencer, influencer can bring changes through threatening influencee [27]. This sources of power based on the influencee's beliefs that influencer can punish influencee in case of fault in cooperation with influencer [31]. *Informational power* implies that influencer explains why and how work should be done in an effective and different way with convincing reasons. Then influencee understands and accepts the changing reasons [27]. *Expert power* infers that inferior believe in that superior has specific knowledge and expertness [26]. In the event of expert influence, it is surely for two parties that relationship which is based on the trust should be established [28]. Expert power source distinguishes from informational power due to influencee's believes that influencer has the knowledge about what behaviors should be implemented in any circumstances without understanding the reason [27].

Interdependency exists among channel members and means that all channel member can be affected by practices of one channel member greatly [32]. Hence distribution channel theory explains power and dependence relations that [35] determines social relations as *ties of mutual dependence between parties.* These ties refer that each party has position which grants or denies, restrains or facilitates. Besides dependence structure is highly effected by behavioral response of channel member [33]. Hence power is a function of dependence that power of channel member comes from dependence of one another member [34].

Conflict arises from channel members' divergent goals, ideas and perceptions of reality. Moreover conflict is essentially stimulated by the use of power. Superiority of conflicts or disagreement between firms have an impact on benefits stemmed from influencing the other [30]. Furthermore conflict can be evaluated in the sense of influence attempts among intergroup or interpersonal by the way of strategies and using sources of power and viewing the impacts of sources of power which have an influence over the other [27]. Potential reasons of conflicts under four issues are classified as role deviance, perceptual error, goal incompatibility and inefficient communication system. In addition to four issues coercive and noncoercive sources of power have also significant effect on conflict in the channel [31].

In distribution channel, cooperation and coordination activities are needed in terms of interdependency of organization in order to achieve predictability and trustability which allow organizations to plan effectively among the members. Therefore the conflict may rise between members inevitably when there are different aims, perceptions, ideas. Conflicts need to be controlled in order to prevent disruptions in channel, [30]. In order to operate in an integrated way in the channel, co-operation and coordination between channel members should be achieved [30].

Various studies about power and conflict have been found in distribution channel literature. Power and conflict dimensions in distribution channel theory have been used many different fields i.e. retailer-supplier relationships [39], manufacturing in different sectors [36]-[26]-[31]-[37]-[38], retailer- supplier relationships [39]-[40]-[41], manufacturer-retailer relationship [33]-[42], supply chain [20]-[24]-[34]-[43]-[44]-[45]-[46]-[47]-[48]-[49] manufacturer-retailer relationship [33]-[42], franchisor-franchisee relationship [50]-[51], e-commerce [38]-[52]-[53], multichannel corporations [54] and export distribution channel [55]. Considering distribution channel literature, studies which are related to fresh produce supply chain [6]-[20]-[24]-[44]-[48] are limited. While [6] touched on conflict between supply chain members, [48] examined dyadic relationship in food supply chains on the basis of market, network social relations and hierarchy or power. Similarly [24] examined role and effects of power on coordination and cooperation in fresh produce supply chain. [18] discussed the power of UK supermarkets which forces to processors and farmers in order to reduce prices. [44] investigated power in business to business relationships in fresh produce supply. [20] analyzed power of intermediaries over farmers and nature of their trading relationships from the viewpoint of farmers. However these studies did not discuss the price changing mechanisms in the context of distribution channel approach. There is a gap in the literature that price changing mechanism has not been examined from the viewpoint of distribution channel perspective within a holistic view which covers all the fresh produce supply chain parties. Hence this study aims to fill such gap in the relevant literature.

METHODOLOGY

Within the context of the study, interview method was used to collect data. Interview is an effective and powerful way of qualitative data collection (views and opinions) based on verbal communication and narrative which enables flexibility to researcher [56]-[57]-[58]-[59]-[60]. Interview question form for semi-structured interview was prepared on the basis of distribution channel theory and fresh produce supply chain studies. Although there are many types of interview [61], semi-structured interview was determined in this study since it provides extensive flexibility and fluidity enabling proper extent to research field and topics to researcher. Also it provides the opportunity to ask additional questions which are not scheduled before the interview [59]-[61]-[62] [63]. Once interview guide was designed, researcher must consider gaining as much information as possible about study and correspond them with the aims of study [61]. Interview guide which explores the effects of conflict over fresh produce prices was prepared considering factors that affect fresh produce prices [1]-[2]-[3]-[4]-[5]-[8]- [9]-[11]-[13]-[14]-[15]-[16]-[17]-[18]-[19] [21]. Besides questions which aim to find out the effects of power dimensions on price changes were borrowed from distribution channel literature [26]-[27]-[28]-[30]-[31]-[32]-[33]-[34]-[35].

Sampling is a crucial stage in research process in terms of quality of implications [64]. Snowball sampling method was used in the study that enables to researcher identify a first subject who refers to another actor's information [65]. First interviewee was determined by the help of academicians working on this subject. After second interview, authors attended İzmir Tarım Grubu meeting on 17.05.2016. Three interviews were conducted in Izmir Tarım Grubu meeting. Generally interview is performed and held minimum with two parties [66]. Within the context of the study, 24 experts were contacted in order to get appointment for the interview. However interviews were conducted with 16 interviewees due to the busy schedule of the experts or unwillingness to share information. 26 pages of data was obtained from interviews.

Content analysis was used to interpret the data. Obtained data is interpreted and summarized under main headings [67]. Also observational methods can be used in qualitative research by using notes which comprise interpretations of researchers [68]. Interviews were recorded in accordance with the permissions of interviewees. In addition to that important points were noted by authors. Finally information has been imported to NVivo so as to apply content analysis to interview data. NVivo is a software used in qualitative researches that provide analysis of data, management and synthesis of views and research design while enabling coding, reviewing, text editing, retrieving [69]-[70]-[71]. 18 words which evocate sources of power and conflict were determined in the light of distribution channel literature [20]-[24]-[26]-[28]-[27] [30]- [31]-[32]-[33]-[34]-[36]-[37]-[38]-[39]-[40]-[41]-[42]-[43]-[44]-[45]-[46]-[47]-[44]-[48]-[49]-[50]-[51]-[52]-[53]-[54]-[55]. These words were entered into NVivo software and searched in every interview folder.

CONTENT ANALYSIS OF INTERVIEWS

NVivo was used to analyze word frequencies which were associated with power sources. Word groups were determined on the basis of literature review and then they were translated by authors and matched with interviews through NVivo [26]-[27]-[28]-[30]-[31]. Primarily every interview folder were imported to the software. Text search was applied for every interview folder. NVivo analysis revealed the frequencies of the determined words. Since NVivo performs analysis on word basis, documents were checked for manual content analysis. Grey cells represent NVivo data and white cells represent manual content analysis. Findings of text search is presented in Table 1.

Table 1: Analysis of Power Association Words by NVivo Software and Manual Content Analysis

Word		Number of Interviewee	Word Times	Number of Interviewee	Mention Times
Reward	Encourage	3	7	-	-
	Promotion	1	1	-	-
	Reward	-	-	-	-
Legitimate	Liable	-	-	-	-
	Obligate	1	4	-	-
	Contract	7	18	1	1
	Agreement	5	5	-	-
Referent	Model	-	-	-	-
Coercive	Threaten	1	1		
	Punish	-	-	1	1
	Force	6	8	4	8
Information	Convince	3	4		
	Knowledge	2	2	-	-
Expert	Information	1	1		
	Experience	5	7	1	1
	Trust	2	2	3	4
Conflict		9	19	-	-
Power		11	32	-	-

Source: Authors

Content analysis of interviews reveals the perceptions of related parties in supply chain. Unsurprisingly, “power” and “conflict” words have been mostly used by interviewees. However it has not been expected that “liable” word has not been used by any interviewees. Results of content analysis assist having idea about power and conflict dimensions in fresh produce supply chain and determining sources of power in the channel.

FINDINGS OF THE INTERVIEWS

Interview questions aim to (i) determine problems encountered by fresh produce supply chain members in Turkey, (ii) analysis of fresh produce supply chain members relations based on power and conflict factors and (iii) analysis of effects of these factors over price mechanism and analysis of problems occurred in fresh produce supply chain. Within the context of the study interview questions have been tried to conduct to every party of fresh produce supply chain members. These members are producers (farmers), merchants (as intermediaries), wholesale market commissioner (WMC) (also intermediaries but different from the merchants with regard to property right of crops), wholesale market office (WMO), retailer, agricultural cooperatives (unions), industrial buyers and stallholders. Parties should be cleared that merchants and WMC are different due to property right of crops in fresh produce market in Turkey. Merchants perform its commercial activities by taking possession of crops. However WMC does not take possession of crops, but perform as taking commission over each sale. Retailers represent that retailer store chains, main duties of chambers of agriculture are registering of producers and preparing documents and related to producing activities [72]. Cooperatives are legal entities in which producers are organized. Industrial purchasers represent canned fruits and vegetables industry. Stallholders purchases fresh produces from wholesale market then sells retail to consumers. In addition to these members, various advisors who worked in the sector before, association administrator, members of Union of Turkish Engineers and Architects, academicians, journalists, personnel of ministry, personnel of municipality.

Power and conflict perceptions between these actors are analyzed considering 7 parties in the fresh produce supply chain. Perception of retailers have been excluded due to could not be able to attend a meeting.

Producers

Producers are in contact with merchants, WMC, WMO, retailers, cooperatives, chambers of agriculture and industrial purchasers. In addition to these parties, producers can directly sell their products to final consumer in market place. Once evaluating producers in fresh produce supply chain, producers are seen as weakest members in general. In relationship between producers-WMC-retailers-industrial purchasers, producers have not any power in order to be able to determine crop prices. They accept prices only what intermediaries offer. Main reason of being weakest in fresh produce supply chain is providing cash money to producers even if not in harvest-time by these parties when producers needed.

[…] Producers have two options to get cash money. First one is banks but producers do not prefer to take money from banks due to several enforcement (interest rates, payment guarantee, payment period).. Therefore they turn to merchants who have already in contact. Producers demand cash money from merchants, but merchants determine time of payment. How does producer pay money back? Of course merchants want to buy fresh produces at lower prices than the market level. Although producer meet cash money needs, they do not solve their real problems. Crops are not sold in its real value and they will face with finance problem again…

Besides characteristics of some fresh crops are not suitable for being stored. Even if crops can be stored, most of producers have not these infrastructures. In relationship of producers-merchants, merchants provide cash money or assure payments on the strength of their long term commercial activities. Also producers-WMC build their relationship based on the trust [28]. However WMC can threat producers in order to pay imposed fine by WMO due to misreporting of WMC. If WMC withhold the payments to producer WMO has power of sanction over commissioner. In relationship of producers-retailers, producers-industrial buyers, based on contract. While predetermined price levels are under the market price levels that retailers and industrial buyers may desist from purchasing decisions, in case predetermined prices are upper the market price level, producers may desist from selling decision. Furthermore payment conditions and contract terms can be change according to requests due to vast amount of purchases power of these parties. In producers-retailers relationship, retailers return unsold products even they control quality in the process of purchasing. In addition to that retailers cut back on total payments instead of physically returns of products.

[…]Although retailers control quality and calibration of our crops, they return waste crops if crops are not sold. Besides crops are not returned physically. Retailers report us only amount of the unsold crops and cut back on total payments. Refunding of money in return for waste crops? It is not even a matter of discussion!

Relationships between producers-cooperatives stem from encouragement (provides cheaper fertilizers, seeds, agricultural pesticides) and expertness of bargaining power of cooperatives on behalf of producers which lead to trust. Conflict between these parties stems from different aims of parties [30] that producers desire to sell their crops with expensive price while merchants, retailers and industrial buyers want to buy the crops at a cheap price.

[…] Reason of conflict arises from different aims of parties. Producers want to sell their crops with higher prices and buyers (retailers, merchants etc.) want to purchase crops with lower prices.

If producers keep company with each other, they can play a major role when determining price level. Coupled with different aims of parties, buyers expect from producers to fulfill homogeneity of product quality but producers do not meet needs of buyers. Therefore some of conflict situations effect price changings.

Merchants, Wholesale Market Commissioners and Wholesale Market Office

Power perception of parties about merchants and WMC stem from wide distribution network, providing cash money, experience, financing producers and dominating in the market. Besides general views of parties about merchants, during the period of low prices of products, merchants purchase large tonnage of products. But in high prices periods, they sale the products which have stored before and they can offer speculative prices for unharvested products. Also financing producers by intermediaries lead to low offering for crops.

[…] When crops are cheap, merchants buy huge amount of crops and keep waiting for market gap. When less products in market they sell their crops with high prices.

Due to having wide distribution networks, merchants are able to control of quantity of products in their market area. Despite perception of industrial buyers, merchants and WMC that supply and demand equilibrium determines market prices [1]-[4]-[8]-[17]-[18] perception of other parties of fresh produce supply chain is totally different due to possession of crops by merchants which enables to regulate the market. Possession of crops is the main instrument in order to allow supply and demand equilibrium. Merchants and WMC have market dominance owing to family relationship. Accordingly, merchants and WMC work with together and producers require to sell vast amount of crops to these intermediaries regarding product characteristics. Furthermore merchants incline commissioners to sell determined prices owing to power of holding vast amount of crops in relationship of merchants-WMC. As it stated in [31] merchants punish WMC through selling the products through another WMC due to not cooperate with merchants.

[…] When merchants decide to sell crops through commissioner, merchants determine commission charge. Otherwise merchants threaten the commissioners to not sell the crops through the commissioner.

Additionally power perception of merchant about producer stems from advance payments. Relationship of WMC and retailer is established by contract and power of retailer stems from regularity in purchasing activities and vast amount of purchases. Retailers demand quality products and imposes sanctions about quantity that retailer terms are accepted in general. According to Act. 5957, WMC, merchants, producers, stallholders, cooperatives, industrial buyers and retailers should be registered wholesale market register system to be able to perform trading activities [73]. Rather than determining general level of prices, WMO monitors that declaration of quantity of products, buyer and seller in wholesale market. In case of misreporting by WMC, the office imposes fine. WMO aims to decrease undeclared product sell and supervises whether the sales revenue has been paid to producers by WMC in the system. Together with duties of WMO, conflicts between producers and WMC arise from the audits. Imposed fine is reflected to producers by WMC yet the problem does not affect general price levels hereby.

[…] In case wholesale market office imposes a fine to wholesale market commissioner, commissioners dictate producers to make payment of the fine.

Industrial Buyers

The parties related to industrial buyers are producers, merchants and WMC. Industrial buyers perform procurement activities in different ways that they purchase from informal intermediaries who are also producers and intermediate crops of other producers. Additionally industrial buyers purchase crops from WMC on the basis of commission. Apart from commission basis, industrial buyers purchase from merchants and producers. Within this framework industrial buyers encourage producers by knowhow, struggling with decease, irrigation, planting, procuring advance, seed, seedling, pesticide, garden frame and fertilizer.

[…] We encourage grown of specific crops by giving seedling, seed, fertilizer, pesticides, procuring advances, garden frame.

The fact remains that industrial buyers sign a contract with producers and ensures purchase guarantee without any encouragement. Due to provide value added services control and standardized products, cooperatives are preferred by industrial buyers.

[…] Cooperatives coordinate producers and they are planting, harvesting and applying pesticide. Applying pesticides is very important by reason of residues. We cannot control all producers. But cooperatives apply pesticides in a controlled manner. In addition to that cooperatives standardize crops and provide same quality crops and value added services.

These activities was carried out commonly in recent years owing to absence of industrial-oriented production. Increasing in industrial oriented production, industrial buyers have been tend to establish buying centers so as to purchase the crops instead of encouragement activities. Infringement of contract is main conflict reason but the conflict does not stem from power of industrial buyers. The reason is breach of contract by the producers when fresh produces price level is higher than the contract terms which is determined before. With the supply and demand circumstances [1]-[4]-[8]-[17]-[18] quantity, price and contract terms are determined by industrial buyers.

Cooperatives (Unions)

All interviewed parties agree about encouraging cooperative system. Producers support cooperatives that being organized provides to be more powerful against the other parties. Since lack of bargaining power of producers leads to having no right to determine price levels. Along with encouraging producers, cooperatives also try to organize producers by training and traveling with reasons of why producers need to be more organized. Bargaining on behalf of producers by cooperatives leads to trust which promotes future collaboration.

[…] producers do not have bargaining power since they are not in an unionized structure. Thus they cannot play an active role in determining price levels.

Other parties encourage the cooperative system in terms of supplying more standardized and quality products. General view of producers and cooperatives is that owing to absence of production planning, producers do not sell their productions acceptable prices. Once comparing producers and buyers, number of producers is less than buyers. By virtue of cooperatives, producers can play an active role in determining price levels. If characteristics of production is suitable for storage, productions can be sold by the help of providing equilibrium between supply and demand. According to producers and cooperatives, cooperatives need to access consumers directly. In this point cooperatives need to develop either marketing department or establishing new marketing cooperatives.

Stallholders

Along with formal parties in or out of wholesale market, informal parties fulfill intermediary activities. Vast amount of fresh crops sold in marketplaces are not registered and are sold by these informal intermediaries [3]. Apart from stallholders, merchants and WMC, perception of different parties which worked in the sector before that merchants have an impact on stallholders, while determining final price levels. Within the scope of the relationship, as it in merchants-WMC, stallholders can be motivated by merchants in terms of sale prices [31]. Perception of stallholders about determining price levels is supply and demand equilibrium [1]-[4]-[8]-[18]-[17]. Additionally transportation costs [11]-[14]-[16]-[17] and profits [3]-[8]-[11]-[16]-[17] are added to final prices. Informality reduces competitiveness with regard to prices between stallholders. Rather than conflict between stallholders-merchants-WMC, stallholders need to these parties due to supplying crops to them. Besides there is also family relationship between merchants-stallholders and WMC-stallholders. Generally they support each other in the market and compromise in selling crops. If the relations between that parties are not based on family relation, merchants and WMC are more powerful in comparison to stallholder in terms of market domination.

DISCUSSION

Considering interpretation of interview, relationship of power between the parties in fresh produce supply has been summarized in **Table 2**.

Table 2: Determination of Sources of Power between Fresh Produce Supply Chain Parties

	WMO	WMC	Merchant	Industrial Buyer	Cooperative	Stallholder	Retailer
Producer	**L**	**E/C**	**E**	**I/L/E**	**E/R*/I**	**L**	**L**
WMC	**L**		**E/C**	**L/C**	**L**	**C**	**L/C**
Merchant	**L**	**E/C**		**L**	**--**	**C**	**L/C**
Industrial B.	**L**	**L/C**	**L**		**L**	**--**	**--**
Cooperative	**L**	**L**	**--**	**L**		**--**	**L**
Stallholder	**L**	**C**	**C**	**--**	**--**		**--**

C-Coercive Power
E-Expert Power
I-Informational Power
L-Legitimate Power
R-Reward Power
Source: Created by Authors

WMO has the legitimate right on all related parties. Owing to fact that wholesale market is the system which has been stated by laws and regulations. Registered parties are obliged to declare of product details. WMC-producers relationship is expert power that WMC provides its power through trust [28] (payment guarantee and advances) and expertness (selling products in a short time by wide distribution networks). Additionally WMC has coercive power over producers due to illegal sanction of WMC. Producer-merchant relationship is based on trust that expert power explains the power source [28]. Relationship of producer-industrial buyer is based on informational, legitimate and expert power that industrial buyers has legitimate right on producers [27]-[31] but determination of contract terms stem from expert power [26] (expertness, vast amount of purchasing capacity) of industrial buyer. In addition to that industrial buyers has informational power over producers that provide knowhow to producers and teach how producing should be done effectively [27]. Power of producers-cooperatives relationships based on expert (trust about bargaining experience [28] and reward power (encouragement). Producer-stallholder power relation is based on an agreement guaranteed by a contract. Contract terms are determined to fulfil the requirement of both sides. In this point amount of crops traded by producer and stallholder is less than amount of crops traded by merchants, WMC and industrial buyers. Relationship of retailer-producer is legitimate power which based on contract terms [27]-[31].

WMC-merchants is based on expert power due to be able to control and hold vast amount of crops and long term commercial activities [26]. Merchants has also coercive power in virtue of threatening [27] WMC about selling crops by another WMC if there is no family relationships between merchants and WMC. Relationship of WMC-industrial buyer and WMC-cooperative are based on legitimate power that contract terms arrange the relationships [31]. WMC-retailer relationship is based on legitimate and coercive power. In case of WMC does not meet the retailer requirements, threatening with changing commissioner [27] and contract terms determine relationship between parties [31].

Merchants and industrial buyers relationship is based on legitimate power determined by contract terms [31]. Relationship of merchant-retailer is based on legitimate and coercive power. If merchant does not meet to requirements of retailer, retailer changes its suppliers [27]. Relationship of merchants and cooperatives is not identified in the study. Because cooperatives are directly associated with producers. Merchant- stallholder relationship based on coercive power that stem from controlling quantity of product and threatening with not to sell crops.

Industrial buyer-cooperative is based on legitimate power. There is no relationship determined between industrial buyer and stallholder due to stallholder is not a supplier of industrial buyer. Also industrial buyer-retailer relationship has been excluded owing to processed product loses its fresh characteristics.

No relationship between cooperative-stallholder has been determined due to the fact that cooperatives sell vast quantity of products. But stallholder purchases limited quantity of products. Relationship of cooperative-retailer is based on legitimate power. In the event of being more organized, providing value added services and quality products, cooperative has right to set price levels.

Relationship of stallholder-retailer has not been determined. Since supplier of retailers is not stallholder due to purchasing large quantity of crops. In merchants-stallholders relationship, merchants and WMC have power over stallholder if there is not any family relation. Merchants arrange either promissory note or cash money as in the relationship of WMC-stallholder. Considering market dominance of merchants and WMC according to interview consequences, their relationship is based on coercive power.

Reasons of conflicts between fresh produce supply chain members arise from claim of purchasing lower prices, then selling higher prices. Although conflicts between fresh produce supply chain parties effect price levels from time to time, main reason of price fluctuation is power dimensions owned by parties in addition to reasons mentioned in literature [1]-[2]-[3]-[4]-[5]-[8]-[9]-[11]-[13]-[14]-[15]-[16]-[17]-[18]-[19].

CONCLUSION

Within the scope of the study, power relations and conflict factors were examined by interview technique and sources of power, impacts of power sources over fresh produce price levels and conflict between fresh produce supply chain parties were analyzed. Although prices are affected by many reasons as discussed in the literature, effects of power relations between fresh produce supply chain members on price are neglected. Although conflict fundamentally is incited by power usage [30], effects of power on conflict were not specified in the study. Considering interviews, weakest member in fresh produce supply chain is producers since unorganized producers have no right to intervene on determination of price levels. Merchants, WMC, industrial buyers and retailers gain dominance in fresh produce supply chain due to such reasons of paying in advance, providing vast amount of quantity orders and incentives, concerns of producers regarding no purchase decisions, cash money requirements of producers, claim of selling crops faster due to product characteristics. However debate is still continue between the parties in accordance with their power. Fresh produce cooperatives are weak in Turkey. It is obvious that strengthening the cooperatives provides more systematic and organized fresh produce supply chain in terms of ensuring value added services, legal conformity, eliminating illegal parties in the supply chain and enhancing contentment of both producers and final consumers. It should be said that it is difficult to put forward power and conflict dimensions between the parties correctly due to parental relationship. Within the study, examining relationships and power sources of each party provides a holistic view in terms of determining critical points of price mechanism, rather than finding most powerful party in fresh produce supply chain.

LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

No study is without limitations. Fresh produce supply chains involve a wide range of product groups with various characteristics. It is clear that the characteristics of a certain product would be different compared with other product groups as well as the price mechanisms. Although this study provided an overview of various experts in fresh produce supply chains, the number of parties interviewed could be increased. The total number of participants were sixteen due to time limitations.

Since this study is a preliminary study in identifying the main price mechanisms in fresh produce supply chain, there are rooms for research. For further research, seed suppliers can be added in order to understand starting point of determining price levels. Other specific product groups can be selected in order to examine the supply chain extensively. Also systematic solutions should be applied for the purpose of minimizing price fluctuations in the market. Additionally organic agriculture supply chain should be analyzed on the basis of distribution channel perspective for providing a better understanding in price mechanisms. Although interview method provided fruitful insight in understanding the current situation in fresh produce supply chains, other qualitative research methods can also be employed. For instance, Delphi study may reflect the views of various parties by considering the main areas of consensus or disagreement. Hence, the main points of the problem resolutions may be achieved by understanding the views of various experts in the field. Moreover, a quantitative approach including the application of surveys may help the scholars to test the hypotheses regarding the power and conflict issues as well as the price changing variables in a typical fresh produce supply chain.

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THE ENVIRONMENTAL IMPACTS OF FREIGHT MODES ON HAZARDOUS MATERIALS TRANSPORTATION

Tuğçe Tuğral[1]

Abstract - *The environmental effects of freight are structured by transport modes which are defined road, rail, water, air and pipelines. These modes are compared to the environmental advantages and disadvantages of using multimodal carriers as part of combined transportation. It begins with a brief overview of the major environmental mechanism through which transport can affect the environment. These include air pollution, water pollution, Global climate concerns, accidents, noise, habitat fragmentation and land use. And these indicators have a direct impact on ecosystems such as human health, vegetation, Global climate and biodiversity. The most important mode is Hazardous Material Transportation which can have a considerable amount of impact on the environment. Hazardous materials are grouped in nine major classes. Also Potential hazard is defined as fire/explosion, spill/ leak and other environment damage due to releases of hazardous materials. Environmental risk assessment is identified on all transport mode risks caused by hazardous transportation. The methodology of research is related information and Data collected from countries statistical database published as official report by the public authority. According to these; statistical Data is analyzed with accident database through recognized incident trends. This projection shows both the effects associated with different types of transport and solutions based on a holistic perspective with historical Data. As a result; the research indicates that minimizing the result of climate change through is chosen as the best possible green mode.*

Keywords - *Environmental Risk, Green Logistics, Hazardous Material Transportation, Transport Modes*

Related Topics - *Logistics Management, Multi-modal Transportation*

INTRODUCTION

In recent decades the environmental effects of transportation has become a topic of increasing importance around the world. Green issues are now a significant part of many companies' logistics strategy and more customers are interested in alternatives, more economic and friendly transportation options. As environmental protection is an increasingly pressing issue all over the world, every business today needs to consider how they can contribute to a more sustainable future. As the climate changes in response to Global warming, sea level rise, wildfires, hurricanes, serious health risks, droughts, rain falls, damaged coral reefs, animal and habitat risk.

In this study, According to the US department of Transportation historical statistic data is listed as the category of all modes of transportation cited in the following tables includes freight movements by highway, rail, vessel, pipeline, air ,other and unknown modes of transport. It has seems the Table 1. [1]

Each of the modes of transport has specific characteristics in terms of logistics management, strengths and weaknesses, determine the possibilities of its use in the logistics system. According to the latest cost and supply demands, but also increased environmental awareness, companies are trying to find other and cheaper ways to transport their goods. Transport modes are defined road, rail, water, air, pipelines. There modes is compared general and environmental advantages and disadvantages. (Table 2 and Table 3)

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Table 1 For Modal Shares of U.S. - NAFTA Freight Flows)

Mode	Share of Total by Mode (percent of total value)		
	%2005	%2014	%2015
Truck/Highway	62.1	59.9	64.3
Rail	14.8	14.9	14.9
Pipeline	6.5	7.9	5.2
Vessel/Water	7.4	8.7	6.6
Air	4.2	3.7	3.9
Other/Unknown modes	5.1	4.9	5.1

Source: Bureau of Transportation Statistics, Trans Border Freight Data,

February 2016. http://transborder.bts.gov/transborder/

Methodology

Data was obtained from the U.S. Environmental Protection Agency (EPA), OECD, RITA, IEA, PHMSA.The methodological basis for the approach derives from the statistical data trend analysis. Key sources of data is government real data. The population data are Censusbased, critical infrastructure and some threat information would be obtained from the federal government, and roadway network data would be used with historical accident data to derive the potential accident frequencies. Other probability and vulnerability information would be elicited from subject matter experts. In addition, implementation of the methodology would include data about vehicle location, shipment characteristics, and dynamic operating conditions. These outlooks were generated using numerical models, with the rest using statistical and heuristic approaches.

Table 2 Advantages of Transportation Modes

	Road	Rail	Water	Air	Pipelines
Advantages	*Low cost of entry. (As The capital cost of vehicles). *Transit times faster than rail or water. *Various volume/size can be offered to customers . High relative speed of vehicles. Fairly fast	*Low cost of transport over long distances. *High speed delivery of goods over long distances. * Full capability and Capable of carrying a wide variety of products. *Extensive routes. Inflexibility	*Operating cost per ton - mile are low. And Relatively low cost provides easy entry and exit. *Provide low rates to transport bulky products . * Do not have to own rights of way	*The warehousing costs are reduced to the minimum. *The major advantage is speed. The movement of the goods is very fast.*Highly reliable arrival and departure times and possibility of intercontinental transport.	*Low variable cost. Products are able to move.*The most economically transportation service for crude oil natural gas and refined petroleum product.**Relatively unaffected by weather or road condition and mechanical failures. **Provide warehousing function due to the slow movement (3-5 miles per hour).

	*The availability of global positioning technology (GPS) enhance the visibility of movement and increased of safety.*High accessibility - can offer door-to-door. And Flexibility of route choice	*High volume - Large carrying capacity to handle large-volume movement of low-value commodities over long distance. *Environment damage – nose visual drainage impacts	*High capacities and Water Carriers Advantage (Environmental impact are relatively except of oil spills occur and other accidents)	*Has a distinct advantage in terms of loss and damage. The risk associated with deterioration and obsolescence of the goods are reduced	*High dependability due to few interruptions to cause transit time variability. (most dependable in terms of transit time). *The highest integrity. high agility. high capacity. *More reliable. Frequent departures.*Loss and damage rate is low. Very reliable high safety of the cargo as oil.

Source: https://en.wikipedia.org/wiki/Transport

Table 3 Disadvantages of Transportation modes

	Road	Rail	Water	Air	Pipelines
Disadvantages	*High cost of transportation. Relatively high cost compared to rail and water carriers. *More labor intensive Tradeoff with faster service.*Reliability can be affected greatly by weather. **Traffic and parking difficulties. Size and weight restrictions.	*High set up cost, terminal costs, Fixed rights-of-way. *Accessibility can be a problem. limited types of cargo (gas. the relatively high cost of transport over long distances. *Environment damage- noise visual drainage impacts,accidents pollution. **Unsuitable and uneconomical for short distances and small traffics of goods	*Capital cost of vessel is high. *Low accessibility. *Low speed and Slow movement. *Affected by weather condition. Environmental effect relatively low but if oil spills ocur serius problem rise* Lack of environmental cleanliness	*High substantial fix Cost, variable cost, transport cost Rates are highest. *Much affected by weather condition *Low accessibility thus usually combined with other modes. Non-direct points. *High Emission	*Very high set up cost and high fix cost.* Longer transit time and Speed is quite low . *Accessibility is very low. Mostly privately owned and if not, the industry is oligopolistic in nature.*Very limited range of service and capabilities.* Limited range of products thus is not suitable for general transportation. Mostly used for gases and liquid such as oil, water and natural gas.
	*Public transport inadequasy. *Accident rate is high. Environment impacts as damage pollution noise visual drainage.*High Emission	*Transit times are spotty and generally long. Inflexibility -Provides differing degrees of service completeness (need other mode to complete door to door service).	*Due to today's environmental concerns, ports are having trouble keeping pace with the accelerated developments in global trades.	*Due to the large numbers of air carriers, the competition amongst air carriers is very intense. *Environmental impacts Noise	* Lack of environmental cleanliness regulation

Source: https://en.wikipedia.org/wiki/Transport

The importance of understanding the links between transport and environmental issues is widely acknowledged in areas such as energy conservation, climate change and management of sustainable resources. There are different approaches to categorising environmental impacts. The International Organization for Standardization (ISO) has issued a non-hierarchical categorisation of impacts in its standard ISO 14042:2000 (life-cycle impact assessment), which serves as the basis of OECD work on key environmental indicators [2] . Table 4 provides an overview of environmental impact categories defined under ISO 14042 (left-hand column) along with their causes and examples. [3]

Table 4 Categories of environmental impacts

Impact category	Causes	Examples of environmental impacts
Global warming	*Carbon dioxide (CO2) *Nitrogen dioxide (NO2) *Methane (CH) *Chlorofluorocarbons (CFCs) *Hydro-chlorofluorocarbons (HCFCs) *Methyl bromide (CH3Br)	*Polar melt, change in wind and ocean patterns
Primary energy use	*Fossil fuels used	*Loss of fossil fuel resources
Toxicity	*Photochemical smog: Non-methane hydrocarbon(NMHC) *Terrestrial and aquatic toxicity: Toxic chemicals *Acidification: Sulphur oxides (SOx), nitrogen oxides (NOx), hydrochloric acid (HCL),hydrofluoric Acid (HF), ammonia (NH4), mercury(Hg) *Eutrophication: Phosphate (PO4), nitrogen oxide (NO), nitrogen dioxide (NO2), nitrates, ammonia(NH4)	*"Smog," decreased visibility, eye irritation, respiratory tract and lung irritation, vegetation damage*Decreased biodiversity and wildlife *Decreased aquatic plant and biodiversity; decreased fishing *Acid rain *Building corrosion, water acidification, vegetation and soil effects *Excessive plant growth and oxygen depletion through nutrients entering lakes, estuaries and streams
Non-energy resource depletion	*Minerals used, scarce resources such as lead, tin, copper	*Loss of mineral resources
Land use	*Landfill disposal, plant construction and other land modifications	*Loss of terrestrial habitat for humans and wildlife; decreased landfill space
Water use	*Water used or consumed	*Loss of available water from water sources
Ozone layer depletion	*Chlorofluorocarbons (CFCs) *Hydro-chlorofluorocarbons (HCFCs) *Halons *Methyl bromide (CH3Br)	*Increased ultraviolet radiation
Impacts on biodiversity	*Toxicity *Land use	*Decreased biodiversity and wildlife *Loss of terrestrial habitat for humans and wildlife

Source: Adapted from U.S EPA 2006 ISO 14042

AİR POLLUTİON

The Global warming potential is the estimated potential of a greenhouse gas contributing to Global warming in the atmosphere. 'Greenhouse' gases are a set of gases which are indicated to have a negative impact on our environment. These are most commonly released from consumption of carbon based fuels and industrial processes. [4] Greenhouse Gases are Carbon dioxide, Methane, Nitrous Oxide and Fluorinated Gases. Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. [4]

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. In 2014, CO_2 accounted for about 81 % of all U.S. greenhouse gas emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle–both by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere.

Table 5 US Greenhouse Gas Emissions in 2014

Carbon Dioxide	81%
Methane	11%
Nitrous Oxide	5%
Fluorinated Gases	3%

Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, Total Emission in 2014 is 6870 Million Metric Tons of Co2 equivalent https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Carbon dioxide is the hight level of greenhouse gas emitted by humans, but several other gases contribute to climate change, too. The Table 5 shows which activities produce the most greenhouse gases in the United States. [5] The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, although certain industrial processes and land-use changes also emit CO_2. Since the combustion of fossil fuel is the largest source of greenhouse gas emissions in the United States. Changes in emissions from fossil fuel combustion have historically been the dominant factor affecting total U.S. emission trends. Between 1990 and 2014, the increase in CO_2 emissions corresponded with increased energy use by an expanding economy and population, and an overall growth in emissions from electricity generation. Transportation emissions also contributed to the 9 percent increase, largely due to an increase in miles traveled by motor vehicles. [6]

According to the Global Carbon Budget Global carbon dioxide emissions from fossil fuel use and cement production grew to a record high of 36 billion tons in 2013, while emissions from deforestation were relatively low at 3.3 billion tons. These emissions are contributing to changes in the planet's climate that could lead to harmful effects, such as sea-level rise and changes in Global hydrological patterns. Although the United States makes up 4,4 percent of the world's population, it emits about 16 percent of carbon emissions from fossil fuel combustion. [7] Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our cars, trucks, ships, trains, and planes. Overall, transportation contributes 27 percent of national GHG emissions. [8]

Table 6 Sources of Greenhouse Gases (2013)

Electricity	31%
Transportation*	27%
Industrial	21%
Commercial&Residential	12%
Agriculture	9%

Source: U.S. Environmental Protection Agency, U.S. Greenhouse Gas Inventory Report: 1990-2013, https://www3.epa.gov/climatechange/ghgemissions/usinventoryreport.html

In contrast to most criteria pollutants, emissions of GHGs have been rising from most sectors. From 1990 to 2013, carbon emissions from transportation grew by 16 percent. On Table 7 Highway vehicles are the largest users of transportation energy, accounting for 82 percent of the total.[9]

Table 7 Transportation Energy Use by Mode (2012)

Highway	82%
Air	9%
Water	4%
Pipeline	3%
Rail	2%

Source: U.S. Energy Information Administration, Annual Energy Outlook 2015, Table A7–Transportation Sector Key Indicators and Delivered Energy Consumption, April 2015, http://www.eia.gov/forecasts/aeo/data/browser/.

SEA POLLUTION

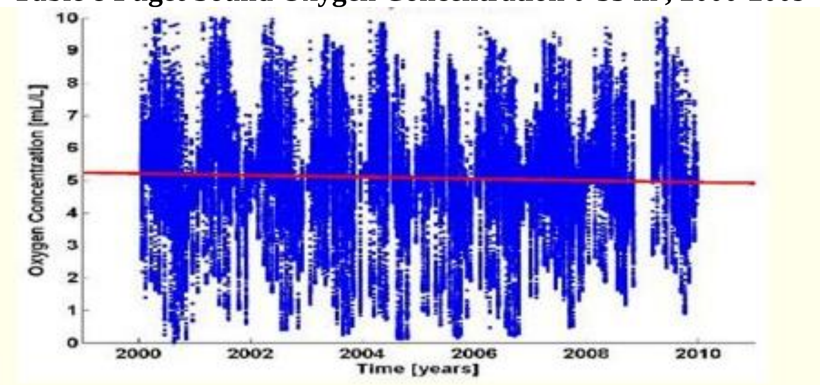
Pollution is directly affect the human and animal health with diversity. And pollution is caused to be decreased oxygen. Oxygen levels are currently declining in oceans and coastal waters around the world in part due to climate change. Also it involves too much nitrogen and phosphor in the water caused algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. Large growths of algae are called algal blooms and they can severely reduce or eliminate oxygen in the water, leading to illnesses in fish and the death of large numbers of fish.

Major categories of water pollution is involve as inflection agents (human and animal excreta etc.),organic chemicals (oil, gasoline etc.) ,storm water (carriers pollution etc.) inorganic chemicals (fossil fuels, petroleum distillation etc.) ,radioactive materials (weapons production, power plant etc.) ,sediments (urban construction, logging, plant nutrients (sewage, manure, urban runoff, agricultural etc.) ,oxygen demanding wastes (sewage, animal manure, plant residues etc.) and thermal (heat, power plant etc.)

In oceans, rising carbon dioxide levels increase ocean temperatures. Warmer temperatures reduce nutrient quantity and diversity, jeopardizing plankton and other marine life. Higher temperatures also weaken shells of crustaceans and creatures with shells, increasing their vulnerability. On land, more carbon dioxide facilitates the growth of some plants, while impairing growth for others.

According to Puget Sound Marine Water Condition index below the Table 8 below show dissolved oxygen data collected in Puget Sound between 2000 and 2009 at the depth intervals: 0-35 meters. The red line through the table shows the approximate trend over time. The downward slope of these lines shows a negative trend in the oxygen concentration since 2000. [10]

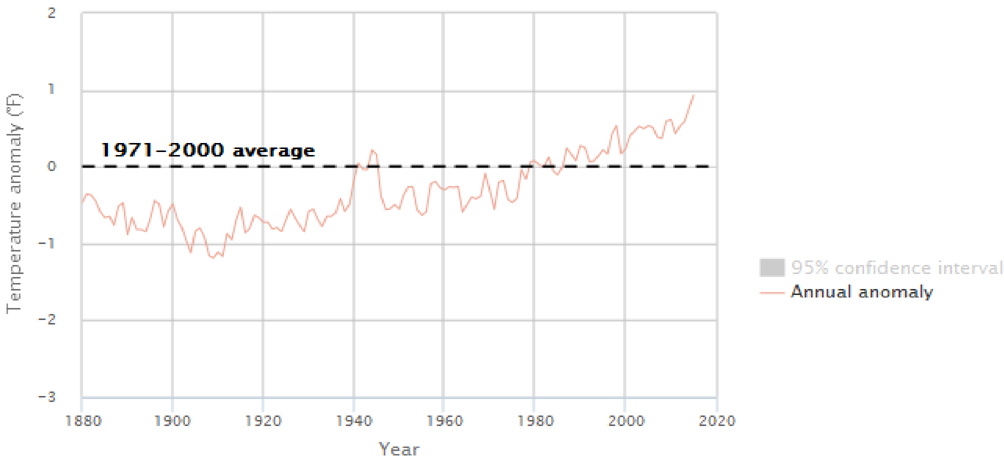
Table 8 Puget Sound Oxygen Concentration 0-35 m , 2000-2009



Source: https://www.epa.gov/salish-sea/marine-water-quality

National Oceanic and Atmospheric Administration (NOAA) research in Table 9 is below has that Data shows that Sea surface temperature increased over the 20th century and continues to rise. From 1901 through 2015, temperatures rose at an average rate of 0.13°F per decade. Sea surface temperature has been consistently higher during the past three decades than at any other time since reliable observations began in 1880. [11] Sea surface temperature the temperature of the water at the ocean is an important physical attribute of the world's oceans. The surface temperature of the world's oceans varies mainly with latitude, with the warmest waters generally near the equator and the coldest waters in the Arctic and Antarctic regions. As greenhouse gases trap more energy from the sun in the atmosphere, most of this energy—in fact, more than 90 percent of the energy accumulated by the climate system between 1971 and 2010 —accumulates as heat in the ocean.

Table 9 Annual Global Sea surface temperature anomaly, 1880-2015



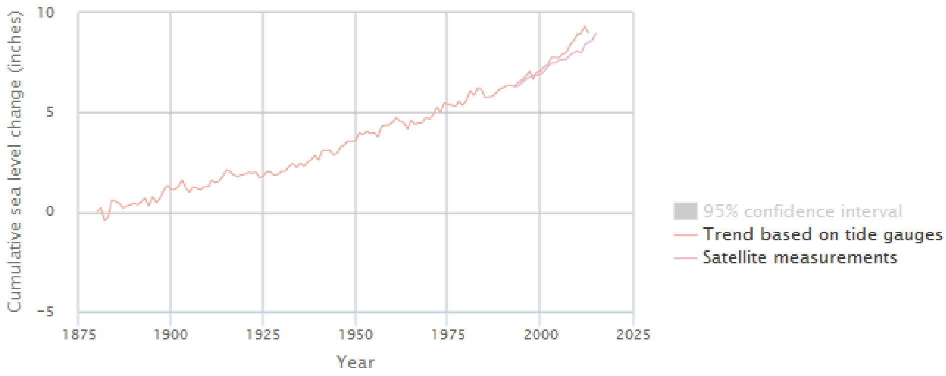
Source: NOAA,2016 https://cfpub.epa.gov/roe/indicator.cfm?i=88

As the oceans absorb more heat, sea surface temperature increases and the ocean circulation patterns that transport warm and cold water around the globe change. [12]Changes in sea surface temperature can alter marine ecosystems in several ways. For example, variations in ocean temperature can affect what species of plants, animals, and microbes are present in a location, alter migration and breeding patterns, threaten sensitive ocean life such as corals, and change the frequency and intensity of harmful algal blooms.[13]

Over the long term, increases in sea surface temperature could also alter the circulation patterns that bring nutrients from the deep sea to surface waters. Changes in reef habitat and nutrient supply could dramatically alter ocean ecosystems and lead to declines in fish populations.[14]Because the oceans continuously interact with the atmosphere, sea surface temperature can also have profound effects on Global climate. Increases in sea surface temperature have led to an increase in the amount of atmospheric water vapor over the oceans. This water vapor feeds weather systems that produce precipitation, increasing the risk of heavy rain and snow. Changes in sea surface temperature can also shift storm tracks, potentially contributing to droughts in some areas. Increases in sea surface temperature are also expected to cause foodborne illnesses, thereby increasing the risk of health effects [15]

Table 10 shows the Global Average See Level Change from 1875 through 2015. Sea level has increased steadily overall, particularly in recent decades, regional trends vary, and absolute sea level has increased from 1900s to 2000s. At those sites, even though absolute sea level has risen, land elevation has risen more rapidly. As a result of global warming the ice cap level is decreaased. [16]

Table 10 Global Average Absolute Sea Level Change, 1880-2015

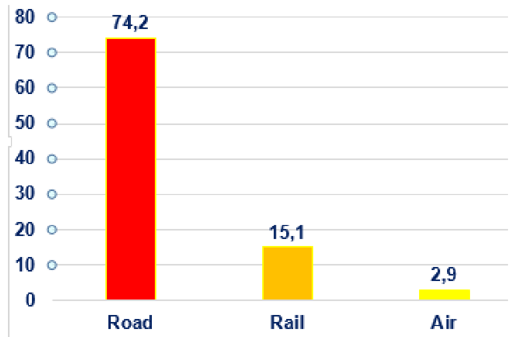


Sources: CSIRO, 2015; NOAA, 2016,https://www.epa.gov/climate-indicators/climate-change-indicators-sea-level

NOİSE

The main negative impacts of almost all transport modes (road, rail and aviation in particular). Noise pollution consistently ranks high on the list of citizens' concerns. Noise from road transport is the major source, followed by aircraft and rail-way noise.(Graph 1) [17] Transport noise can cause severe negative effect on public health. The relation between exposure to noise and health effects of exposure to environmental noise as impaired quality of life are as mention of Communication disturbance ,Sense of wellbeing, Loss of Concentration, Performance loss, Annoyance/Disturbance, Auditory discrimination deformity, Speech perceptual disorder, Cognitive performance, Lack of motivation, Sleep disturbance, Stress/Hormonal variability, Loss of memory, Myocardial infarction, stroke and depression. [18]

Graph 1 Number of persons in EU22 exposed to Lden > 55 dB in Mio. (Mapping 2012ff)



Source: European Environment Agency , November 2015 , http://forum.eionet.europa.eu/etc-sia-consortium/library/noise_database/end_df4_df8_results_2012_150630

The purpose of this public hearing is to provide comprehensive information on noise related problems and the respective technical and regulatory options to reduce transport noise as far as possible. Some of Noise reduction options is below [19]

1. Reduction of the sound emissions (Vehicle sound emission reduction) on new vehicle design
2. Speed limits (For Ex: Nighttime speed limit of 30 km/h on the inner-city prescribed measures
3. Low noise Road Pavements : Innerurban roads: double-layer porous & Sound optimised asphalt , Set noise barriers for train route,)
4. Use Electrically driven vehicles and Reduction of the sound propagation (e. g. barriers)
5. Sound insulation of buildings (e. g. sound proof windows,damming vantilation)
6. Make action planning on noise mapping with Noise regulation: the legal frame work.
7. Proposals for tightening the Road/tyre directive

8. Noise Barrier for rail road(gabion, rail lube facility, bridge vibration damber. etc.)
9. To decrasing air noise Its Needed the Land use restrictions, some of quotas, different rut planning.
10. Reduction of the private motorised traffic.

Landuse And Habitat Fragmantation

Most habitats in most parts of the world are declining in extent, although forest area expands in some regions, and the loss of mangroves has slowed significantly. Habitat loss and degradation create the biggest single source of pressure on biodiversity worldwide. For terrestrial ecosystems, habitat loss is largely accounted for by conversion of wild lands to agriculture, which now accounts for some 30% of land globally. In some areas, it has recently been partly driven by the demand for biofuels. For inland water ecosystems, habitat loss and degradation is largely accounted for by unsustainable water use and drainage for conversion to other land uses, such as agriculture and settlements.

Extensive fragmentation and degradation of forests, rivers and other ecosystems have also led to loss of biodiversity and ecosystem services. Natural habitats in most parts of the world continue to decline in extent and integrity, although there has been significant progress in slowing the rate of loss for tropical forests and mangroves, in some regions. Freshwater wetlands, sea ice habitats, salt marshes, coral reefs, seagrass beds and shellfish reefs are all showing serious declines. [20]

Freshwater habitats and wetlands, mangroves, coral reefs, Arctic and alpine ecosystems, dry and subhumid lands and cloud forests are particularly vulnerable to the impacts of climate change. Ecosystems are already showing negative impacts under current levels of climate change. In addition to warming temperatures, more frequent extreme weather events and changing patterns of rainfall and drought can be expected to have significant impacts on biodiversity. The related pressure of ocean acidification, resulting from higher concentrations of carbon dioxide in the atmosphere, is also already being observed. [21]

The Global Carbon Project (international partners of USGCRP;) reported that this wet phase also led to a “greening” of semi-arid ecosystems in the Southern Hemisphere. Globally, the increase in vegetation production had a major effect on terrestrial carbon storage: in 2011, vegetation soaked up 4.1 billion metric tons of carbon (significantly more than usual) and offset about 40% of annual emissions from burning fossil fuels. In addition, fires that typically affect semi-arid regions were suppressed during the wet phase by 30%. This research drew attention to the effect that water extremes can have on the global carbon cycle. Because semi-arid regions make up 40% of the world’s land area, a change in hydrology could have concatenated effects on vegetation, fire, carbon storage, and ultimately the climate system. These findings underscore the need to better understand how atmospheric phenomena like ENSO may behave under future climate conditions. [22]

While emissions from fossil fuel combustion started before the Industrial area, they only became the dominant source of anthropogenic emissions to the atmosphere.Anthropogenic emissions occur on top of an active natural carbon cycle that circulates carbon between the atmosphere, ocean, and terrestrial biosphere reservoirs on timescales from days to millennia, while exchanges with geologic reservoirs ocur at longer timescales.

Biodivercity and Climate Change

Climate change and excessive nutrient load and other forms of pollution affacs the biodivercity as negatively. Impacts of climate change on biodiversity vary widely in different regions of the world. The five principal pressures directly driving biodiversity loss (habitat change, overexploitation, pollution, invasive alien species and climate change) are either constant or increasing in intensity. These types of changes can alter food chains and create mismatches within ecosystems where different species have evolved synchronized inter-dependence, for example between nesting and food availability, pollinators and fertilization.Climate change is also projected to shift the ranges of disease-carrying organisms, bringing them into contact with potential hosts that have not developed immunity. [23]

Loss of Arctic sea ice threatens biodiversity across an entire biome and beyond. The related pressure of ocean acidification, resulting from higher concentrations of carbon dioxide in the atmosphere, is also already being observed.

In addition to being hotbeds of biodiversity, tropical forests are important to Earth's water, energy, and carbon cycles but they are increasingly impacted by climate change and human activities. Atmospheric chemistry in the once-pristine Amazon Basin, for example, is rapidly changing with deforestation, biomass burning, and pollution related to development in the region.The proportion of warm-water coral, bird, mammal and amphibian species expected to survive into the near future without additional conservation actions has declined over time.

Soil biodiversity reflects the variability among living organisms including a myriad of organisms not visible with the naked eye, such as micro-organisms and meso-fauna, as well as the more familiar macro-fauna. These diverse organisms interact with one another and with the various plants and animals in the ecosystem forming a complex web of biological activity. Soil organisms contribute a wide range of essential services to the sustainable function of all ecosystems. They act as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission, modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation and enhancing plant health. These services are not only essential to the functioning of natural ecosystems but constitute an important resource for the sustainable management of agricultural systems.[24]

Hazardous Materials and Classify

Hazardous waste is poisonous to life forms and affects the environment by debilitating plants and animals, interrupting their growth cycles and even leading to extinction. By harming the environment, hazardous waste threatens humans. The environmental ramifications of hazardous waste deplete natural resources and can contaminate people as well. Hazardous waste exposure can potentially destroy an entire ecosystem. Exposure to hazardous waste is extremely harmful to humans, plants and animals. It is especially dangerous for young, fledgling life forms. Fetuses, whether human or animal, are in a process of rapid development. For this reasons Transporting hazardous materials requires special precautions, handling, and reporting, with separate safety regulatory systems in place for pipelines and vehicles. These special requirements recognize that incidents involving the transportation of hazardous materials can affect the environment in addition to creating the potential for risk of injury and death to persons.[25]

According to U.S department of Transportation is accepted the Classification system is a hazard analysis system as below.

Class 1.Explosives,

Class 2.Gases,

Class 3.Flammable Liquide and Combustible Liquid and combustible Liquid

Class 4.Flammable Solid, Spontaneously Combustible, and Dangerous When Wet

Class 5.Oxidizers and organic peroxide

Class 6.Poison (Toxic and Infectious Substances) and poison Inhalation Hazard,

Class 7.Radioactive

Class 8.Corrosive

Class 9.Miscellaneous

EPA Annual Report shows that The nature of the incidents is comparable to previous years. In summary the most incidents resulted from spills or leakages most incidents occurred in workplaces or public places the most common substances associated with the incidents were petrol, diesel, hydrocarbon gases (including LPG) and fireworks. [26]

Table 11 Type of hazardous substance incidents 2013-2014

Type	2013-2014	%	2012-2013	%
Spill/Leakages	711	65%	930	63%
Fires	312	28%	496	34%
Other	66	6%	30	2%
Explosion	10	<1	17	1%
Spray Drift	1	<1	3	<1
Total	1100	100%	1476	100%

Source: EPA- Environmental Protection Authority Annuel report year 2014 auidit

http://www.epa.govt.nz/Publications/EPA_Annual_Report_2014.pdf

National Transportation Statistics on the U.S. transportation data system shows on Table 11 that is the most rate of incidents occured with Flammable-Combustible Liquid in 2011. [27]

Table 11 2011 Hazmat Incidents by Material Type

Material	Class Type	Percent of Total
Flammable - combustible liquid	Class 3	48,9
Corrosive material	Class 8	24,8
Combustible Liquid	Class 3	6,7
Non-Flammable compressed Gas	Class 2	3,6
Qxidizer	Class 5	3,5
Flammable Gas	Class 2	2,2
Poisonous Material	Class 6	2,2
Other		8,1

Source: Source: National Transportation Statistics https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Dashboard

Accidents

National Transportation Statistics presents statistics on the U.S. transportation system, including its physical components, safety record, economic performance, the human and natural environment, and national security. This is a large online document comprising more than 260 data tables plus data source and accuracy statements, glossary and a list of acronyms and initialisms. The category for all modes of transportation cited in the following tables includes freight movements by truck, rail, vessel, pipeline, air, other and unknown modes of transport.

Table 12 National Transportation Statistics, Share of Total by Mode forFreight Flows of U.S (Nafta)

Modes And Share of Total by Mode (percent of total value)	2005	2014	2015
Truck	62.1	59.9	64.3
Rail	14.8	14.9	14.9
Pipeline	6.5	7.9	5.2
Vessel	7.4	8.7	6.6
Air	4.2	3.7	3.9
Other/Multimode	5.1	4.9	5.2

Source: National Transportation Statistics
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html

Table 13 shows the Transportationof hazardous substances on highways involves tanker trucks ortrailers, which are responsible for the greatest number of hazard substance release incidents.

Table Shows the North American Transborder Freight Data for percentage of Hazardous Materials Transportation Incidents Mode [28]

Table 13 Hazardous Materials Transportation Incidents Mode, 1985- 2009

Highway	Railway	Air	Water	Freight Forwarder	Other
82,80%	14,90%	1,30%	0,20%	0,60%	0,10%

Source: PHMSA, 2011

The department of transportation Reseach and Innovative Technology statistics presents the U.S Accidents number of Transport Mode. According to the 2014 accident data for all freight type ,the highest accident number is Highway transport. [29]

Table 14 Transportation Accidents by Mode

	2000	2014
Highway, total crashes	**6.394.000**	**6.064.000**
Passenger car	4.926.243	5.982.000
Motorcycle	68.783	110.000
Truck, light	3.207.738	4.184.000
Truck, large	437.861	438.000
Bus	55.594	69.000

Railroad, total	**14.024**	**10.376**
Highway-rail grade crossing	607	532
Railroad	13.417	9.844
Waterborne, total	**13.143**	**10.112**
Vessel-related	5.403	6.048
Recreational boating	7.740	4.064
Air	**1.985**	**1.288**
U.S. air carrier	56	28
Commuter carrier	12	4
On-demand air taxi	80	35
General aviation	1.837	1.221
Pipeline, total	**380**	**701**
Hazardous liquid pipeline	146	445
Gas pipeline	234	256

Source: Source: U.S RITA,Transportation statics annual report 1975-2015
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_02_03.html

In the sequel on the Table 15 shows the hazardous Material Accident rate. According to the result of data, the number of accidents is resembling as sorted in Table [30]

Table 15 Hazardous Material Accidents Data

	2000	(R) 2014	2015
Highway incidents	**15.063**	**15.312**	**15.111**
Air incidents	**1.419**	**1.327**	**1.129**
Rail incidents	**1.058**	**717**	**582**
Water incidents	**17**	**47**	**24**
Pipeline incidents	**376**	**689**	**700**
Total hazardous liquid	146	445	453
Total gas transmission and distribution	230	244	247

Source: Rita(U.S department of transportation Reseacrh and ınnovative Technology) Transportation statics

annual report 1975-2015
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_02_06.html

On Table 16 and Table 17 shows the rate on injuries number and property damage as following to the hazardous accidents data. [31] According to the data the highest risky transport mode is highway and rail way. [32]

Table 16 Hazardous Materials Injuries Data

	2000	(R) 2014	2015
Highway injured persons	**164**	**134**	**156**
Air injured persons	**5**	**15**	**20**
Rail injured persons	**82**	**14**	**213**
Water injured persons	**0**	**0**	**0**
Pipeline injured	**79**	**95**	**50**
Total hazardous liquid	4	0	0
Total gas transmission and distribution	75	95	50

Source: Rita,U.S department of transportation Reseacrh and ınnovative Technology Transportation statics 1975-2015 http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_02_06.html

Table 17 Hazardous Materials Property Damage Data

(Millions of current dollar)	2000	(R) 2014	2015
Highway property damage	**51.030**	**59.602**	**61.252**
Air property damage	**272**	**129**	**47**
Rail property damage	**26.547**	**22.657**	**46.186**
Water property damage	**283**	**117**	**3**
Pipeline propery damage	**191**	**259**	**328**
Total hazardous liquid	150,6	131,4	247,7
Total gas transmission and distribution	40,4	127,1	80,7

Source: Rita,U.S department of transportation Reseacrh and ınnovative Technology Transportation statics 1975-2015 http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_02_06.html

In the sequel on the Table 18 shows the water accidents damage to envirenment. Eventhough the number of accident is low rate, water accidents is caused the huge environmental pollution.[33]

Table 18 Result of spill accidents

	2010		2014		2015	
	Incidents	**Gallons spilled**	**Incidents**	**Gallons spilled**	**Incidents**	**Gallons spilled**
TOTAL all spills	**3.008**	**207.712.793**	**3.077**	**668.363**	**2.413**	**304.689**
Vessel sources, total	**1.508**	**894.934**	**1.716**	**273.432**	**1.375**	**276.059**
Tankship	23	421.583	18	146	21	461
Tank barge	73	965	89	199.667	70	144.046
Other vessels	1.412	472.386	1.609	73.619	1.284	131.553
Nonvessel sources, total	**1.008**	**206.809.141**	**963**	**386.350**	**681**	**26.782**
Offshore pipelines	34	4.627	41	5.267	25	432
Onshore pipelines	0	0	0	0	0	0
Other	974	206.804.514	922	381.083	656	26.350
Mystery	**492**	**8.718**	**398**	**8.581**	**357**	**1.847**

Source: U.S RITA,Transportation statics annual report 1975-2015

http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html

Table 19 Shows the Fuel Consumption by Mode of Transportation in Physical Units on Bureau of Transportation Statics. The Gas Emissions is calculated on the 2014 data. According to the metrics ton rate, The most green mod is Pipeline. [34]

Table 19 Fuel Consumption by Mode of Transportation in Physical Units

	1990	2000	2014	The sum of the greenhouse gas emissions that entered above is of CO2 Equivalent (2014)		
Air	**13.228**	**15.209**	**11.888**	**106 metric tons**	**232.915 pound**	**116 tons**
Certificated carriers						
Jet fuel (million gallons)	12.212	13.904	10.321			
General aviation						
Aviation gasoline (million gallons)	353	333	197			
Jet fuel (million gallons)	663	972	1.370			
Highway	**130.755**	**162.554**	**172.889**	**1536 metric tons**	**3.387.324pound**	**1694 tons**
Gasoline,diesel,other fuels(mil.gallons)						
Light duty vehicle,short wheel,motorcycle	69.759	73.275	89.301			
Light duty vehicle, long wheel base	35.611	52.939	37.343			
Single-unit 2-axle 6-tire or more truck	8.357	9.563	14.894			
Combination truck	16.133	25.666	29.118			
Bus	895	1.112	2.233			
Water	**9.691**	**9.796**	**6.859**	**61 metric tons**	**134.385 pound**	**67,2 tons**
Residual fuel oil (mil.gallons)	6.326	6.410	3.847			
Distillate / diesel fuel oil (mil.gallons)	2.065	2.261	1.593			
Gasoline (million gallons)	1.300	1.124	1.419			
Pipeline						
Natural gas (million cubic feet)	**659.816**	**642.210**	**835.757**	**3,71 metric tons**	**81.857 pound**	**40,9 tons**
Total Train				**45,5 metric tons**	**100.126 pound**	**50,1 tons**
Fuels	**3.882**	**4.453**	**4.542**	40,4 metric tons	88.989 pound	44,5 tons
Electricities	**5.167**	**5.852**	**7.188**	5,1 metric tons	11.137 pound	5,6 tons
Transit (Tram and Subway)						
Electricity (million kWh)	4.837	5.382	6.673			
Motor fuel (million gallons)						
Diesel	651	591	542			
Gasoline and other nondiesel fuels	34	24	108			
Compressed natural gas	N	44	138			
Rail, Class I (in freight service)						
Distillate / diesel fuel (million gallons)	3.115	3.700	3.687			
Amtrak						
Electricity (million kWh)	330	470	515			
Distillate / diesel fuel (million gallons)	82	95	66			

Source: Bureau of Transportation Statics 1970-2014: U.S. Department of Transportation,Energy,Association of American Railroads ,U.S. Department of Transportation, Federal Aviation Administration http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_05.html

CONCLUSION

Many human activities cause pollution, habitat destruction and climate change, all of which are destructive to ecosystems. The observed increase in average temperature near the Earth’s surface and in the lowest layer of the atmosphere. In common usage, “global warming” often refers to the warming that has occurred as a result of increased emissions of greenhouse gases from human activities. Global warming is a type of climate change; it can also lead to other changes in climate conditions, such as changes in precipitation patterns.

Gases that absorb heat in the atmosphere near the Earth’s surface, preventing it from escaping into space. If the atmospheric concentrations of these gases rise, the average temperature of the lower atmosphere will gradually increase, a phenomenon known as the greenhouse effect. Greenhouse gases include most of carbon dioxide, water vapor, and methane. Carbon dioxide is constantly being exchanged among the atmosphere, ocean, and land surface as it is both produced and absorbed by many microorganisms, plants, and animals.

Over the last decade we have seen unprecedented changes in the human and biophysical environments (e.g. increase in the growth of fossil fuel emissions, ocean temperatures, and strength of the land sink), which call for more frequent assessments of the state of the planet, and by implications a better understanding of the future evolution of the carbon cycle, and the requirements for climate change mitigation and adaptation. Both the ocean and the land surface presently remove a large fraction of anthropogenic emissions. Any significant change in the function of carbon sinks is of great importance to climate policymaking, as they affect the excess carbon dioxide remaining in the atmosphere and therefore the compatible emissions for any climate stabilisation target. Better constraints of carbon cycle models against contemporary data sets raises the capacity for the models to become more accurate at future projections.[35]

Changes in the global environment that may alter the capacity of the Earth to sustain life. Global change encompasses climate change, but it also includes other critical drivers of environmental change that may interact with climate change, such as land use change, the alteration of the water cycle, changes in biogeochemical cycles, and biodiversity loss. Mitigation speed is important for measures to reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.

An addition to emissions from human activities, natural emissions of greenhouse gases such as carbon dioxide and methane can affect the climate system, and vice versa. Quantifying these natural fluxes, especially in Arctic ecosystems, is critical to understanding how they may interact with human-driven changes to affect future climate. Some research has shown increased emissions of greenhouse gases from tundra and boreal forests during warming in the spring, but little is known about what causes this or whether its occurrence is widespread enough to influence atmospheric greenhouse gas concentrations.[36]

Future scenarios of natural gas supply and demand (top left) are generated using an integrated assessment model. This information serves as input (open arrow) to an infrastructure model, which projects required pipeline growth, new storage needs, and other infrastructural changes for each scenario (bottom). Finally, output from climate models (top right) is used to evaluate (shaded arrow) the resilience of each configuration produced by the infrastructure model. This multi-model approach helps to capture the complex dynamics that link human and natural system. [37]

The study shows the most green mode is pipeline. For this reason pipeline usage rate should increase in future. And according to the all related statistical database, the most negative mode is highway in affecting to envirenment. But this result is directly related to capacity and number of using vehicle by changeable.So If the transport mode choice is balanced between each other modes; and if the pipeline structure is become widespread, emission could be decrase with all the other adding sollutions applicable(etc.using electrical vehicles, solar power)

Planning to manage the effects of climate change to increase positive impacts and decrease negative impacts.There has been much analysis of policies for sustainable transportation in governments and research institutions globally. It could be help to improving to provide the solution and that action is needed simultaneously on the following criteria: [38]

I. Improving vehicle technology leading to increased vehicle energy efficiency;
II. Changing driver behaviour to use less fuel per mile driven;
III. Reducing the distances travelled per vehicle; and
IV. Shifting travel to the most sustainable modes of transport.

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Abbreviations and Acronyms

CO2	Carbon dioxide
EDI	Energy Development Index
EPA	Environmental Protection Agency (United States)
FAO	Food and Agriculture Organization of the United Nations
IEA	International Energy Agency
OECD	Organisation for Eurepean Economic Cooperation
PHMSA	Pipeline and Hazardous Materials Safety Administration.
RITA	U.S department of transportation Reseacrh and ınnovative Technology
NTSB	National Transportation Safety Board
NAFTA	The North American Free Trade Agreement
GWP	Global Warming Potentials
DOT	Department of Transport
IUCN	International Union for Conservation of Nature
ENSO	El Niño Southern Oscillation

NETWORKS OF RESEARCH COLLABORATION IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT: THE CASE OF TURKEY

Ender Gurgen[1], Chee Yew Wong[2]

Abstract – This study aims to conduct a network analysis between authors, institutions, and countries in the field of supply chain and logistics management in Turkey by using Social Network Analysis. Our analysis showed that there is a collaboration in supply chain and logistics publications whose at least one of the authors's affiliation is located in Turkey, the most collaboration is made with authors from Turkey and internationals from the U.S., the EU countries, and Canada. The author network introduces us a large network is created, but small unconnected networks to the others also detected. The most popular keywords are industrial management, mathematical models, problem solving, computer simulation, and decision making. The knowledge generation in supply chain and logistics management field in Turkey will be possible with more collaboration in both national and international level.

Keywords: Social Network Analysis, Collaboration in Supply Chain Literature in Turkey, Citation Analysis

INTRODUCTION

Publications of academic papers are very important for sharing knowledge, assessments by the academic scholars, and ranking the institutions of authors. The analysis of these attributes are also used for competition among authors, institutions and countries. Citation to the previous related works are vital for both acknowledgment of contributions to the literature and introducing a summary of what has been done and where we are going next with the author's current work. Therefore, citation analysis plays a critical role in academic literature.

Bibliographic research studies in academic publications try to follow any track between papers, authors, institutions, countries, keywords, and citations. The analysis can be made in different perspectives: searching by specific topic in any journal or search every academic work in leading journals in specific field of study. Survey analysis, Cluster analysis, factor analysis, citation/co-citation analysis and social network analysis are the main research methodologies in literature analysis.

Individuals and institutions are connected each other in both social and professional relations as seen commonly in Social Media Softwares (e.g. Facebook, Twitter and Linked In). The same type of analysis also can be done by creating a network of authors, individuals and countries by examining academic publications. Publications in academic journals, conferences/symposiums and other academic meetings enable to create a network to share and distribute the knowledge, and to develop their work to reach a better result in their work. Sharing knowledge also requires creating a good network, and current information systems can make this network possible.

Although SC and Logistics management concepts in academics have been studied in the literature nearly last 3 decades in international level, the history of the SC & logistics concepts studies in Turkey goes back to only early 2000's. One of the main contributions in logistics and supply chain manement field started in Turkey with foundation of Logistics Association in Turkey (LODER) in 2001 [26]. Today, LODER plays an important role by organizing training sessions for practitioners, national and international academic conferences to improve the academic knowledge and practical skills in logistics sector. LODER co-hosts "The International Logistics and SC Congress" since 2003 and National Logistics and SC Congress since 2012 consecutively. The SC and Logistics topics have been found special tracks in different academic meetings too in Turkey such as Production Research Symposium, International Econometrics Operations Research and Statistics Symposium, Marketing Congress and National Business Administration Congress. Unfortunately, there is no peer-reviewed academic journal published in Turkey specialized in the field of SC & Logistics Management. But the academic studies find places in different university/faculty journals in Turkey. These oppurtunities creates a network in the field SC and Logistics.

In this study, we analyse the academic papers published in international journals and confrerences with at least one of the authors' institution is located in Turkey by using Social Network Analysis (SNA) technique. We first

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start with literature review of ranking journals, citation/cocitation analysis and social network analysis (SNA), then continue with the Methodolgy section by giving a brief definition of social network analysis, data collection, and finally we introduce our findings by network figures and related information about the network in following categories:

- Creating collaboration/relationship networks among authors, institutions and countries in the field of supply chain and logistics in Turkey.
- The keyword analysis that will show the main research interests of scholars in Turkey in the field of SC and Logistics.

LITERATURE REVIEW

We introduce the literature review section into three main groups: literature on journal and institution evaluation, citation/ co-citation analysis and social network analysis (SNA).

Studies on Journal and Institution Evaluation

Literature survey and analysis have been a key study field in academic studies at all times because journals, articles, authors and institutions have been ranked by their influence in the literature. The bibliographic literature study analysis can be collected in three types: survey based analysis, citation/co-citation analysis, and commentaries [25]. We can also add mathematical models to Watson and Montabon's classification to measure the quality of a journal.

Survey based anlysis are used in determining the importance of journals and ranking them by asking researchers, academicians, professionals, practitioners and any other relevant group of people by questionaers. Most of the survey based journal quality studies in SC and Logistics field are conducted regionally or selected regional groups: The U.S. [17], EU countries [18] or Nordick countries [21].

Studies finds that there may be some differences in measuring quality of journals depending on the regions. Although some journals in supply chain and logistics management field are overlapping in terms of usefulness, US and EU researchers thinks differently in usage, research merit, ourreach merit and teaching perspectives [17]-[18]-[23]. Geographical perspective similarities to the quality of a journal also applies in EU or Nordick countries [21].

Since SC & Logistics Management is an interdisciplinary field, using journals in different disciplines are necessary in the research articles. The academia finds operations research and operations management journals higher quality than specialized in SC and logistics journals, although SC & logistics journals have high mpact factors such as Journal of SCM (3.320), Transportation Research: Part E (2.272), Journal of Business Logistics (2.020), Int. Journal of Physical Distribution and Logistics Management (1.826) and Transportation Science (1.814) [25]. The impact factor measurement must be redefined to catch the trends in the SC and logistics field [11], and comparison among newly added journals to Web of Science in SC and other business disciplines showed that the journals in both categories received similar results in meeting the publication standards and number of citations for authors, on the other hand, journals in other business disciplines has greater diversification and balance in authors, editors and editorial boards, finally SC journals received more citation and less self-citation ratio in Web of Science [14].

The affiliations of authors are also in the focus of researches. In the supply chain and logistics management field, the US universities ranked top in the most published list, but the number of non-US universities rising, and the ratio of non-university affiliations getting lower over time [8]-[10].

From the history periodicals in Turkey, the first journal published in Turkey and indexed in Web Of Science is Hacettepe Bulletin of Social Sciences and Humanities (1973), and the number of publications is 69 as of 2013 [5]. Unfortunately, there is no publications based in Turkey dedicated to SC and logistics field.

The literature also covers the evaluation of the journals by using mathematical models such as Data Envelopment Analysis. [15] calculated the efficiency scores of operations management journals in the assessment of journal quality. The authors found that Journal of Operations Management, Management Science, International Journal of Production research, Operations research, Manufacturing and service operations Management, Mathematics of Operations research, and Transportation Science received the highest efficiency score 1, and be concluded as efficient journals. The authors' study also showed that top 10 journals in efficiency include 5 journals in operations management, 2 operations research, 1 engineering and 2 operations research focused journals [15].

Studies on Citation Analysis

Intellectual accumulation can be created by sharing knowledge in academic meetings and journals. Citation analysis becomes a vital role in analysing the effects of cited articles, authors and journals. The creation and analysis of intellectual accumulation can be done in two ways: analysing the publications in all sources within the subject area as in [16] and [24]'s studies and analysing specific publication(s) asuch as in [9]. [16] argues that a journal cannot provide a knowledge exchange among citations of its authors, it is only possible with citing from other journals, and there is a positive trend in number of publication years and self-citation.

A number of articles also detected the key research fields in SCM by using citation/co-citation analysis: Strategic orientation of SCM, sustainable SCM, value of information and development of SCM, sustainability, relationships between organizations and bullwhip effect, logistics, operations research, decision sciences and supplier development strategies [24]-[12].

[9] also conducted a citation analysis for the Journal of Supply Chain Management by tracking the number of citation in individual article, tracking percent of cited articles from different fields and from the journal, finally identifying the universities contributed to the journal.

One of the key studies in logistics and supply chain field in Turkey conducted by [1]. Their study focused on searching thesis and journal articles in SC and logistic fields from the databases in Turkey, and summarized their results in terms of diversification by university, institute, language and keywords. Their results are matching with other studies in terms of popular topics used in the field such as SC & Logistics Management such as inventory management, network design and distribution management, transportation management. Their finding also matches with our study here in terms of the universities with the highest number of publications list.

Social Network Analysis and Software Packages

Social Network Analysis has been used in different fields to determine any link between actors. [6] examined the FT 40 journal list in terms of diversity of board members (country, continant and gender), network of board member affiliation, clustering the relationship of journal field and the board members, the connection on network of two or more board members in common, and network of board members serving in three or more journals.

[2]-[3]-[4] studies also have a similar perspective with our study except for the focused disciplines. The authors searched for all journal articles from the Web of Knowledge database with the selection of at least one of the authors' affiliation is Turkey. In their study, they summarized the publications as the claasification by field of studies, development of co-authorship ratio over years, the number of international and national co-authorship over years, the main countries collaborated with, and the scholars who have the most number of publication from 1970-2009. They found the most publications for Turkey and Hacettepe University case are coming from the Health Sciences such as surgery, pediatry, clinic neurology, pharmacology, cardiac & cardiovascular systems. 88% of the publication were written with co-authors and 80% of them published in the year 2000 and beyond; and finally, the collaboration by country also matches with our study with the most collaboration made with USA, the EU countries and Japan [2]-[3]-[4].

There are a number of social network analysis software packages available. The first categorization could be done by type of usage as general purposes (e.g. MultiNet, NetMiner, Pajek and UCINET) and specific purposes such as communications networks (e.g. Commetrix), citation networks (Citespace), egocentric networks (e.g. E-Net and EgoNet), financial networks (e.g. Financial Network Analzyer), kinship networks (e.g. PGRAPH), statistical methods (e.g. SIENA and PNET), analysis of subgroups (e.g. CFinder), and network surveys (e.g. Network Genie and Ona Surveys); and the second classification is if the softwares are for free (such as Pajek and Citespace) or commercial (e.g. UCINET) [20].

METHODOLOGY

Visualization of a network brings to the readers better understanding of the relationships among the social units. In this study, we used Social Network Analysis (SNA) to identify possible network connections among authors, institutions and countries. In this section we will give some basic definitions on SNA & Citation/co-citation analysis, data collection and cleaning procedures, and research questions.

Social Network Analysis

A social network can be defined as "a set of socially relevant actors (nodes in the network) connected by one or more relations" [22]. Graphs and matrices are two types of tools used in the social network analysis for identifying any relations between social actors while graphs show the relationships with arcs or arrows (directed relationship) and edges or lines without arrow heads (no directional relationship), on the other hand, matrices represent the strength of the relationships by the number of activity occurred in the crossing cell of nodes [19]. To draw a network, a square matrix, called sociomatrix. Must be prepared with actors (nodes) placed in columns and rows, and each cell represents the number of relationship occurred [7]. The matrix can be prepared manually for (e.g. in UCINET and Pajek) or specific softwares can make this automatically from the databases (e.g. in citespace for citation analysis).

The relationship can be a direct tie between two nodes, or an indirect tie over a relationship from a different node. Therefore, an actor may not be aware of there is a link between it and another actor. The network analysis allows us to bring out this fact within a big picture.

The networks can be analysed in two main groups [22]:

- Whole vs. ego network: whole network represents the whole picture for all links between nodes within the dataset; on the other hand, ego network focuses on relationships on only one node. In our study we use whole network analysis to show all links between actors (authors, institutions, and countries).
- One mode vs. two-mode networks: One mode networks represents the same nodes places in rows and columns; on the other hand, two mode networks are used if the researches examine the relationship of one actor with different entities, and it can be created by rows and columns have different actors such as academicians in the rows and attended conferences in the columns. In most cases the researchers using whole network select one mode networks as in our study.

In this study, each node represents an author, his/her affiliation, country of affiliation, keyword. The line between each node is indirected which means there is no direction between nodes, and thickness of the line represents the strength of the relationship.

Research Questions

We aim to answer two research questions in this study:

- what are the networks of authors, institutions and countries which are collaborated with in the field of Supply Chain and Logistics Management?
- What are the main "keywords" that are used the most from the studies in SC and logistics management in Turkey?

Data Collection and Cleaning:

We started collecting data from SCOPUS database in 16 Sept 2015 and March 22 2016 (for updating new data) by searching following fields:

- Search: "supply chain" or "logistics" terms from article title, abstract and keywords:
- Subject Areas: Social Sciences, Health Sciences, Life Sciences and Physical Sciences.
- Country/Territory: Turkey

- Document Type: article, conference paper, article in press.

These four filters give us the papers which are indexed in SCOPUS database in all subject areas in supply chain and logistics management fields with at least one of the authors are from Turkey. We used all subject areas because SC and logistics may be applied in different disciplines.

We used a publicly available citation software, Citespace IV introduced by Chen in 2004 [13] to analyse the bibliographic research in this study. The software is designed for reading the data from a text file format, but, the data extracted from the SCOPUS database is in RIS format; therefore, we converted the RIS file to the text file by using the Import/Export module embedded to the Citespace. After converting the file to the text ffile format, we found some irregularities because of the conversion process and then data cleaning process is needed before running the programme. The data cleaning process can be summarized as follows:

- Topic checking procedure: Since the data was retrieved from different subject areas, we need to check if the paper covers logistics and supply chain management concepts. Some of the data points appeared in the list because of matching some words with "logistics" such as "logistic regression" or "supply" or "chain". Unrelated papers from the scope of the study were withdrawn from the list.
- Author name checking procedure: Conversion from RIS format to text format creates some irregular letters (such as letters from Turkish, French, Danish etc. alphabets) and middle name-surname mixtures. They have been fixed by changing the letters to standart English alphabet and standardize the name line as Surname, initials of First and Middle names.
- Affiliation name and address format standardization procedure: Each Journal records the affiliation names of the authors and addresses in different formats such as including department, street, city, postal-code and country. We deleted the street, city and postal-code information from the address line, and keeping the institution name and country of each author for each paper. In addition, affiliation names were found in different formats such as "Selcuk University" and "University of Selcuk" and fixed it. Another correction is in the affiliation name of "Gebze Technical University" formerly "Gebze Institute of Technolgy". Those records are joint under the latest affiliation name "Gebze Technical University".

RESULTS

We found 20 journals which appears "logistics" and "supply chain" word/phrases in SCOPUS database. The major journals within this concepts are Naval Research Logistics, Transportation Research Part E: Logistics and Transportation Review, International Journal of Physical Distribution and Logistics Management, Supply Chain Management, Journal of Supply Chain Management. But our data set includes other jounrlas which does not include supply chain or logistics in their title. Unfortunately, there is no peer-reviewed journal specifically logistics and supply chain management concepts, but, the scholars in Turkey may publish university, faculty, or institute journals. TUBITAK-ULAKBIM Social Sciences Database, Cahit Arf Information Center and Dergipark plays an important role on searching specific topic and articles [4].

There are 753 records found in the SCOPUS database which include "logistics" or "supply chain" words/phrases in the article title, abstract and/or keywords fields and at least one of the authors's affiliation is in Turkey. The first records appeared in our data set in 1997:

- Burgess, T.F., Gules, H.K., and Tekin,M., 1997. "Supply-chain collaboration and success in technology implementation", Integrated Manufacturing Systems, Vol.8, No.5, pp.323-332.
- Altinel, I.K., Oommen, J., and Aras, N., 1997, "Vector quantization for arbitrary distance function estimation", INFORMS Journal on Computing, Vol.9, No.4, pp. 439-451.

The average number of authors per paper is 1,72 that indicates a collaboration in publishing papers. Table 1 shows top 20 author list which is has the highest number of publications. The authors who have the highest number of publication in SC and logistics fields within the SCOPUS database also are appeared as in the the largest font in the co-authorship network.

Table 1. The authors which have the highest number of publications in logistics and SC field in Turkey

Freq.	Author	Freq.	Author
26	Buyukozkan G	10	Ulengin F
26	Paksoy T	10	Turkay M
19	Ozceylan E	10	Aras N
13	Kahraman C	9	Guneri A
13	Vayvay O	8	Karaoglan I
12	Sabuncuoglu I	8	Kaya O
11	Ustundag A	8	Onut S
11	Baykasoglu A	8	Toptal A
11	Altiparmak F	8	Tuzkaya U
10	Bilgen B	8	Tatoglu E

Figure 1 illustrates the whole co-authorship network of the supply chain and logistics management papers authors in Turkey. The figure looks like there is a close relationship in the center, at the same time other than this cluster there are many unconnected smaller networks. These small networks appear separated from the center network and to be scattered to the pheriphery of the circle. Therefore, we can devide our networks into three parts: center network, close to the center but not connected to the center, and networks in the periphery of the circle.

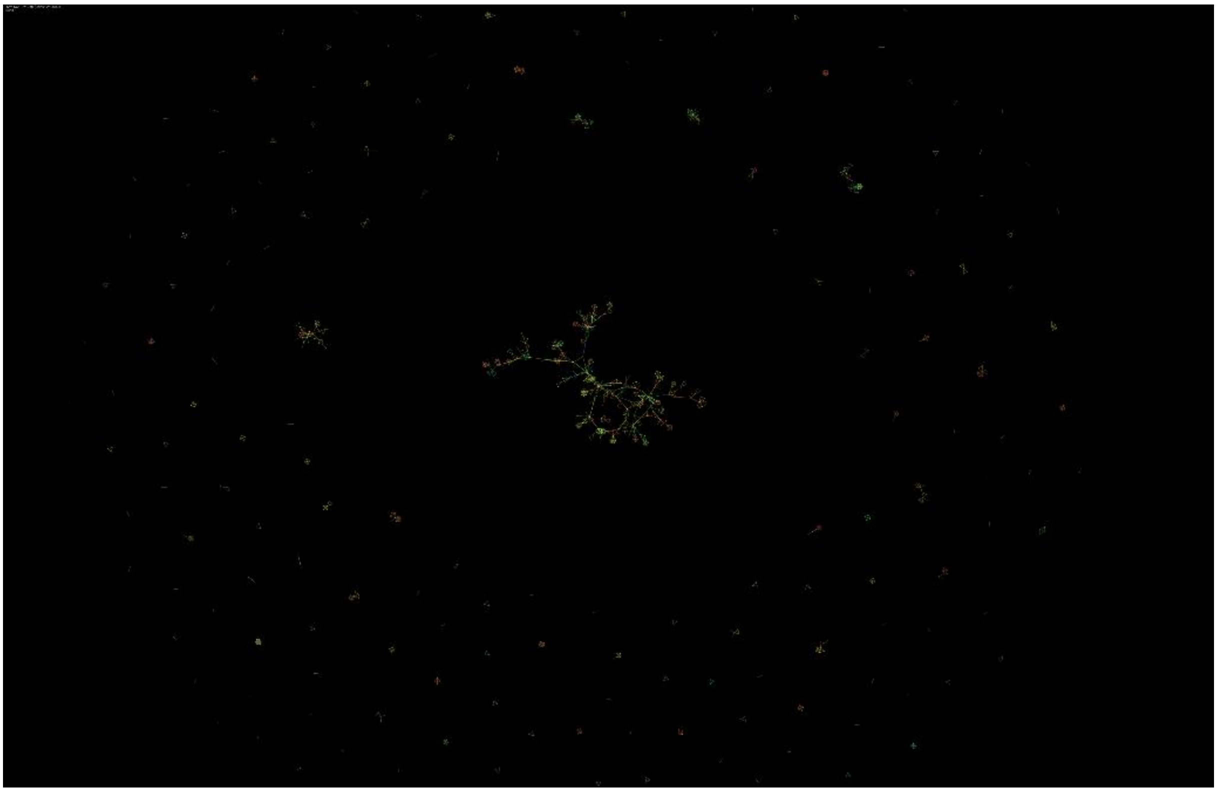

Figure 1. Whole Authorship Networks

The central network has the highest number of co-authorship connections as illustrated in Figure 2. The network in the center has the largest co-authorship network. The connections in networks can be collected into two groups: direct relationships by co-authorship within paper(s) directly, and indirect relationships by connections of co-authorships of their co-authors. For example, although Büyüközkan and and Paksoy have the highest publications in our list, they do not have any published paper together. They are located in the center network and both authors are connected with other authors who are co-authored in different papers. On the other hand, Paksoy and Özceylan has a direct strong relationship because of the number papers co-authored together. In the figure, each node (authors in this case) appeared in different sizes. The authors which has the highest number of papers appeared large fonts, and the others appear smaller fonts regarding with the number of papers published.

Buyukozkan who is in the center of the central network has a connection with Aras, Ustundag, Baskak, Eryuruk, Kayakutlu and Tanyas; In the subgroup of Kahraman, there is a close connection between Oztasi, Onut, Tuzkaya, Temur and Kongar. There is a similar network in the lower section of the network with Vayvay, Tatoglu, Ulengin and Guneri. On the upper side of the central network, main nodes are Paksoy and Ozceylan. Their network also reaches to Altiparmak, Baykasoglu and Kaplanoglu on one side, and Gules and Tekin on the other side. Tekin has a special feature in the central network because he connects the upper level side of the network to the main network by co-authoring with Aras and Aksen. Left side of the central network starts with Aras and Aksen, and continues with Kaya, Barabarosoglu, Turkay and Ozdemir, finally ends with Karaesmen and Tan.

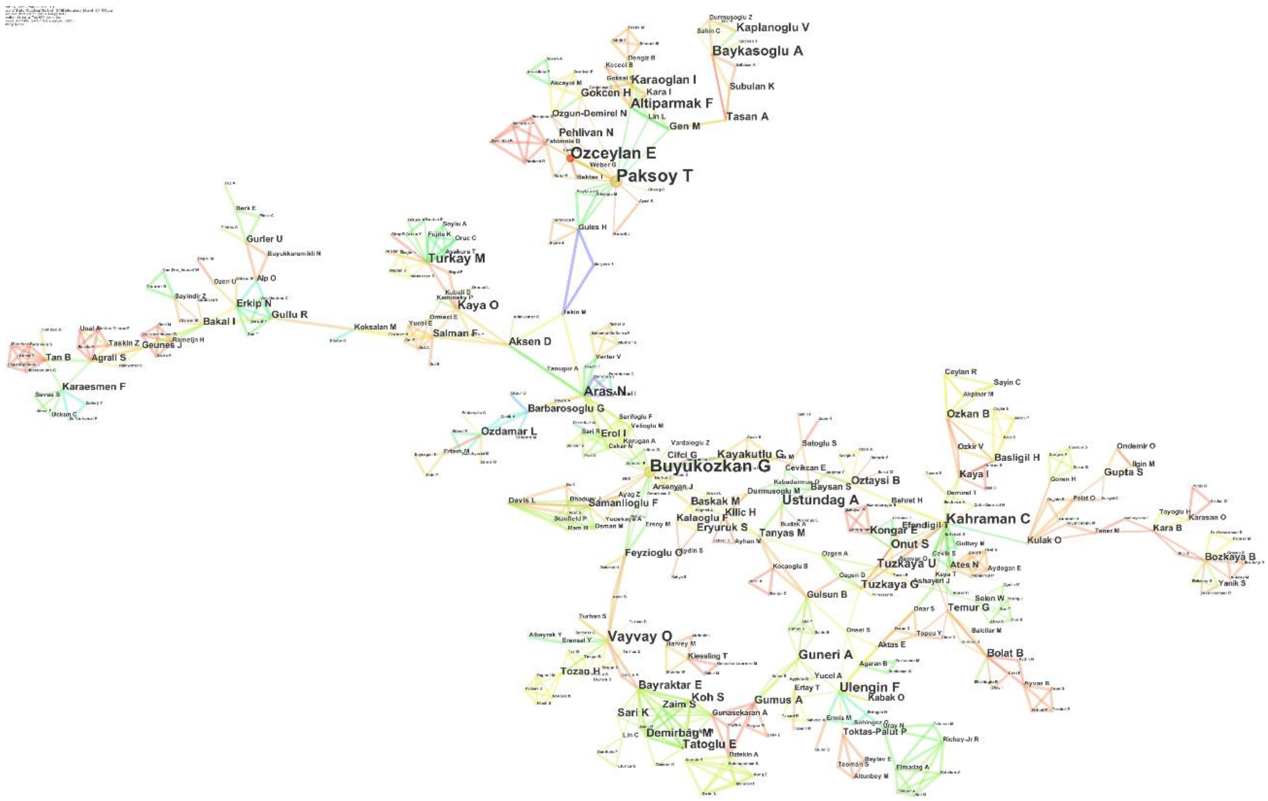

Figure 2. Co-authorship Social Network (central cluster)

In figure 3, we see close but separated networks from the central cluster, and comparing with the network in the center, there are fewer connections in these networks, but they are not connected with the other networks. The size of the nodes in Figure 3 is not scaled with other networks; they are in larger fonts to be read easily. But, in each quantile in Figure 3, the nodes with larger fonts shows the authors who has more connections in each network. For example, Bilgen in the first, Catay in the second, Saatcioglu and Tuna in the third, Sabuncuoğlu and Toptal in the fourth quantile in Figure 3 have the highest ranking node in their individual separated networks.

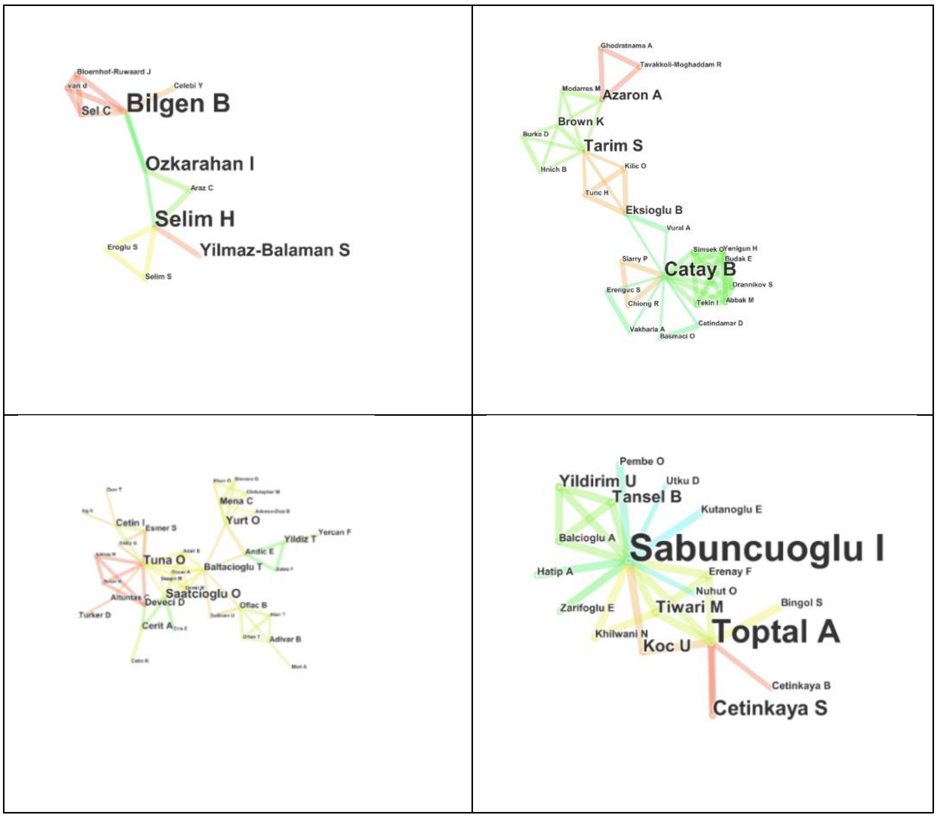

Figure 3. Co-authorship Social Network (Near to the center network)

Next analysis consists of the relationships within institutions and countries. Our dataset includes the papers whose at least one author's institution located in Turkey. Figure 4 shows the relationship network between institutions of the authors. The size of any node (affiliations in this case) related with number of publications from the institutions, and the strength of the relationships between institutions is shown with the thickness of the line which connects two nodes. The institution which has the largest node is Istanbul Technical University with 103 publications, Dokuz Eylul University follows with 60, and Yildiz Technical University with 57.

The centrality is also a good figure to detect the important nodes within the network by the indicators of power, influence, popularity, and prestige [7]. Table 2 shows the institution list which has the highest number of publications and centrality. Majority of the institutions of the authors are mostly from the universities, but, we find some other public institutions (such as Turkish Land Forces, The Scientific and Technological research, Council of Turkey–TUBITAK) and private companies (such as Borusan Logistics) as affiliations.

When we analyse the collaborations between countries, we can summarize that the most of the authors in Turkey collaborated with other scholars in Turkey, and other most collaborated countries the U.S.A with 107, the United Kingdom with 28, Canada with 14, Netherlands with 12, and France with 11. Scholars in Turkey have been collaborated not only with other authors in the US or the EU, but also with scholars from the countries in other continants such as Japan with 8, Iran with 7, Australia with 5, China with 3, and Mexico with 2.

The final finding from our analysis is detecting the most influenced keywords appeared in these studies. The most effected keywords over the time used in these publications are industrial management, mathematical models, problem solving, computer simulation, and decision making. These keywords are matching with previous bibliographic studies such as in [12] Charvet et al (2008).

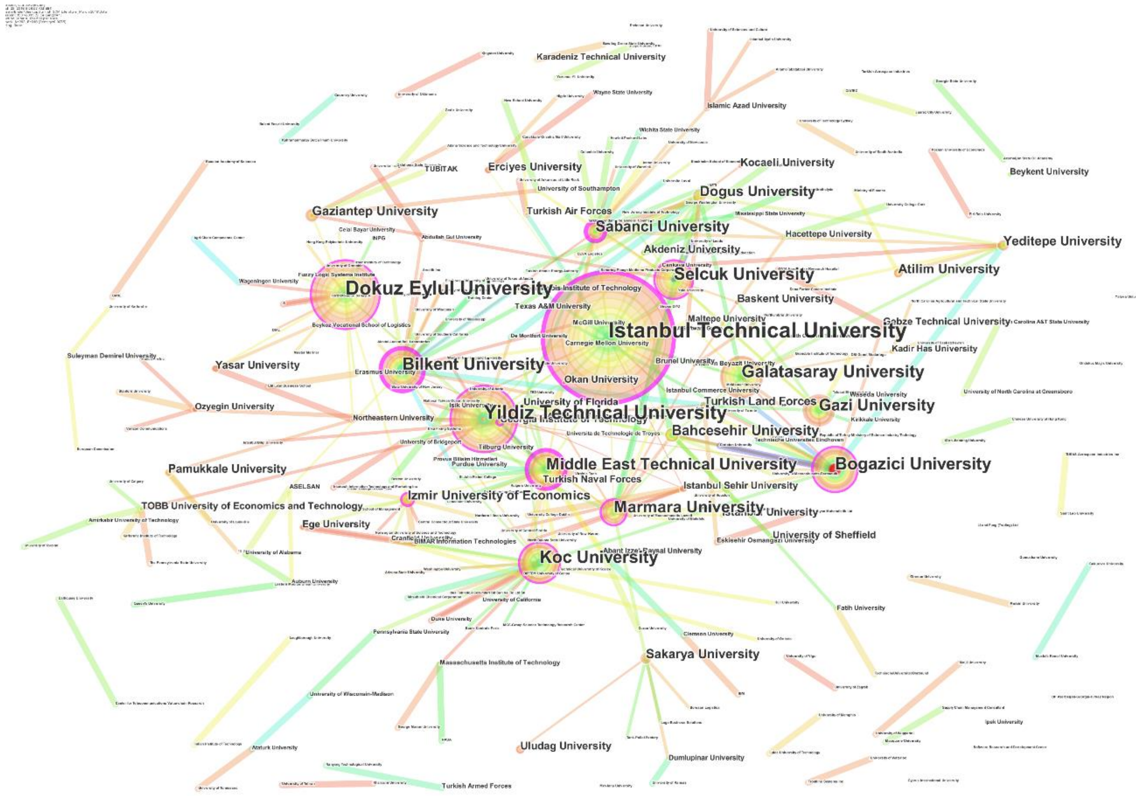

Figure 4. Affiliation Network

Table 2. The Number of Publications and Centrality by Affiliation

Freq	Centrality	Affiliation	Freq	Centrality	Affiliation
105	0.28	Istanbul Technical University	28	0.16	Marmara University
60	0.19	Dokuz Eylul University	25	0.20	Sabanci University
57	0.20	Yildiz Technical University	19	0.07	Bahcesehir University
42	0.08	Galatasaray University	18	0.05	Dogus University
42	0.17	Bogazici University	15	0.06	Sakarya University
40	0.17	Koc University	14	0.10	Izmir University of Economics
40	0.28	Bilkent University	14	0.03	Gaziantep University
35	0.16	Selcuk University	14	0.05	Yeditepe University
32	0.05	Gazi University	13	0.01	Atilim University
32	0.39	Middle East Technical University	10	0.05	Turkish Land Forces
			10	0.02	Pamukkale University

CONCLUSION

This paper is an exploratory study on supply chain and logistics management articles whose one of the authors is from Turkey by using social network analysis. Although the first record in our database appeared in 1997, the number of articles has increased over years. During the time period from 1997 to 2015, it seems a quite large academic network has been created in Turkey. We detected the relationships between authors, institutions (affiliations) and countries. Some relations could be realized directly as seen between the co-authors, but, most of the time an author cannot link another because there is no direct connection between them. We were also able to show both relationships in one big picture. We believe those networks will continue to grow and help to generate and improve the knowledge in supply chain and logistics management field while expanding the collaborations with overseas.

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A CONCEPTUAL MODEL FOR CUSTOMER RETENTION IN AIR CARGO INDUSTRY

Kemal YAYLA[1], Murat KOCAMAZ [2]

Abstract –. Firms incur higher charges when attempting to win new customers than to retain existing ones. However, customer retention efforts have also been costing organizations large amounts of resource. In order to increase value of business, predictive analytics provides organizations with new opportunities to 'know what they know', but also predict future behaviors of customers. Firms with better insight can get transparent and make better policies to retain their existing customers. This paper is aimed towards individuals who wish to develop their own churn management solution that can be extracted from the data that already stored in existing database. The paper analyzes a process of customer churn modeling in the aspect of decision tree algorithm with KNIME.

Keywords – Air Cargo, Decision Tree, KNIME, Churn Prediction

INTRODUCTION

In line with world trade liberalization and global logistics operation, air cargo has gained more importance for airlines, forwarders, shippers, airports and the economy in general. In today's world economy, air freight industry acts as main mode of transport for high-value products and luxury goods [1]. Although the air freight industry only covers a limited amount of world trade in terms of tonnage, the share of air freight in terms of value is substantial. The demand of air cargo will increase as the trade volume and economic activity increases. An efficient, reliable air cargo industry can be a significant engine for economic development. Boeing forecasts the demand for air freight to grow by %4 over the next decade [2]. However, since 2008, the global air cargo industry is experiencing a severe slowdown. Several air cargo carriers disappeared from the market while others reduced capacity to adjust to decreasing demand [3]. In addition, many shippers and forwarders switched to cheaper ways of transport. In order to resume the current profit level, air freight firms have focused on creating and managing service packages to maximize revenue [4]. By thoroughly understanding customers' value functions and behavior, a firm can design different packages using appropriate combinations of attributes such as price, amenities, purchase restrictions, and distribution channels. One of the prominent models of CRM is Revenue management (RM) [5]. RM originates from the airline industry and is traditionally aimed at maximizing a firm's revenue by analytically predicting consumer behavior and demand [6].

The air cargo industry shares many common characteristics with airlines [4]. In fact, air cargo revenue management differs from classic CRM management models that are currently used by airlines in several aspects because of the distinct characteristics of different cargo types in terms of available capacity estimation, network capacity allocation, and capacity booking behavior [7]. There is a large variety of air cargo customers and shipments, all with different needs and characteristics. In order to understand dynamics of air cargo revenue management several researches' have been undertaken with different aspects [8-10]. Those researches have been tried to identify the unique characteristics of air cargo revenue management as multi-dimensional and variable capacity, irregular and multi-dimensional service-level-bound demand, and pre-determined mid-term commitment with OR methods. But none of these studies have been focused on customer expectations and behavior in terms of customer retention. In this study, we have proposed a framework for predictive analytical customer churn model based on decision tree algorithm with KNIME.

CUSTOMER CHURN MANAGEMENT

Customer Relationship Management (CRM) is used broadly in different fields as a company strategy for building long lasting customer relationships. Effective management of information and knowledge is central and critical to the concept of CRM for [11]:

- Product tailoring and service innovation.
- Providing a single and consolidated view of the customer.

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- Calculating the lifetime value of the customer.
- Designing and developing personalized transactions.
- Multichannel based communication with the customer.
- Cross-selling/up-selling various products to customers.

Customers are increasingly mobile and ever-more demanding, the cost for customer acquisition is much greater than the cost of customer retention. In some academic researches, findings are up to 20 times more expensive. Due to improved access to information, customers are more transient and it is easier and less costly for them to switch between competitors [12]. Firms recognize this and are interested in identifying potential churners in order to attempt to prevent defection by targeting such customers with incentives. In this regard, behavioral data of customer reflects potential value for predicting future decisions. Customer churning will likely to result in the loss of businesses; customer retention models (churn models) are become more important and are essential in business intelligence applications [13]. In addition, churn prediction is considered one of the key activities of a proactive customer retention strategy.

Churn management is the term that has been adopted to define customer turnover. More specifically adopted to describe the process of identifying customers who intend to quit a company and move to another service provider [14]. churn prediction has received increasing attention in the marketing and management literature over the past time [15]. Customer churn prediction is the process of assigning a probability of future churning behavior by building a prediction model based on past information [16]. Intuitively, customers' past behavior is in line with their future behavior. From an analytical viewpoint, churn management consists of (1) predicting which customers are going to churn and (2) evaluating which action is most effective in retaining these customers [17]. Churn-prediction studies typically use two strategies to improve model performance: an algorithm-based strategy and a data-based strategy [17]. Data based modeling is essentially used Customer Relationship Management (CRM) data and data mining (DM) techniques to deliver customer-based models that depict the probability that a customer will take a specific action.

Churn Prediction Methods

In the context of churn management, predictive modeling uses historical transactions and characteristics of a customer to predict future customer behavior. Churning customers can be divided into two main groups, voluntary and non-voluntary churners. Non-voluntary churners are the easiest to identify, as these are the customers who have had their service withdrawn by the company. Voluntary churn is more difficult to determine, because this type of churn occurs when a customer makes a conscious decision to terminate his/her service with the provider [18]. The aim of churn prediction is generally to classify these types of customers. Many techniques have emerged for the purpose of predicting a required outcome. The methods that are most frequently used in research, neural network (NN), support vector machine, logistic regression models and decision tree [19, 20].

Decision Tree Models

Decision tree models are primarily used for classification and prediction that are the most popular type of predictive models [14, 18, 21]. The decision trees very informative visualization and its flexibility make it practically advantageous. There are two main decision tree used in literature. Classification trees are when the predicted outcome is the class to which the data belongs. Regression tree is when the predicted outcome can be considered a real number. Classification trees where used to establish if they would offer a better method of predicting customer churn using complaints and repairs data.

The decision tree creation basis is a universe of objects that are described in terms of collection of attributes. Each attribute measures some important feature of an object and taking mutually exclusive values and each object in the universe belongs to one set of mutually exclusive classes [22]. A tree consists of branches, paths (i.e., a collection of branches), and leave nodes, where the paths represent the values of relevant attributes and the leaves represent the values of classes. Each path through a decision tree model represents a rule for performing a classification or making a prediction [23].

Decision tree development usually consists of two phases, tree building and tree pruning. The tree-building phase consists of recursively partitioning the training sets according to the values of the attributes. In the process of choosing which attribute is most appropriate to split, there is a concept called impurity which is also known as goodness-of-fit. In case of missing attributes to choose an attribute among not-split ones to make use in time of splitting, in the literature, there are famous measures addressed to estimate the impurity of a node, such as GINI index, entropy, misclassification, Chi-square, and G-square measures. The partitioning process continues until all, or most of the records in each of the partitions contain identical values. Certain branches may need to be removed because it is possible that they could consist of noisy data. The pruning phase involves selecting and removing the branches that contain the largest estimated error rate [24]. Tree pruning is known to enhance the predictive accuracy of the decision tree, while reducing the complexity.

There are many specific decision-tree algorithms. Notable ones include [23]:

- ID3 (Iterative Dichotomiser 3)
- C4.5 (successor of ID3)
- CART (Classification and Regression Tree)
- CHAID (CHi-squared Automatic Interaction Detector).

A classification and regression tree (CART) is constructed by recursively splitting the instance space into smaller subgroups until a specified criterion has been met. The decrease in impurity of the parent node against the child nodes defines the goodness of the split [14]. The tree is only allowed to grow until the decrease in impurity falls below a user defined threshold. At this time the node becomes a terminal, or leaf node. The technique is best explained by referring to its prediction phase. To determine the churn probability of a customer in the test dataset, the customer enters the decision tree at the start or root node at the top of the decision tree. This node represents a test that attributes the customer to one of the lower-level or child nodes. The test is a logical question formulated in terms of the input variable, chosen in such a way that it discriminates maximally between churners and non-churners. The result of the test determines which child node is chosen for the customer. Tests at subsequent child nodes redirect the customer through the decision tree until a terminal or leaf node is reached [16].

CONCEPTUAL MODEL

KNIME data analytic platform is used to development conceptual model of customer churn prediction model with decision tree. KNIME is used to build workflows [25]. These work-flows consist of nodes that process data; the data are transported via connections between the nodes. A work flow usually starts with nodes that read in data from some data sources, which are usually text files or databases that can be queried by special nodes. Imported data is stored in an internal table-based format consisting of columns with a certain data type (integer, string, image, molecule, etc.) and an arbitrary number of rows conforming to the column specifications [26]. In predictive modeling, two distinct phases are identified, a leaner phase and a prediction phase. In the learner phase, a model that links future customer behavior to historical customer information is created using a training dataset. This dataset consists of input variables and a target variable for a range of customers. The input variables describe the customers' profiles and their past behavior in a certain time period, and usually include demographic characteristics and historical transactions. General procedure of model development process in KNIME has shown in Figure 1.

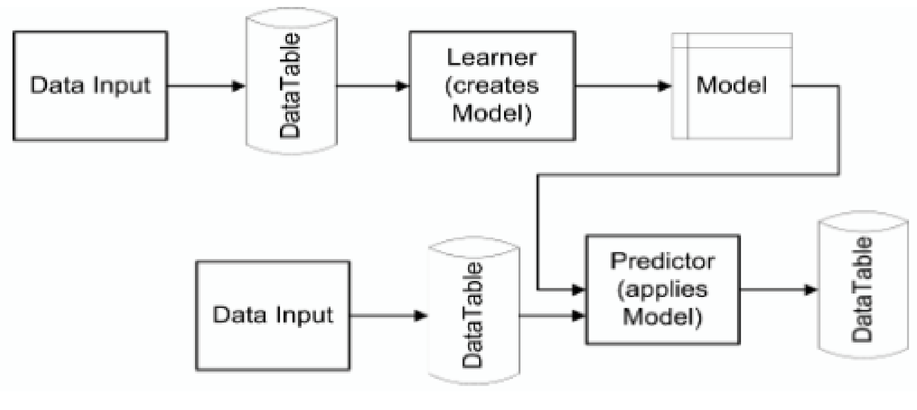

Figure 6 A schematic for KNIME workflow

Figure 1 illustrates data analysis process consists of pipeline nodes, connected by edges that transport either data or models. In regard of these bases, the first step of a conceptual model for air cargo industry is shown in Figure 2.

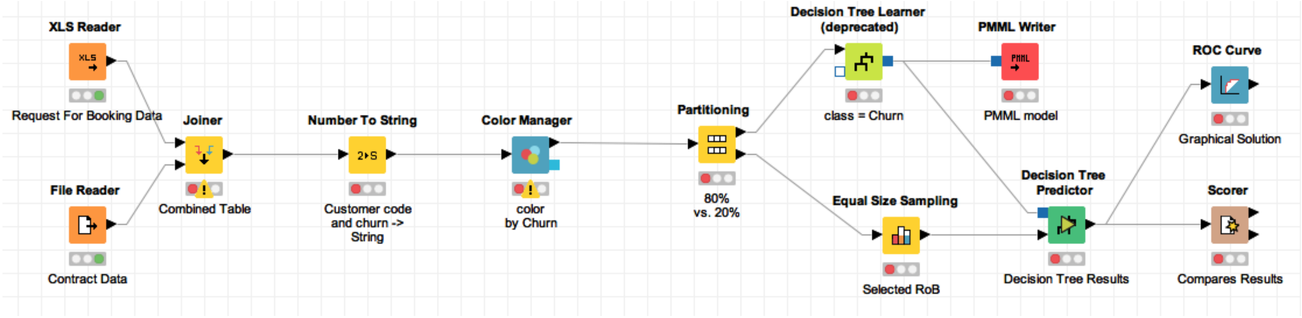

Figure 7 Learner Phase Model in KNIME

As shown in Figure 2, learner phase consists of different type of raw data that are stored in different databases. Contract data and Request for Booking data sets are used as an input variable dataset in learner model. The input variables describe the customers' profiles and their past behavior in a certain time period, and usually include demographic characteristics and historical transactions. In conceptual model customer code and churn status are used for differentiate the customer current status. Combined dataset is split into two partitions with partition node to train decision tree learner and predictor nodes. ROC curve and Scorer nodes are used test prediction accuracy with user defined ranges. If prediction accuracy of model is satisfied, trained model will be saved in PMML model node to use in second phase. The test phase of model can be seen in Figure 3.

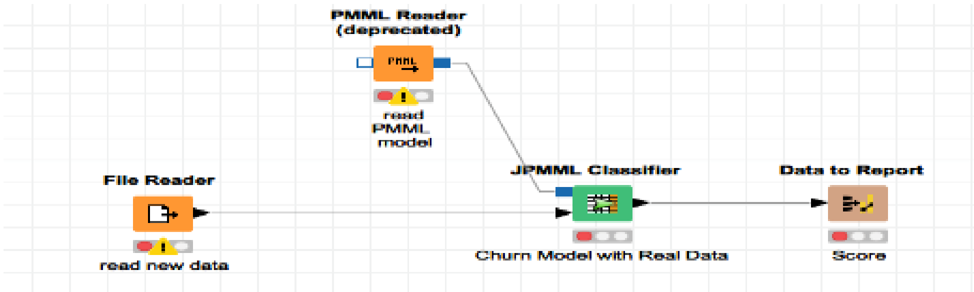

Figure 8 Prediction Phase Model in KNIME

In Figure 3, real time data are used to predict customer decision according to trained model. In order to develop a customer specific offering, prediction phase model will have used to improve decision making process. Further to the profiling of the customers a real time environment will be developed to constantly monitor the customer's interactions with the company.

CONCLUSION

Retention of possibly churning customers' has emerged to be as important for service providers as the acquisition of new customers. High churn rates and substantial revenue loss due to churning have turned correct churn prediction and prevention to a vital business process. Although churn is unavoidable, it can be managed and kept in acceptable level. Since air cargo market has exhibited the fastest growth rate in the world for the past few years, it has become apparent customer retention efforts have been explored in different methods .In this paper, a simple conceptual model based on decision tree techniques was introduced to keep track its customers and their behavior against churn in air logistic industry. The current churn modeling efforts is more on classifying the customers into two groups therefore it can take into account both churn and non-churn. This study limits itself with conceptual model of churn and no steps were analyzed to include retention policies.

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AN ANALYTIC HIERARCHY PROCESS (AHP) BASED LOGISTICS MODEL PROPOSAL IN LINE WITH TURKEY'S FOREIGN TRADE TARGETS: TURKEY-AFRICA APPLICATION

Murat Düzgün[1], Mehmet Tanyaş[2]

Abstract**–***Turkey-Africa relations have been steadily growing and improving, especially in the last two decades. The African continent has become an increasingly important partner in Turkey's trade and economic growth, which can help Turkish firms to further diversify and position themselves better at the interdependent and highly competitive global markets. Logistics currently remain on of the main problem areas in Turkey-Africa foreign trade. AHP can be a highly important solution method for improving the foreign trade between Turkey and Africa, as it allows decision-makers to consider two of the main elements of the logistics problem, namely time and cost, and come up with an optimal solution. This research proposes an AHP model to evaluate and facilitate cross border trade between Turkey and the African Continent, which is being represented by three main countries: Algeria, Ghana, and Kenya. The aim of the proposed framework is to allow Turkish firms involved in trade with the African Continent to identify and evaluate their best logistics options, increase their business volume, and to bring out a model suggestion which will not only support them, but eventually enable improvement and growth in the sector of Turkey-Africa trade. This study focuses on the logistics hinterlands, as well as the economic and social structures of Turkey and Africa, and evaluates the main characteristics of Turkey-Africa foreign trade and logistics.*

Keywords**–***Analytic Hierarchy Process (AHP), International logistics and trade, Logistics models and Turkey-Africa foreign trade.*

INTRODUCTION

Modern international trade has made the world much more interdependent. It's a vast and constantly changing field, and one of the main determinants of economic growth, improved life quality and higher levels of consumer satisfaction. Nowadays many developing countries (such as Turkey and some African countries) start taking over the developed countries' comparative advantage in three main ways: firstly, by increasing the quality, quantity and efficiency of their production; secondly, by improving the economic partnerships with other developing countries; and last but not least, by producing high-quality finished and semi-finished knowledge-sensitive goods, which are later distributed through well-developed logistics and transportation channels.

The role of logistics in the modern interdependent business world cannot be underestimated. Logistics have become one of the main factors towards the growth of an effective, efficient, and sustainable global economy. An effective transportation and logistics network adds value to the goods at hand, and enhances their competitive power in the market place. The transportation costs in logistics constitute a big part of the total product costs and have a huge effect on the competition of the companies and even countries.

The socio-economic relationships between Turkey and Africa have been constantly growing and improving since the beginning of the new millennium. Some of the main reasons behind Turkey's opening to Africa include (and are not limited to) Turkey's re-orientation in the global political arena, Turkey's need for economic diversification, the realization of Africa's potential, and the need for improved cooperation with other developing countries [1].

The increasing intensity of global competition in world trade is making it harder for enterprises to compete at the international markets and retain their customers. Companies need to differentiate themselves, and they achieve that by finding and creating innovations and models for each trade application. The need of Turkish firms for innovation and new foreign models and markets is becoming more and more crucial, especially considering the country's goal to become one of the ten leading global economies by 2023 – the year when the 100th anniversary of the foundation of the Republic will be celebrated. World Bank data from April 2016, Turkey is the world's 17-th biggest economy with a Gross Domestic Product (GDP) of $ 799.54 billion [2]. Turkey, in a sense, is a bridge

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between two continents – Europe and Asia. In the last years Turkey started to implement more internationally open policies, which in time became more liberalized and globally integrated. Turkey's constantly increasing foreign trade volume and quality will give superiority and comparative advantage to Turkish firms, which will allow the country to take its worthy place among the global competition.

Figure 1 Hinterlands of Turkey

Africa has also gone through important changes and new developments: the Continent has become an important factor of the world's economic growth. As high income developed economies have been growing more and more dependent on the middle and low income developing market economies, there has been an increased interest towards the African continent and the great potential it holds for the future development of the global world. An analysis made by UNCTAD (2014) shows that the numerous international companies which have already been established in Africa are increasing their presence and boosting their growth by reinvesting their profits. Further intensive economic improvement is expected in the next decade [3].

The future is unclear, and although the potential of Turkish-African cooperation is yet to be observed, many scholars involved in Turkey-Africa research argue that the importance of the international economic relations between Turkey and Africa will only grow in the future [4]-[9]. Lots of Turkish companies are already starting to discover the potential of African markets and trying their luck there. [10]

The Analytical Hierarchy Process Model (AHP), a special technique based on mathematics and psychology, is a highly important solution method of improving the foreign trade between Turkey and Africa via the time and cost elements, as it doesn't determine a "correct" decision but supports decision makers in defining the strategy that will help them to achieve their goal in an optimal way depending on their understanding of the problem [11].

The aim of this research is to create a logistics model proposal that will go in line with Turkey's foreign trade targets and will be applicable in Turkey – Africa trade relations. In order to accomplish that, mainly six Turkish cities and three African countries were selected as crucial for Turkey-Africa trade and were analyzed during the creation of this model. Istanbul, Bursa, Izmir, Konya, Kayseri and Gaziantep are amongst the biggest industrialized and economically developed cities in Turkey which export to Africa (Figure 1). Algeria, Ghana and Kenya (Figure 2, Hinterlands 1, 2 and 5) are among the countries with greatest trade potential for Turkey. There are already established trade patterns between Algeria and Turkey, and future of the cooperation between these countries seems bright and high potentially. According to statistics; Ghana is the centre of West Africa and it has the potential to become an important economic partner for Turkey due to its geographic position and capital endowment. Kenya is an important player from Eastern Africa and with its rapid development is attracting foreign direct investment from all around the world, especially Europe and the USA.

Figure 2 Hinterlands of Africa

Of course, one is certain – Africa is going to play an increasingly important role for Turkey's economy as both, a source of new resources and a trade partner for Turkey's export. The purpose of this study is to help Turkish firms involved in foreign trade with Africa to increase their business capacity, as well as to provide a model suggestion which will support them to create correct strategies and apply effective and efficient policies towards Africa and also is focused on the economic and social characteristics, as well as the logistics hinterlands of both – Turkey and Africa. The main characteristics of Africa's foreign trade will be evaluated by focusing on African countries' dispersion, which has been determined according to a number of specifically defined criteria. The regression analysis of the logistics field is evaluated with the help of AHP (Analytic Hierarchy Process) model.

THE AHP METHOD

The Analytic Hierarchy Process (AHP) is a structured technique used to organize and analyse complex decisions. It was developed by Tomas L. Saaty in the 1970-ies, and has its roots in mathematics and psychology [12]. AHP has been extensively studied and refined since its first appearance four decades ago. [13]

Tomas L. Saaty (1994) created AHP as an effective system for solving complex decision making problems, which could assist the decision maker to set priorities and make the best decision [11]. Thus, AHP doesn't prescribe one and only one "correct" decision. Rather, it assists the decision makers in finding the optimal solution, which will best suit their objective and perception of the problem at hand [10].

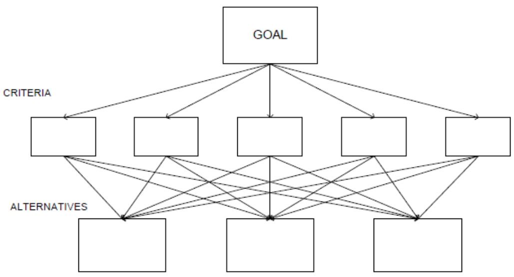


Figure 3 Three Level Hierarchy Framework Design

The AHP users have to decompose their decision problem into a hierarchy of sub-problems, which can be independently analyzed. These elements can be related and applied to any aspect of the decision problem: tangible and intangible, carefully measured and roughly estimated, well or poorly understood [13].

AHP consists of three levels of hierarchy [11], [12]. The first one is the *goal* – the objective of the decision making. The second one is *criteria*, representing how each of the existing criteria contributes to the achievement. The last one is *alternatives*, which are showing how each of the alternatives contributes to each of the criteria.

Decision-makers should be extremely careful while structuring the hierarchy, as the structure should present the problem in a best way, all side factors that affect the problem should be considered, all of the participants who take part in the decision-making problem should be considered and defined in advance [14]. It is important to mention that more elements could be added to the hierarchical structure, at any level, and more levels. A general rule is that the hierarchy should be complex enough to capture the situation, but small and nimble enough to be sensitive to changes [15].

T.L. Saaty and R. Ramanathan give a detailed and exhaustive overview of AHP and its main elements, while some scholars focus on a review of AHP applications [11], [12], [15]-[16]. AHP can be successfully used and implemented not only for academic questions and theoretical debates, but for real-life problems in various fields due to its effectiveness and well-known advantages. AHP has started to play a more prominent role in the analysis of the sectors of trade and logistics, especially in such spheres as *evaluation and ranking of suppliers* [22]-[23], *selection & analysis of logistics providers* [24]-[25], *reverse logistics* [26]-[28], *location decisions* [29]-[30], *transportation and network systems* [31], *global trade & logistics* [32], *corridor and transport mode selection* [33], etc.

A1	Istanbul Port - Algeria Annaba Port
A2	Istanbul Port - Ghana Tema Port
A3	Istanbul Port - Kenya Mombasa Port
A4	Istanbul Airport - Algeria Algiers Airport
A5	Istanbul Airport - Ghana Accra Airport
A6	Istanbul Airport - Kenya Nairobi Airport

A7	Izmir Port - Algeria Annaba Port
A8	Izmir Port - Ghana Tema Port
A9	Izmir Port - Kenya Mombasa Port
A10	Mersin Port - Algeria Annaba Port
A11	Mersin Port - Ghana Tema Port
A12	Mersin Port - Kenya Mombasa Port

SIGNIFICANCE OF THE STUDY

A detailed and extended literature overview and analysis has allowed us to point out the main sources and determine the main gaps in current scientific literature regarding the development of Turkey-Africa relations, the role of trade and logistics in this cooperation and the application of scientific models (with special focus of AHP) which could depict future patterns and facilitate real-life aspects of Turkey-Africa trade and logistics. Our analysis has helped us to determine five main 'gaps'.

Firstly, the literature devoted to the analysis of the development of Turkey-Africa relations is mainly descriptive and presents a theoretical debate related to such issues as economics, trade, logistics and politics. A. Akel's article depicting the way Turkey's Africa strategies affect Turkey's exports to Africa can be considered an exception [36]. The main objective of A. Akel's research is to examine whether Turkey's new Africa strategy has had significant contributions effect on Turkey's exports to Africa in the last decade or not. This study is the first of its kind due to its empirical assessment of real-life business dynamics of Turkey-Africa trade. However, no suggestions are made for the concrete actions and procedures that Turkish firms should undertake.

Secondly, to our knowledge, currently there are no concrete models depicting and/or forecasting the development of Turkey-Africa economic relations. Thirdly, there is a lack of models that investigate the effect of logistics and trade on the economic development and the evolution of Turkey-Africa relations. Fourthly, currently there are no scientific models of Turkey-Africa trade or Turkey-Africa logistics that are applicable for the real-life business issues Turkish firms are dealing with, or could assist Turkish companies in the creation of correct strategies and the application of the effective and efficient policies towards Africa. Last, although there has been an extensive use of AHP in different spheres of logistics, currently there are no AHP models applied to Turkey-Africa continent logistics and trade.

The aim of our research is to provide a ‘filling’ to the gap described above. Its main aim is the design of a theoretical model, as well as its empirical analysis with this field work. This model’s main goal is to help Turkish companies to increase their business capacity of foreign trade with Africa by providing suggestions which will support and guide them, so that they could create correct strategies and apply effective and efficient policies towards Africa.

In addition to that, this model will not only assist the firms, but also investigate the effect of the logistics on the development of economic partnership and cooperation between Africa and Turkey. It will help decision makers to determine the attributes, factors and dimensions of successful implementation of efficient transportation and logistics practices that will affect the performance of the organizations and improve Turkey-Africa trade.

This five-in-one approach (assisting Turkish firms, investigation and determination of best practices, empirical analysis framework, analysis of current trends and forecasting) and focus on real-life issues and the adaptability of the suggested model to the constantly changing global environment can be considered as the contribution of our research. The suggested model will be useful to companies doing business with Africa, as it will allow them to decrease their logistics costs, improve the effectiveness and efficiency of their logistical processes, increase the quality and speed of response to customers and decrease the lead time of all the included processes.

Up to this study, all of the factors that can be effective in Turkey-African trade are presented for the evaluation of 2.044 companies from 6 different hinterlands in Turkey operating to 3 different African hinterlands, specifically selected by the this study performer. These factors are presented to 166 numbers of companies related of them which are selected via sampling in accordance with different product manufacturer groups, and lastly based on actual practices 25 effective criteria is identified and employed for the models. An applied survey has given us the opportunity to evaluate the relationship between the features of the companies and trade patterns they are having with the Chi-square tests. The factors that are beneficial for the companies involved in Turkey-Africa trade and the effect of the demographics of the companies are put forth with the hypothesis tests in accordance to how much companies value them, and in compliance with the distribution of possibilities. This inferential statistical analyzes continue with a regression model of the factors which affect the demographics of the companies in explaining the features of Turkey – African trade.

There are 12 different trade models (see Table 1) which can be applied in this case; we have selected the Analytical Hierarchy Process(AHP) as the most appropriate scientifically tested Multiple Criteria Decision Making model for the case of Turkey-Africa trade. The AHP application is used in the sensitivity analysis of the effecting way of other possible 11 trade models with the best model identified. It is put forth and based on the opinions of 5 experts and companies in this area, and allows researcher to determine the relative importance of the identified criteria. Furthemore, the proposed model is applied on a transportation project of a logistic service provider, which gives service in a multi-modal and multi-echelon transportation network, so that the results of the model could be compared with the current situation by using different scenarios.

4 different Product Groups had been choosen for this work, 1- Machinery and Automobile, 2- Textiles and Apparel, 3- Iron and Steel and 4- Wooden Products that constitutes big part of Turkey-African mutual trade and also “others” (All Other Product Group) forms the rest of the groups. Our high level work consist of only “SEA” and “AIR” Transportation mode as obligational because of Turkey and Africa location on the world.

Furthermore, the trading companies’ annual revenue, export point in Africa and logistics activities are being explored and investigated through a set of regression models. The sample size is determined assuming 0.635 standard deviation, (σ), and 0,1 sampling error (*e*). Then with 95% Confidence Level ($Z_{0.025}$ = -1.96) the required sample size is found to $n = \frac{Z^2_{\alpha/2}\sigma^2}{e^2}, n = \frac{(1.96)^2(0.635)^2}{(0.1)^2} \approx 155$. Therefore, the obtained sample of 166 participating companies is assumed to be large enough according to the above mentioned assumptions. The gathered data is analyzed by *SPSS v22.0* and *Mini Tab v17.0*. For all of the analysis, the significant level is assumed to be $p<0.05$.

GENERAL MODEL PRACTICE

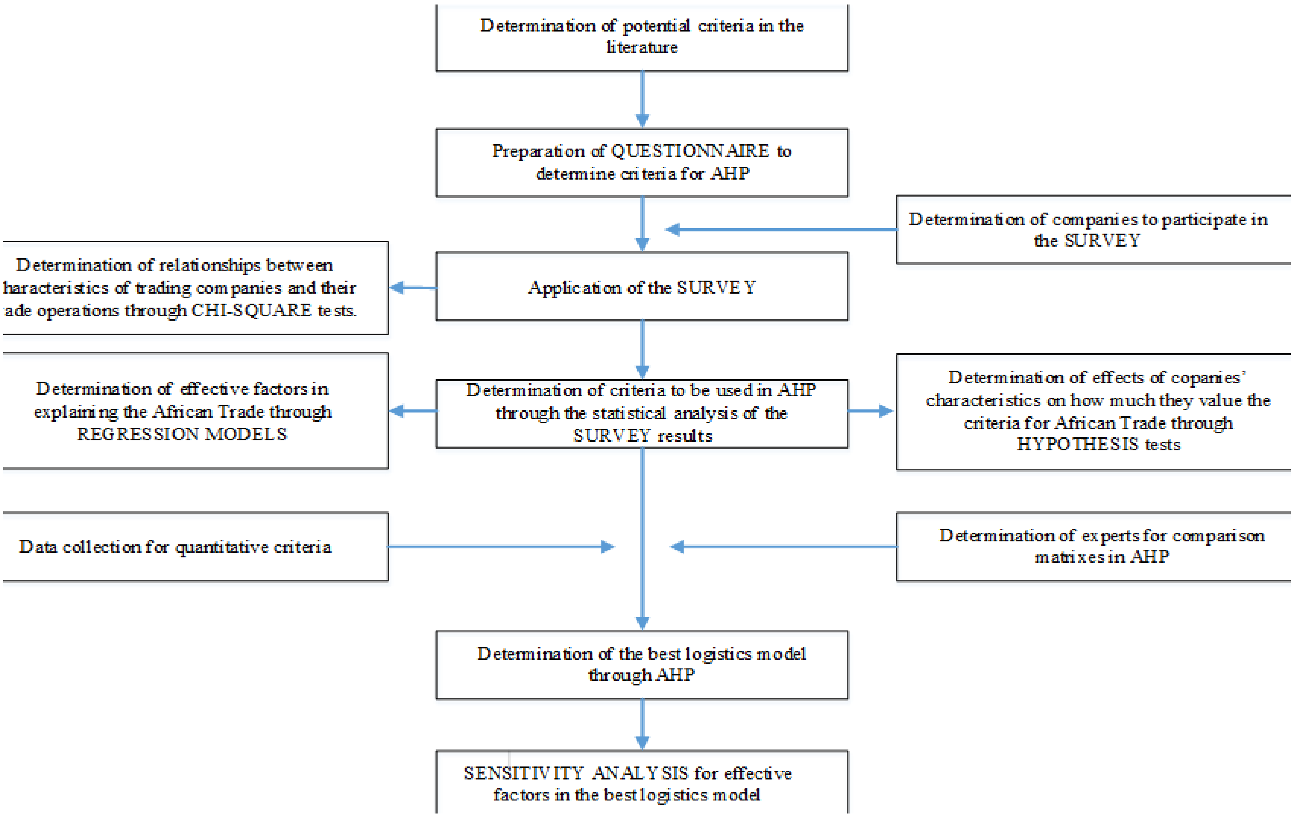


Figure 4 Flowchart of the Model

The importance and influence of the variables "*Time*" and "*Cost*", the main subject matter of the study, compared to the other variables is proved to a considerable extent under the above mentioned models and evaluations. Therefore if the questionnaire study covering 155 companies defined as a result of the thesis sampling size calculation is extended by 40 or 50 percent for a much higher reliability level (98,3%), the results will be more consistent.

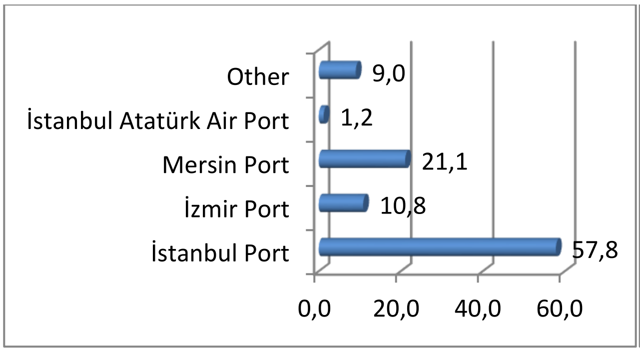


Figure 5 Ports used the Most for African Trade Percentage

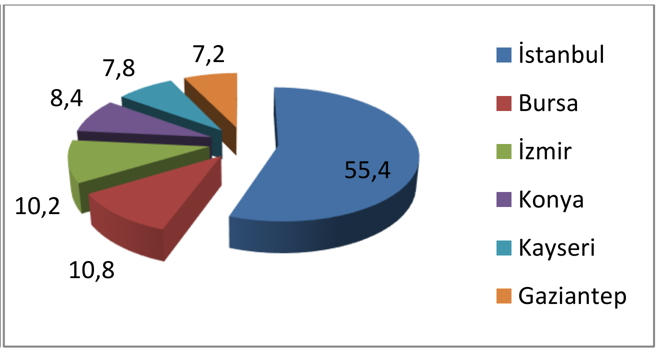


Figure 6 Hinterlands' Percentage in Turkey for Africa Export

IMPLEMENTATION OF AN AHP MODEL ON *EXPERT CHOICE v2000*®

Analytic Hierarchy Process (AHP) is employed as a multi-criteria technique to find out the best practice out of twelve existing models based on the judgements of five experts in the field. The resulting best practice determined is further analyzed according to criteria' priority weights through sensitivity analysis. Steps of AHP and sensitivity analysis are conducted through *Expert Choice v2000*. As AHP model is based on experts' opinion, about 12 existing models (see Table 1) for African trade achieved through pairwise comparison matrices for each criterion (attribute), the current total 25 sub features are likely to be too cumbersome and prevent the experts from providing consistent judgements.

Expressed above 7 main criteria and related 25 sub criteria are:

1. ***Product*** features with 7 sub features: volume, product value, insurance necessities, stacking features, product sensitivity, transportation features and product life.

2. ***Reliability*** with 2 sub features: timely deliveries and responsibility on delays.

3. ***Speed*** with 3 sub features: transportation distances, transportation times and transportation speeds.

4. ***Traceability*** with 2 sub features: traceability of load and vehicle & traceability of documents.

5. ***Cost*** with 6 sub features: transportation costs, handling and packing costs, warehouse and transmission point processing costs, communication costs, wastage costs and delaying costs.

6. ***Security*** with 2 sub features: product damaging possibility and thief possibility.

7. ***Risks*** with 3 sub features: warehousing risks, political and social risks.

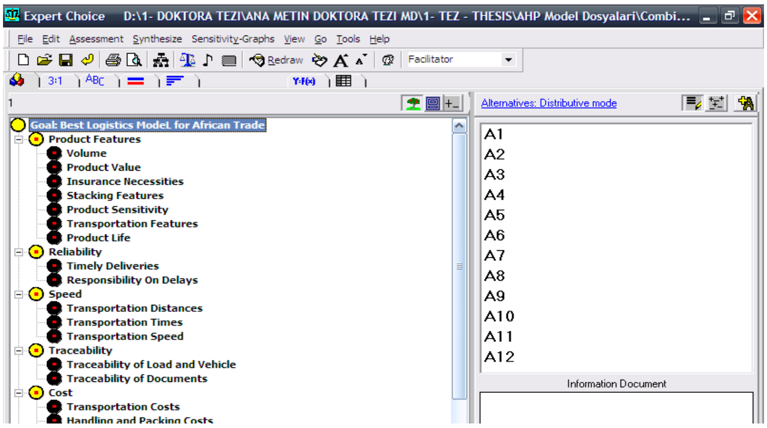
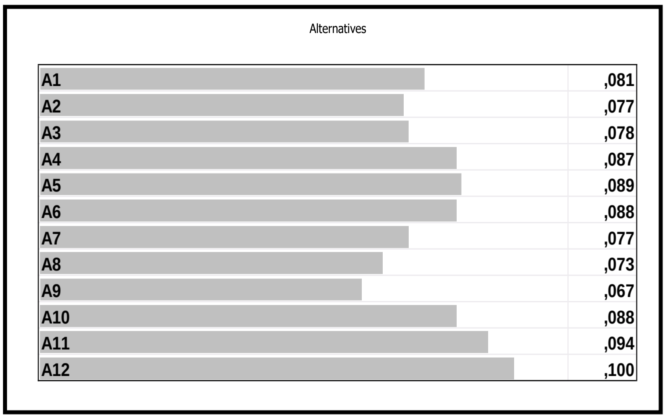


Figure 7 Main, Sub-criteria and Alternatives in Combined AHP Model View



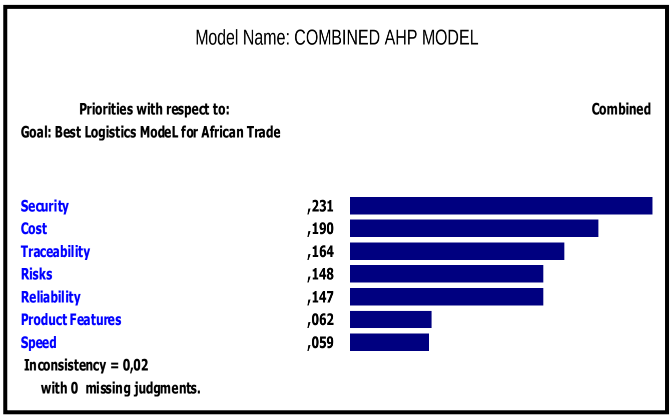


Figure 8 Main Criteria's Priorities on Expert Choice. **Figure 9 12 Alternatives' Priorities in Combined AHP Model**

CONCLUSION

Turkey-Africa economic and social relations are still in their initial stage of development. However, recent developments and latest data signify that they are steadily and constantly growing and improving. In the literature there is equivocal evidence showing that the future of Turkey-Africa cooperation in various fields and spheres of life seems bright and prosperous.

This study focuses on the role of logistics in the development of Turkey-Africa economic and trade relations. First of all, statistical analyzes used for checking the data reliability and relation between mutually main criteria then to carry the results to AHP model that has been prepared for checking the relation mainly between "Cost" and "Time (Door to FOB Africa Port)" because of the most important two important parameters in logistics. The main goal of the thesis is to create a model that could assist Turkish firms participating in export-import activities in Africa to increase the quality of their processes, achieve more effective and efficient operations, optimize their performance and maximize their profit, while simultaneously ensuring economic stability, sustainable development and ultimately, international growth. It provides an in-depth analysis of the current situation of Turkey-Africa trade, a suggestion regarding the issues that could be addressed in the future in order to improve Turkey-Africa export and import, as well as a forecast regarding the future of Turkey-Africa cooperation.

The AHP model suggested in this study aims to help Turkish firms involved in African trade to determine the attributes, factors and dimensions of the successful implementation of efficient transportation and logistics practices by offering an empirical analysis for the measurement and evaluation of the impact of logistical factors on organizational performance and by lining out the most important criteria and factors of economic and trade growth between Africa and Turkey in the coming decades.

The performed analysis showed that the "Mersin Port – Kenya Mombasa Port" alternative was the best from among the other 12 Alternatives and was chosen as the "*Best Logistics Model"* with a "Relative Importance" of 0,10 after the model was solved. Two other alternatives, namely "Mersin Port – Ghana Tema Port" and "Mersin Port – Algeria Annaba Port" were ranked as second best and third best option with a weight of 0,094 and 0,088 respectively.

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SUPPLIER SELECTION FOR A TIRE COMPANY WITH PROMETHEE METHOD

Haluk Ç. Kasımoğlu[1] Atakan Alkan[2] Zerrin Aladağ[3]

Abstract - Supplier selection decision in a globalized competitive environment is very important for a company to be successful. The aims at choosing the right supplier; to increase customer satisfaction, improve the competitive ability and continue to exist at minimal cost. This study was intended to choose the most suitable raw material supplier in a company engaged in the production of agricultural tires. In the study Promethee I method of multi-criteria decision-making methods were applied in order to select the most suitable supplier to a company. In the first stage of the study; literature was made and the most widely used and most effective supplier selection criteria were identified by the researchers. As a result of surveys conducted by firms active in terms of these criteria and degree of importance of the criteria was determined by the procurement team. In the second stage of study; ranking of the suppliers was made using Promethee I method. In conclusion, Promethee I method used by the company to determine the suppliers with the highest score among its' suppliers and brought several recommendations.

Key Words - Promethee I, Supplier Selection, Tire Company.

1. INTRODUCTION

Within this competitive environment where customer needs change quickly, companies should increase their performance to survive. However, recent competitive environment has shown that it is not possible only through the improvements within the company. New players of the market are not the companies but the supply-chains constituted by the companies. Therefore, performance of the elements constituting the supply-chain is an essential factor for the companies The supply-chain includes management of supply and demand, supply of raw material, production and montage, stocking, inventory management, order management and product delivery to customers and it also involves information system necessary for the maintenance of these operations [1]-[2]. When we look at the development of Supply chain Management (SCM), we see that early developments took place in the 1960s.. The physical distribution step that is required as the initial step for the establishment of SCM was carried out by Bowersox, Furthermore, Bowersox put forth that distribution function outside the company through the integration of channels provides a competitive advantage [3].

In today's world, within the competitive environment, quick and effective decision-making has been one of the foremost goals of the companies. Multiple Criteria Decision Making (MCDM) is one the most important methods used during this process [4]-[5]. The problem of choosing a supplier is a MCDM problem since it requires the evaluation of various criteria. Evaluating existing alternatives according to deterministic criteria, MCDM helps us reach the most agreeable solution.

Maragoudaki and Tsakiri with the Promethee method dealt with flood problems and suggested ways to assist the process of selecting alternative methods to minimize the loss caused by these problems [6]. Gökalp and Soylu specified the supplier scores using Analytic Hierarchy Process (AHP) to calculate the weights of factors and afterwards making use of the Promethee methods [7]. Dağdeviren and Eraslan approached one company's problem of choosing a supplier with the Promethee method and figured out the priorities of the alternative suppliers. At the end of the study, both partial and full priorities were determined for alternative suppliers [5]. Yılmaz and Dağdeviren used the Promethee method and Fuzzy Promethee methods to solve a management's welding machine selection problem.

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In this study, both partial and full ratings were determined [8]. Arıkan and Küçükçe aimed to create a supplier selection and evaluation and a suitable pricing policy considering the best criteria for a public enterprise. Identified criteria were weighted using AHP model. Promethee method was used for the selection and evaluation of 32 suppliers and the best supplier was determined [9].

This study was intended to choose the most suitable raw material supplier in a company engaged in the production of agricultural tire. In the second stage, the method used in this study was informed about. In the third stage, Promethee I method was carried out for supplier selection problem in an agricultural tire production company. In the last stage, results of the study were determined and several recommendations were brought.

2. PROMETHEE METHOD

Supplier selection can be carried out together with various methods. AHP, ANP Data Envelopment Analysis, ELECTRE, TOPSIS, Promethee and multi-criteria-decision-making methods like integration of these methods usually have used. Selection criteria and determination of the methods are the most significant aspects of supplier selection [10]. Promethee I method will have used for the supplier selection problem. A different perspective was tried to provide with this method.

Promethee method, developed by Brans in 1982, is a multiple criteria decision-making method [11]. Promethee method was developed considering the difficulties experienced during the implementation of existing methods within literature and has been so far used in several studies on supplier management [5]. Promethee is a method that provides the rating of a series of alternatives through consideration of contradictory criteria. The initial point of this method is the evaluation chart. In this evaluation chart, alternatives are assessed according to different criteria [12]. Two kinds of information are required for the implementation of the Promethee. These are [12]: The relative importance of criteria under consideration and the decision maker's choice of function to compare contributions of alternatives of each different kind.

Promethee method consists of 7 steps [5]; In the first step; the data matrix related to alternatives A=(a,b,c,…) evaluated by $w=(w_1,w_2,\ldots,w_k)$ weights and c criterion $c=(f_1,f_2,\ldots,f_k)$ is formed. In the second step, selection functions for criteria are identified. In the third one, based on their selection functions, shared selection functions are determined for alternative pairs. In the fourth step; with reference to shared selection functions, selection indexes for each alternative pair are specified. The selection index of a and b alternatives evaluated by c criterion having w_i (i=1,2,…k) weight is figured out. In the fifth step; positive (Φ^+) and negative (Φ^-) priorities are determined for the alternatives. In the sixth step, partial priorities are determined with the Promethee I. Partial priorities help to determine the preferability of alternatives compared to each other and to note identical and incomparable alternatives

3. APPLICATION

In this study, supplier selection was applied in the company engaged in the production agricultural tire company. Promethee I method was used in this study. The existing suppliers were put in order with Promethee I method in this study. Promethee I method used by the company to determine the suppliers with highest score among its' supplier (the existing supplier) and brought several recommendations. Visual Promethee software package program was used for the steps of Promethee I method computations.

In the first stage of the study; before starting the application, the criteria used in the supplier performance evaluation that was reviewed with the procurement team and a standard evaluation study was applied. After the analysis of the present evaluation chart, in consequence of the meeting with the procurement team, a 1-5 ranked evaluation was carried out for each single criterion in the identification of criteria. The list of the criteria was established from the used various studies and the suggestion of academic staff with the procurement team. In the result of evaluation, the geometric mean was calculated from scores given by the procurement team for each criterion. The criteria are shown in Table 1 on which above the geometric mean and passing the last of control by the procurement team.

Table 1. The Main Criteria and The Sub-Criteria to Use in Supplier Selection

Symbol	The Main Criteria	The Geometric Mean of The Main Criteria	The Degree of Importance of the Main Criteria (%)	Symbol	The Sub-Criteria	The Geometric Mean of The Sub-Criteria	The Degree of Importance of Sub-Criteria (%)
K	Quality	2,5	0,4	K1	Percentage of Rejected Products	4,3	0,76
				K2	Product Performance	4,3	0,24
T	Delivery	3,2	0,17	T1	Delivery Performance	4,3	0,24
				T2	Transport/Shipping Cost	4,3	0,76
F	Price	3,5	0,23	F1	Unit Price	5	0,1
				F2	Cost (Ordering Cost)	5	0,47
				F3	Discount	4,6	0,28
				F4	Compliance with Sectoral Price Conditions	4	0,08
				F5	Ease of Payment	4	0,07
E	Flexibility	2,7	0,07	E1	Compliance with Customer Requests	4	0
M	Costumer Relationship	2,7	0,06	M1	Communication Systems	4,3	0,12
				M2	Collaboration	4,3	0,3
				M3	Reliability	4,3	0,58
R	Competition Power	2,5	0,04	R1	Professionalism	4,3	0,14
				R2	Production/Sales Capacity	4	0,26
				R3	Turnover (with OZKA)	4	0,6
Y	Innovation	2,5	0,03	Y1	Ability to Offer New Product	4,3	0

* Flexibility and Innovation main criteria do not have any sub-criteria. Because of that, do not have the degree of importance of the sub-criteria.

In the second stage of the study; Promethee I method was used in this study, after criteria was determined that used the supplier selection problem. *In the first step of this stage;* the procurement team determined supplier. Evaluation results are shown in Table 2.

Table 2. Evaluation The Suppliers According to The Criteria

Criteria / Suppliers	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Criterion
K1	0,00%	0,00%	0,00%	0,00%	Percent
K2	8	8	8	8	Ten Points
T1	1,58 USD	1,89 USD	1,97 USD	1,95 USD	Currency (Dollar)
T2	186705,44 TL	222746,68 TL	232790,96 TL	230427,60 TL	Currency (TL)
F1	0,00%	0,00%	0,00%	0,00%	Percent
F2	Suitable	Suitable	Suitable	Suitable	Ten Points
F3	90 Days	90 Days	90 Days	90 Days	Payment Term (Day)
F4	8	7	7	8	Ten Points
F5	Belonging to Supplier (Yes)	Belonging to Supplier (Yes)	Belonging to Supplier (Yes)	Belonging to Supplier (Yes)	Belonging to Supplier (Yes-No)
E1	7	7	6	7	Ten Points
M1	7	6	6	8	Ten Points
M2	8	7	7	7	Ten Points
M3	8	8	8	8	Ten Points
R1	7	7	7	8	Ten Points
R2	-	-	-	-	Percent
R3	Good	Average	Average	Good	Very Bad-Bad-Average-Good-Very Good
Y1	7	9	7	9	Ten Points

In the second step of this study; after the alternative suppliers were evaluated by the criteria, the hierarchical criterion structure was converted the single-level structure. This process was calculated with the degree of importance of the main criteria multiplied by the degree of importance of the sub-criteria. New criterion degrees were shown in Table 3.

Table 3. One-level Relative Importance Weights, Chosen Selection Functions and Parameters

Symbol	W (%) (1)	Symbol	W (%) (2)	T1	T2	T3	T4	W	Preference Function	Par. Q	Par. P
K	0,4	K1	0,76	0	0	0	0	0,304	Type I (Usual)	n/a	n/a
		K2	0,24	GV-G (8)	GV-G (8)	GV-G (8)	GV-G (8)	0,096	Type III (V – Shape)	n/a	0
T	0,17	T1	0,24	GV-G (8)	G (7)	G (7)	GV-G (8)	0,041	Type III (V – Shape)	n/a	0,3
		T2	0,76	Yes (1)	Yes (1)	Yes (1)	Yes (1)	0,129	Type II (U – Shape)	1	n/a
F	0,23	F1	0,1	1,58	1,89	1,97	1,95	0,023	Type V (Linear)	0,05	0,1
		F2	0,47	186705TL	222746TL	232790TL	230427TL	0,108	Type V (Linear)	7500	12500
		F3	0,28	0	0	0	0	0,064	Type I (Usual)	n/a	n/a
		F4	0,08	Good (4)	Good (4)	Good (4)	Good (4)	0,018	Type III (V – Shape)	n/a	0
		F5	0,07	90	90	90	90	0,016	Type III (V – Shape)	n/a	0
E	0,07	E1	-1	G (7)	G (7)	A-G (6)	G (7)	0,07	Type III (V – Shape)	n/a	0,2
M	0,06	M1	0,12	G (7)	A-G (6)	A-G (6)	GV-G (8)	0,007	Type III (V – Shape)	n/a	0,4
		M2	0,3	GV-G (8)	G (7)	G (7)	G (7)	0,018	Type III (V – Shape)	n/a	0,2
		M3	0,58	GV-G (8)	GV-G (8)	GV-G (8)	GV-G (8)	0,035	Type I (Usual)	n/a	n/a
R	0,04	R1	0,14	G (7)	G (7)	G (7)	GV-G (8)	0,005	Type I (Usual)	n/a	n/a
		R2	0,26	n/a	n/a	n/a	n/a	0,012	Type I (Usual)	n/a	n/a
		R3	0,6	Good (4)	Average (3)	Average (3)	Good (4)	0,023	Type III (V – Shape)	n/a	0,3
Y	0,03	Y1	-1	G (7)	VG (9)	G (7)	VG (9)	0,03	Type III (V – Shape)	n/a	0,5
Correctness (Columns Sum)								1,00			

In the third step of this stage; suitable preference functions were selected to apply Promethee I method and these are shown in Table 3. *In the fourth step of this stage;* after preference functions were determined, Visual Promethee program was used for application of the method. After information belong the suppliers and preferences belong the criteria were entered in the data screen, the problem was solved. Data were analyzed by the method. *In the fifth step of this stage;* the partial ordering was determined with the method and Supplier 1 was selected the best supplier. The ordering was followed by Supplier 4, Supplier 2 and Supplier 3. This is shown in Figure 1.

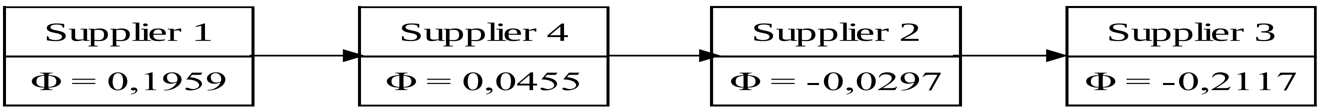

Figure 1. Calculated Ranking Results with Promethee I

4. CONCLUSION

The right supplier selection is a decision that may positively affect in competition power to can fulfil company activity. Because of that, companies try to find suppliers that can provide the best quality service and cost advantage. Many different methods have been developed from MCDM methods in the supplier selection problems that have been applied so far today and continuing, and will continue to be developed. Promethee I method from these methods was used for the supplier selection problem in terms of both the application logic and provided convenience to decision-maker.

The supplier selection problem was handled for the production of an agricultural tires company. Seven main criteria and fifteen sub-criteria were determined that can meet expectations the procurement team. Quality (%40) was determined the best criterion by the procurement team and the ordering was followed Price (%23), Delivery (%17), Flexibility (%7), Costumer Relationship (%6), Competition Power (%4) and Innovation (%3). In consequently of the study that is application of Promethee I method for the evaluation of four raw material suppliers, Supplier 1 was selected the best supplier. The ordering was followed by Supplier 4, Supplier 2 and

Supplier 3. In addition, the method that was applied in this study was used for suppliers of different product groups of the company and other companies.

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CRITERIA FOR SELECTING ERP SYSTEMS: A FRAMEWORK FOR LOGISTICS COMPANIES

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Abstract *− Enterprise Resource Planning (ERP) system has gained a strong consideration over the past decade and widely accepted as one of the most efficient information system by organizations. In fact, ERP links all areas of a company's internal functions and processes with the external ones in order to create a close relationship between customers and suppliers. ERP also allows information to be shared between different partners, supports the effectiveness of the supply chain management, and improves the flow of information. Meanwhile, selecting an appropriate ERP system that best cope with the business strategy of organizations remains a puzzle for decision makers as it involves a Multi- Criteria Decision Making and is critical on the future performance of organizations. This study proposes a framework for selecting ERP systems for logistics companies by using a combination of a Nominal Group Technique (NGT) and the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) methodology. In addition, the study presents a case study of the application of the framework.*

Key Words − ERP, Multi-criteria Decision Making, NGT, TOPSIS

INTRODUCTION

Innovations in information system have turned to a competitive tool for companies. Nowadays the success of companies relies more than ever on the efficiency of their information systems. (Lian, 2005) Indicates that (ERP) systems which makes business process more efficient and business management more simplified is one of the most important information system (IS) to organizations. Further (Ptak, 2004) highlights that ERP includes in its breadth all the resource planning for an enterprise; this includes product design, information warehousing, material planning, capacity planning, and communications system to just name a few. ERP also allows information sharing between different partners, supports the effectiveness of the supply chain management, and improves the flow of information. These should enable managers to make better decisions based on more accurate and up-to-date information (Shatat, 2015). Meanwhile even though the ERP is widely accepted as an efficient tool, evaluating ERP systems and come up with the one that best cope with the business strategy of organizations remains a puzzle for decision makers. According to (Costa, 2008) the selection of the most appropriate solution is a semi-structured decision problem because only part of the problem can be handled by a definite or accepted procedure such as standard investment calculations, and on the other hand the decision maker needs to judge and evaluate all relevant (and intangible) business impact aspects. There is no agreed upon and formal procedure for this important task while nevertheless the corresponding decisions strongly influence long-term business success. The purpose of this paper is to develop a framework for ERP systems selection projects with focus on logistics companies. However, the framework is intended for the pre-implementation phase of the ERP systems. The paper is organized as; a literature review in the second section and at the third section, the problematic, the solution approach and a case study is discussed.

LITERATURE REVIEW

The past decade has seen a tremendous adoption of the ERP systems by organizations, yet it makes sense to recall that the ERP systems came up as a subsequent of Materials requirement planning (MRP) systems. The key to MRP is the calculations used to cascade demand through a bill of material structure, and time – phase this demand based on time requirements for the manufacturing process (J.Piasecki, 2009). After a decade, the production world realized that the MRP system required some essential changes in terms of looking at additional

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manufacturing resources other than materials planning (Keith Porter, 1999). Therefore, Manufacturing resources planning (MRP II) systems evolved and has extended its approach by linking several business functions or modules such as business planning, capacity planning, shop floor control, human resource planning, production planning, purchasing, marketing, finance and accounting (Amad-Uddin, 2011). By the early 1990s, MRP II is expanded to incorporate all resource planning for the entire enterprise thanks to the continuing improvements in technology. Areas such as product design, information warehousing, materials planning, capacity planning, communication systems, human resources, finance, and project management could now be included in the plan. Hence, the term, ERP was coined.

The Benefits of ERP Systems

ERP system is a set of packaged application software modules, with an integrated architecture, that can be used by organizations as their primary engine for integrating data, processes, and information technology in real time, across internal and external value chains (Chiang, 2013). Moreover, ERP systems offer various benefits to the firms. It provides fast and accurate communication in electronic format. It captures all of important data with date and time. It ensures accurate scientific and logical inventory management. It ensures availability of various cost reports. It gives opportunity to analyze the past in the present for the better future (Batuhan Kocaoglu*, 2015).Besides, specifically in the logistics industry the implementation of ERP in logistics strengthens the cooperation between providers, companies, and clients involved in the logistic process. The communication improves the coordination of the agents entailed.ERP represents the specific requirements of the commercial and logistics area for all the shapes of Business: retail and wholesale stores, import and export stores, distribution and service, shipping and transport (Eresource).

In spite of the multiples benefits of the ERP, the failure in selecting the appropriate ERP system firstly leads to the failure of ERP introduction or an adaptation project or secondly to degradation of company performance (Molnár B). There are many ERP alternatives in the market therefore selecting the most suitable among many involve a Multi-criteria Decision Making (MCDM) process.

Multi-criteria Decision Making (MCDM) Process

A multi-criteria decision-making (MCDM) method is a tool aimed at supporting decision makers who face numerous and conflicting evaluations. MCDM aims at highlighting those conflicts and deriving a way to come up with a compromise in a transparent process (Pangsri, 2015). In our study, we will focus on the (TOPSIS) method. In fact, TOPSIS is a simple computation process that can be easily programmed into a spreadsheet (DavoudGoli, 2013). Recently, many interesting studies have applied TOPSIS technique in software selection. Examples of these studies can be found in the literature such as ERP software selection (Huiqun Huang, 2012), ETL software selection (Mohamed Hanine, 2016), computer security software selection (DavoudGoli, 2013).

Technique for Order Performance by Similarity to Ideal Solution (TOPIS)

The technique for order preference by similarity to ideal solution (TOPSIS) is a widely accepted multiple criteria method to identify solutions from a finite set of alternatives. A solution is determined as a positive ideal solution if it maximizes the benefit criteria or minimizes the cost criteria. On the other hand, the solution, which maximizes the cost criteria or minimizes the benefit criteria, is called the negative ideal solution. In the initial step of the technique, let xij be the inputs for matrix of priorities where there are i=1…, alternatives and are j=1…, j criteria. Then from the normalized decision matrix, the positive ideal solution (A+) is determined by selecting the largest normalized and weighted score for each criterion. Similarly, the negative ideal solution ($A-$) is determined by selecting the least normalized and weighted score of each criterion (Pangsri, 2015).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij}^2}} \tag{1}$$

Step 2 Build the weight-normalized matrix

$$v_{ij} = w_i r_{ij}, i = 1, \ldots m, j = 1, \ldots, n \tag{2}$$

Step 3 Calculate the positive and negative ideal solutions.

$$A^{+} = \{v_1^{+}, \dots . v_n^{+}\}, where\ v_j^{+} = \{max(v_{ij})\} \epsilon J; \min(v_{ij})\ if\ j\epsilon\ J' \quad (3)$$

$$A^{-} = \{v_1^{-}, \dots . v_n^{-}\}, where\ v_j^{+} = \{min(v_{ij})\} \epsilon J; \max(v_{ij})\ if\ j\epsilon\ J' \quad (4)$$

Step 4 Measure separation (positive and negative) measures for each alternative

$$S_i^{+} = \sqrt{\sum_{j=1}^{n} (v_j^{+} - v_{ij})^2} \quad (5)$$

$$S_i^{-} = \sqrt{\sum_{j=1}^{n} (v_j^{-} - v_{ij})^2}, i = 1, \dots, m \quad (6)$$

Step 5 Finalize the relative closeness to the ideal solution

$$C_i^{+} = \frac{S_i^{-}}{(S_i^{-} + S_i^{+})},\ 0 < C_i^{+} < 1, i = 1, \dots m. \quad (7)$$

Nevertheless, prior to the application of the TOPSIS, the criteria, and weights that will be in use in the TOPSIS need to be well defined. In our study the group-based research technique known as the Nominal Group Technique (NGT), is used to generate the criteria and their respective attributes and weights that will be taken into account.

Nominal Group Technique (NGT)

A Nominal Group Technique (NGT) is a structured variation of a small-group discussion to reach consensus (Vi Hoang Dang, 2015). When using this procedure, the participants assemble in groups, are told not to speak to each other. Since the members are in a group setting, but are not allowed to interact, the groups are nominal in name only (Ohio State University). The nominal group technique goes by the following steps:

A question is posed to the group. Each member writes down as many responses as possible. The group leader asks each member in turn to state an idea from his or her list and writes it on a flip chart placed before the group. No discussion is permitted until all ideas have been listed. Each item is then briefly discussed in an interacting group format. The participants indicate their preference for important items by rank ordering, a process which may be repeated with intervening discussion and argument. The outcome of the process is the mathematical aggregation of each member's preferences to give the group's ranking of responses to the question (Association for University Centers on Disabilities).

METHODOLOGY

This section is split up in three parts. While the first and second parts define the problem and propose a solution approach, the third part is dealing with a case study.

Problem Definition

ERP is a powerful tool that provides better performance by connecting all the functions of organizations. However when it comes to logistics operations, in recent years ICT technologies have revolutionized the sector of logistics with technologies such as Intelligent Transportation Systems (ITS), Vehicle Information and Communication System (VICS), Global Positioning System (GPS), Electronic Data Interchange (EDI), Radio-Frequency Identification (RFID), etc... Leading to more efficiency in logistics operations and consequently to a competitive advantage. Thus to benefit from these technological advantages, extensions of traditional ERP is more than ever necessary and organizations that aspire to use the ERP must therefore review thoroughly the criteria for the choice of ERP systems. This research is an attempt to provide a solution approach in selecting an ERP system that will fit logistics companies.

Solution Approach

The solution approach proposes a framework for selecting ERP systems. As a methodology, a systematic approach is conducted using the literature review's criteria, the NGT, and the TOPSIS. The overall framework of the solution approach is illustrated below in Figure 1.

METHODOLOGY

STEPS	METHODS
Criteria Generation	Literature Review + NGT
Screening Criteria	NGT
Voting and Ranking Criteria	NGT
Weights and Attributes assignment	NGT
Normalized Weights and Best Supplier Selection	TOPSIS

Figure 9.Framework of the Solution Approach

Case Study with Application of the Solution Approach

The case company XYZ is a Turkish Logistics services provider established in 2010.XYZ provides services including warehousing, domestic land transportation, special distribution, partial transportation, transportation of automotive products. In 2015, the company decided to introduce an ERP system as the new corporate information system and the consultant firm ZZZ was approached to frame the process.

Collection of ERP Selection Criteria from the Literature

From the literature review, some recurrent criteria used in ERP implementation projects have been collected and summarized in table 1 as detailed below.

Criteria	**References**
Vendor Related	
Vendor Reputation	(Costa, 2008) , (Mirian Picinini Méxas, 2015)
Total Cost of Ownership	(Costa, 2008) , (Wen-Hsien Tsai*, 2009)
Financial Condition	(Konakli, 2014)
Professionalism	(The Software Evalutaion Center) , (Ayse Yıldız, 2014)
Service level Agreement	(The Software Evalutaion Center)
Vision	(Adina UŢĂ, 2007), (Ayse Yıldız, 2014)
Software Related	
Ease to Implement	(Panayiotou Nikolaos, 2005), (Costa, 2008),
Ease of Maintenance	(Wen-Hsien Tsai*, 2009), (Adina UŢĂ, 2007)
Upgrade Ability	(Chun-Chin Wei, 2005)
Implementing Time	(Ayse Yıldız, 2014), (Wen-Hsien Tsai*, 2009), (Mirian Picinini Méxas, 2015)
Stability	(Chun-Chin Wei, 2005)
Integration with Third-Party Software	(Panayiotou Nikolaos, 2005)
R&D Capability	(Chun-Chin Wei, 2005),

The Supporting Capabilities in Different Languages	(Wen-Hsien Tsai*, 2009), (Adina UȚĂ, 2007)
Organizational Related	
Mechanism of Risk Management and Security Control	(Wen-Hsien Tsai*, 2009), (Costa, 2008), (Ayse Yıldız, 2014)
The Compatibility Between the System and the Business Process	(Wen-Hsien Tsai*, 2009)
Ease of Use	(Group, 2016), (Wen-Hsien Tsai*, 2009), (Ayse Yıldız, 2014)
Integration with Customized Applications	(Panayiotou Nikolaos, 2005), (Wen-Hsien Tsai*, 2009)
Customizable Screens	(Adina UȚĂ, 2007)

Table 6. ERP Selection Criteria from the Literature

Application of Nominal Group Technique

(1) Group formation: 10 persons from different organizations and gathered under the same roof have formed the group of experts. Among them, we had two supply chains and logistics managers, two warehouse managers, two managers in charge of production, two IT managers and two professors of supply chain and logistics management.
(2) Problem definition: here, it is shared to the group members a set of criteria for selecting ERP systems collected from the literature as shown in table 1, then is posed the question , what are the main criteria that should be taken into account in selecting an ERP system for a logistics company?
(3) Criteria Generation: based on their expertise on logistics and ERP systems and the criteria listed in table 1, members are asked to write down silently as many criteria they think is critical for a Logistics Company.
(4) Discussion of each criteria as a Group: at this stage, the facilitator shares the criteria recorded and gives a fair chance to members to explain their criteria.
(5) Voting, ranking criteria and weights assignment: group's members vote for the listed criteria and based on votes the criteria are prioritized. Here the group members have been asked to rate and rank the criteria based on a scale of 1-5, where 1 is less important and 5 the most important. From the ranking, the sum-weighted method has been used to attribute a weight to each criteria. In the sum-weighted procedure, the weights are the individual ranks normalized by dividing by the sum of the ranks. The formula producing the weights is the following:

$$w_j = \frac{n-r_j+1}{\sum_{k=1}^{n} n-r_k+1}$$

Where, n is the number of criteria, rj is the rank of the jth criterion, j = 1, 2... n. (ROSZKOWSKA, 2013).After completing the Nominal Group Technique, the group of experts came up with 28 criteria and weights and each criterion has been assigned an attribute assuming that three suppliers will be assessed in the TOPSIS application.

Table.7 Criteria, Weights, and Attributes

Code	Criteria	Weights %	Supplier1	Supplier2	Supplier3
	Vendor Related	**15**			
C1	Vendor Reputation	3	Very good	Good	Good
C2	Provide several Successful Examples	2.5	High	High	Very high
C3	Total Cost of Ownership	3.5	100	150	100
C4	Financial Condition	2.5	Good	Very Good	Good
C5	Vision	2	Simple	Very simple	Very simple
C6	Implementation Methodologies and Tools	1.5	Simple	Very simple	Very simple
	General Software Related	**15**			
C7	Ease to Implement	2	Very simple	Simple	Very simple
C8	Ease of Maintenance	2	Simple	Very simple	Simple
C9	Implementing Time	2	1	2	1
C10	The Supporting Capabilities in different Languages	2	High	High	Very High
C11	Integration with Third-Party Software Module	1.5	Very good	Good	Good
C12	Stability	2	Very high	high	high
C13	R&D Capability	3.5	Very high	high	high
	Logistics Related	**50**			
C14	Web Based Cargo Tracking System Module	5	Existing module	Third party solution	Existing module
C15	Bar Code Integration for Inventory Module	5	Existing module	Third party solution	Third party solution
Code	**Criteria**	**Weights %**	**Supplier1**	**Supplier2**	**Supplier3**
C16	Maintenance for Truck and other Equipment Module	5	Third party solution	Third party solution	Existing module
C17	Advanced WMS Module	5	Existing module	Third party solution	Third party solution
C18	E-custom Integration Module	5	Existing module	Third party solution	Existing module
C19	EDI Supplier Portal Module	5	Existing module	Third party solution	Third party solution
C20	GPS and Sensor Integration Module	5	Existing module	Third party solution	Third party solution
C21	RFID Integration Module	5	Existing module	Third party solution	Third party solution
C22	Vendor Management Module	5	Third party solution	Third party solution	Existing module
C23	EPS and Vehicle Routing System Module	5	Third party solution	Third party solution	Existing module
	Organizational Related	**20**			
C24	The Compatibility between the System and the Business Process	10	High	Very high	high
C25	Response Speed	4	Very fast	Fast	Fast
C26	Ease of Use	3	Existing module	Third party solution	Existing module

C27	Integration with Customized Applications Module	1.5	Existing module	Third party solution	Existing module
C28	Customizable Screens Module	1.5	Existing module	Third party solution	Existing module

Application of TOPSIS Methodology and Results Analysis

In this section, three suppliers S1, S2, and S3 were considered to be assessed based on the scale defined as following:

C1, C4, C11: Good: 5; Very good: 7; extremely good: 9

C2, C24 C10, C12, C13: High: 5; Very high: 7; extremely high: 9

C5, C6, C7, C8: Simple: 5; Very simple: 7; extremely simple: 9

C25: Fast: 5; Very fast: 7; extremely fast: 9

C14,C15,C16,C17,C18,C19, C20,C21,C22 , C23,C26,C27,C28: Does not exist :5; Third party solution:7; Existing module :9

Then the step 1 of TOPSIS is summarized in the tables below. The decision matrix is formed by replacing each attribute in table 2 by the corresponding scale. The normalized decision is based on the formula: $r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}x_{ij}^2}}$

Table 8. Decision Matrix

Code	S1	S2	S3
C1	7	5	5
C2	5	5	7
---	---	-----	----
C27	9	7	9
C28	9	7	9

Table 9. Normalized Decision

Code	S1	S2	S3
C1	0.70352647	0.50251891	0.50251891
C2	0.50251891	0.50251891	0.70352647
--	-------------	-------------	-------------
C27	0.61958555	0.48189987	0.61958555
C28	0.61958555	0.48189987	0.61958555

The next table below summarized the step 2 and step 3 of the TOPSIS method. The normalized matrix, the positive and negative ideal solutions are obtained respectively from the formulas, $v_{ij} = w_i r_{ij}$ (w_i represents the weights define in table 2), $A^+ = \{max(v_{ij})\}$, $A^- = \{min(v_{ij})\}$.

Code	S1	S2	S3	A+	A-
C1	0.02110579	0.01507557	0.01507557	0.02110579	0.015076
C2	0.01256297	0.01256297	0.01758816	0.0175882	0.012563
----	-------------	------------	-----------	------------	----------
C27	0.00929378	0.0072285	0.00929378	0.0092938	0.007228
C28	0.00929378	0.0072285	0.00929378	0.0092938	0.007228

Table 10. Weighted Normalized Matrix and Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS)

The step 4 of the TOPSIS that provides the distance of each alternative from the PIS and the NIS is then sum up below in table 5 with their respective formula.

S+= $\sqrt{\sum_{j=1}^{n}\left(v_j^+ - v_{ij}\right)^2}$	0.0259765	0.03059758	0.03000903
S-= $\sqrt{\sum_{j=1}^{n}\left(v_j^- - v_{ij}\right)^2}$	0.0269665	0.02158193	0.02239308

Table 11. The Distance of each Alternative from PIS and NIS

Finally, the table 7 below summarized the step 5 of the TOPSIS that gives the relative closeness and the ranking of suppliers.

Supplier	C*= $\frac{S_i^-}{(S_i^- + S_i^+)}$	Rank
S1	51%	1
S2	42%	3
S3	42%	2

Table 12. The Relative Closeness Coefficient and the Ranking of Different Suppliers

In conclusion, the supplier 1 with the highest percentage will therefore be more suitable for a logistics business.

CONCLUSION

As the market of ERP systems provides many alternatives, organizations should evaluate thoroughly the alternatives and select the one with the most update features in order to improve their performance and gain a competitive advantage.in the light of that, this paper proposed a framework for the pre-implementation phase of an ERP adoption project. The paper focused on logistics companies through a case study that displayed 28 main criteria to take into account when evaluating the ERP suppliers for logistics companies. The criteria have been obtained by applying the logic of the Nominal Group Technique that involved the participation of experts of ERP related issues, logistics professionals and academicians. Afterward, based on the criteria and the weights obtained, three suppliers were evaluated through the TOPSIS technique and the supplier 1 came up with the best attributes for logistics companies. Moreover a systematic review of literature on the application of decision-making techniques in supplier selection, conducted by [29] shows that among 300 articles collected from international journals from 2008 to 2012 none of them has used an hybrid combination of TOPSIS and NGT

.Consequently the framework proposed in this paper comes to enrich the literature and fill up the gap. Nevertheless, the proposed framework does not stand as a standard path for ERP systems selection. Subsequently it is subject to further studies, and can be the trigger point for similar researches or researches aiming at enhancing the framework.

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USING THE ANALYTIC HIERARCHY PROCESS (AHP) FOR SUPPLY CHAIN RISK MANAGEMENT (SCRM): A CASE STUDY IN AUTOMOTIVE SECTOR

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Abstract *−Although the risk and risk management are not new research areas, it has been getting more attention in supply chain management recently. Supply Chain Risk Management (SCRM) is very important for the companies to tackle with the new challenges of the globalization. Because the dimensions of the risk coming from multiple sources including process, control, demand, supply and environment as well as information technologies have widened incredible. To be able to face with these risks adequately, it is necessary to determine the importance of the each risk in a proper manner. In this research the analytic hierarchy process is used as a convincing method to determine relative importance of the risk issues in automotive industry. The risk issues are generated from the survey of the literature and agreed with professionals involving one of the authors of this paper from the automotive industry. Three main risk fields such as material flow risk, financial flow risk and information flow risk including 28 risk issues were analyzed. Pair-wise comparisons were done also by this team. As a result, the risk issues for this sector are clearly determined to focus on and a global risk value could be consolidated from very different risk issues.*

Keywords −Analytic hierarchy process (AHP), automotive industry, supply chain risk management

1. INTRODUCTION

The dimensions of the supply chain operations have changed drastically in recent years. Due to the globalization, supply chains have become more vulnerable. Because of the natural disasters, accidents in any end of the world or volatility of the financial markets, supply chains have to face disruption or even massive losses [6]. On the other side, the number of suppliers was reduced as a way of removing “waste” from supply chain in the frame of lean management. This helps in smoothing the operations but it would also create problems if unexpected events happen in a supply chain. The rising use of internet helps supply network in sharing information visibility. It is indubitable that the emerging uses of enterprise resource planning (ERP) solutions such as Oracle and SAP have cut down the information transaction time and reduced the incidents of inaccuracy and redundancy. Vast assistance from these systems has, however, exposed to another consequence, namely information disruption [15]. Thus supply chain management must be able to identify potential risks, evaluate their impacts and design resilience plans before the risky events occur, and on the other hand, take actions to locate and relocate resources to mitigate risk after it occurs.

However, in many industries risk management is still understood primarily as a company-specific task as it is pointed out by Juttner [7] ‘‘Companies implement organization- specific risk management, but there is little evidence of risk management at the supply chain level’’. Other studies show that only a minority of companies have implemented adequate methods for risk management although they are quite aware of the consequences of risks for their supply chain [23, 24].

To begin with an adequate risk management at the supply chain level, it is the first step to define the risk issues and identify weight of each risk issue for that specific sector. One of the objectives of this paper is therefore to give a guideline for supply chain members to define which risk issues they should concentrate on among all. Analytic Hierarchy Process (AHP), a multi-criteria decision technique, is used to define the weight of the risk issues. The supply chain risk issues are defined via literature review and interview with the supply chain managers and professional involving the author of this paper. After defining risk issues and their weightings a global risk value could be evaluated using the the linguistic measurement scale.

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2. METHODS

2.1. Analytic Hierarchy Process

A study identified the multi-criteria decision technique, known as the Analytic Hierarchy Process (AHP), to be the most appropriate for solving complex decision-making problems [26]. AHP was first introduced by Saaty [20] and used in different decision-making processes. [1, 2, 3, 5, 6, 10, 12, 14, 15] . The basic assumption of AHP is the condition of functional independence of the upper level of the hierarchy, from all its lower parts, and from the criteria or items in each level. Many decision-making problems cannot be structured hierarchically because they involve interaction of various factors, with high-level factors occasionally depending on low-level factors [21, 22]. Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can 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. For this purpose a pairwise comparison scale is used, which is shown in the Table 1 given below. After that AHP converts the evaluations to numerical values that can be processed and compared over the entire range of the problem.

3. PROPOSED RISK MODEL

The proposed risk model is composed of following steps:

Step 1: Establishment of a risk evaluation team composed of managers and professionals. Define the main aim.

Step 2: Determination of the main risk fields and risk fields under each main field and then risk issues.

Step 3: Structure the AHP model (main risk fields, risk fields, risk issues).

Step 4: Determine the local weights of the main risk fields, risk fields, risk issues by using pairwise comparison matrices (assuming that there is no dependence among the risk issues). The scale regarding relative importance to measure the relative weights is given in table 1.

Table 1. Linguistic scales for importance

Linguistic scale for importance	Explanation	Intensity of importance
Equally important (EI)	Two elements contribute equally to the objective	1
Weakly more important (WMI)	Experience and judgment slightly favor one element over another	3
Strongly more important (SMI)	Experience and judgment strongly favor one element over another	5
Very strongly more important (VSMI)	One element is favored very strongly over another; its dominance is demonstrated in practice	7
Absolutely more important (AMI)	The evidence favoring one element over another is of the highest possible order of affirmation	9
Intermediate values		2,4,6,8

Step 5: Calculate the global weights for the risk issues. Global risk issue weights are computed by multiplying local weight of the risk issue with the local weights of the risk field and the local weight of the main risk field to which it belongs.

Step 6: Measure the risk for each risk issue. Linguistic variables are used in this step as shown in the table2.

Table 2: Linguistic values and mean of linguistic value

Linguistic values	The mean of linguistic value
Very high (VH)	1
High (H)	0.75
Medium (M)	0.5
Low (L)	0.25
Very Low (VL)	0

Step 7: Calculation of the global risk for a specific period of time by using the global weights calculated in Step 5 for the risk issue and the linguistic values determined in Step 6.

Schematic diagram of the proposed risk model is provided in Figure 1.

4. AN APPLICATION OF THE PROPOSED RISK MODEL

The application of SCRM-AHP model is performed in a manufacturing firm in Germany. For this purpose, an expert team is established from managers and experts involving authors of this paper. The proposed AHP model is explained with applications based on the steps given in the previous section and risks that the company may be exposed to are computed by using the model.

Step 1: The aim was determined by the expert team, established at the beginning of the implementation, expressed as “minimization of risk through SC”.

Step 2: The main risk fields were discussed and determined first as the followings:

Main Risk field 1 (MRF1): Material flow risk

Main Risk field 2 (MRF2): Financial flow risk

Main Risk field 3 (MRF3): Information flow risk

Then risk fields and risk issues were defined as shown in Table 3 via reviewing relevant literature.

Step 3: The hierarchical model of the main risk, risk fields and risk issues determined in the previous steps is shown in figure 2.

Hierarchical model is composed of four levels: First level includes main aim; second level includes main risk fields to achieve the aim; third level includes risk fields and; fourth level includes risk issues.

Step 4: In this step, local weights of the main risk fields, risk fields and risk issues which take part in the second, third and fourth levels of hierarchical model, are calculated. Pairwise comparison matrices are formed by the expert team by using the scale given in table 1. For example Main Risk field 1: Material flow risk (MRF1) and Main Risk field 2: Financial flow risk (MRF2) are compared using the question “How important MRF1 is when it is compared to MRF2?” and the answer “Strongly more important (SMI)”,to this linguistic scale is placed in the relevant cell “5”. All evaluation matrices are produced in the same manner. Pairwise comparison matrices are analysed and local weights are determined as shown in Table 4

Table 3. Main risk fields, risk fields and risk issues

Main Risk Field	Risk Field	Risk issue
Material flow risk	S: Source	SSR: Single sourcing risk SFR: Sourcing flexibility risk SPQ: Supply product monitoring/Quality SS: Supplier selection/outsourcing
	M: Make	ODR : Operational disruption risk PPD: Product and process design risk
	D: Deliver	DVR: Demand volatility/ Seasonality BDI :Balance of unmet demand and excess inventory
	SC: SC Scope	LO :Logistics PVC: Price volatility of commodity/ alternative energy EDA: Environment degradation and awareness PR: Political risk CE: Cultural and ethics/ Supply chain partners relationship
Financial flow risk	ECR: Exchange rate risk	SRR: Shrinking profit margin CFF: Complicated financial flow
	PCR: Price and cost risk	SRM: Scarcity of raw material LCC: Low cost countries
	FSR : Financial strength of supply chain partners	EQR: Equity risk FLR: Financial Leverage AR: Asset risk
Information flow risk	IA: Information accuracy	ACR: Access control COM: Communications and operations management BCM : Business continuity management
	IO: Information outsourcing	ISIM: Information security incident management ISDM: Information system acquisition, development and maintenance PES: Physical and environmental security
	IS: Information system security and disruption	KHT: Know-how transfer IER: Industrial espionage

Table 4: Local weights and pairwise comparison matrix of main risk fields

Main Risk Field	MRF-1	MRF-2	MRF-3	Weights
MRF-1	1,000	5,000	7,000	0,731
MRF-2	0,200	1,000	0,500	0,111
MRF-3	0,143	2,000	1,000	0,158

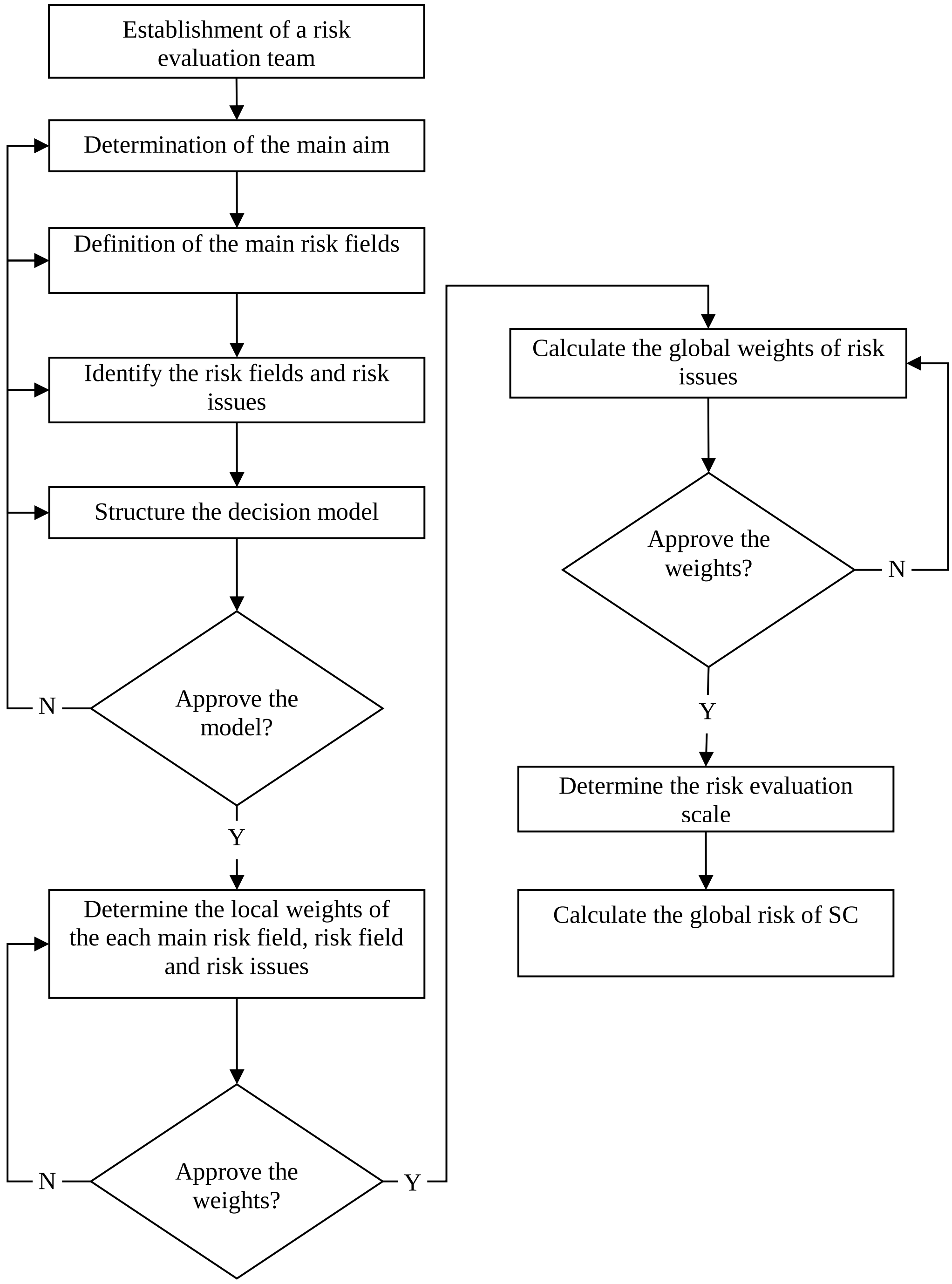

Figure 1. Schematic diagram of the proposed model for SCRM

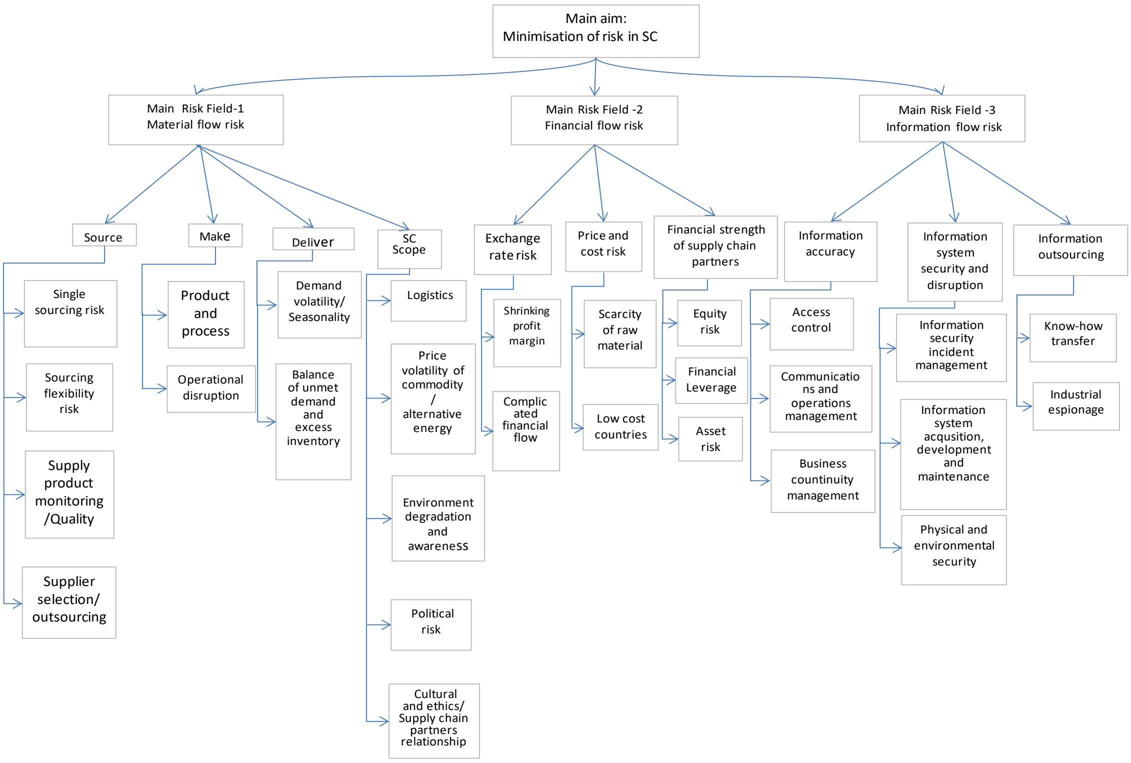

Figure 2. The hierarchical model for SCRM

The local weights for the risk fields are calculated in a similar way as shown under table 5.

Table 5. Local weights and pairwise comparison matrix of risk fields

MRF-1	S: Source	M: Make	D: Deliver	SC: Supply Chain Scope	Weights
S	1,000	7,000	9,000	5,000	0,204
M	0,143	1,000	5,000	3,000	0,048
D	0,111	0,200	1,000	0,333	0,113
SC	0,200	0,333	3,000	1,000	0,204

MRF-2	ECR: Exchange rate risk	PCR: Price and cost risk	FSR : Financial strength of supply chain partners	Weights
ECR	1,000	1,000	0,111	0,097
PRC	1,000	1,000	0,143	0,105
FSR	9,000	7,000	1,000	0,798

MRF-3	IA: Information accuracy	IO: Information outsourcing	IS: Information system security and disruption	Weights
IA	1,000	5,000	7,000	0,724
IO	0,200	1,000	3,000	0,193

IS	0,143	0,333	1,000	0,083

After the determination of the local weights of the each risk field, risk issue weights are defined on the basis of these risk fields. Pairwise comparison matrices developed for this purpose are presented in Table 6 together with the calculated weights.

Table 6. Local weights of risk issues

S: Source	SSR	SFR	SPQ	SS		Weights
SSR: Single sourcing risk	1,000	7,000	5,000	1,000		0,315
SFR: Sourcing flexibility risk	0,143	1,000	0,333	0,143		0,051
SPQ: Supply product monitoring/Quality	0,200	3,000	1,000	0,200		0,105
SS: Supplier selection/outsourcing	3,000	7,000	5,000	3,000		0,529
M: Make	ODR	PPD				
ODR: Operational disruption	1,000	5,000				0,833
PPD: Product and process design risk	0,200	1,000				0,167
D: Deliver	DVR	BDI				
DVR: Demand volatility/ Seasonality	1,000	3,000				0,750
BDI : Balance of unmet demand and excess inventory	0,333	1,000				0,250
SC: SC Scope	LO	PVC	EDA	PR	CE	
LO :Logistics	1,000	7,000	5,000	7,000	1,000	0,584
PVC: Price volatility of commodity	0,143	1,000	3,000	1,000	0,143	0,156
EDA: Environment degradation and	0,200	0,333	1,000	0,333	0,200	0,084
PR: Political risk	0,143	1,000	3,000	1,000	0,143	0,137
CE: Cultural and ethics/ Supply	0,111	0,200	0,333	0,333	0,111	0,040

Step 5: In this step, the global weights of each risk issue are determined by multiplying local weight of the risk issue with the local weight of the risk field and the local weight of the main risk field which it belongs to as shown in Table 7

Step 6-7: In this stage, global risk of supply chain is determined by using the global weight values of risk issue (table 7) and the linguistic measurement scale (table 2). The calculations are shown in table 8.

Total risk value is calculated by multiplying the global weights and scale values of risk issues and then by summing the resulting risk values. Namely, 2016 global risk of the concerned SC was calculated as 43 % by using AHP-SCRM model.

The most important risk issue that has a negative effect on global risk has been determined as “Single sourcing risk”. The others in Top 3 are “Supplier selection/outsourcing” and “Supply product monitoring/Quality”

Table 7: Computed global weights of risk issues

Main Risk Field	Local Weight	Risk Field	Local Weight	Risk Issues	Local Weight	Global Weight
Material flow risk	0,731	S: Source	0,636	SSR:Single sourcing risk	0,315	0,146
				SFR:Sourcing flexibility risk	0,051	0,024
				SPQ: Supply product monito/Quality	0,105	0,049
				SS:Supplier selection/outsourcing	0,529	0,246
		M: Make	0,204	ODR : Operational disruption risk	0,833	0,124
				PPD: Product and process design risk	0,167	0,025
		D: Deliver	0,048	DVR: Demand volatility/ Seasonality	0,75	0,026
				BDI :Balance of unmet demand and excess inventory	0,25	0,009
		SC: SC Scope	0,113	LO :Logistics	0,584	0,048
				PVC:Price volatility of commodity/ alternative energy	0,156	0,013
				EDA: Environment degradation and awareness	0,084	0,007
				PR: Political risk	0,137	0,011
				CE: Cultural and ethics/ Supply chain partners relationship	0,040	0,003
Financial flow risk	0,111	ECR: Exchange rate risk	0,097	SRR: Shrinking profit margin	0,833	0,009
				CFF: Complicated financial flow	0,167	0,002
		PCR: Price and cost risk	0,105	SRM: Scarcity of raw material	0,833	0,010
				LCC ;Low cost countries	0,167	0,002
		FSR : Financial strength of supply chain partners	0,798	EQR: Equity risk	0,633	0,056
				FLR:Financial Leverage	0,260	0,023
				AR: Asset risk	0,106	0,009
Information flow risk	0,158	IA: Information accuracy	0,724	ACR: Access control	0,633	0,072
				COM: Communications and operations management	0,106	0,012
				BCM : Business countinuity management	0,260	0,030
		IO: Information outsourcing	0,193	ISIM: Information security incident management	0,724	0,022
				ISDM: Information system acqusition, development and maintenance	0,193	0,006
				PES: Physical and environmental security	0,083	0,003
		IS: Information system security and disruption	0,083	KHT: Know-how transfer	0,167	0,002
				IER: Industrial espionage	0,833	0,011

	Sum:	1,000

Table 8. Global risk of SC by using the proposed SCRM-AHP model

Risk issue	Global weight (gw)	Linguistic evaluations	Scale value (sv)	Risk Value
SSR	0,146	H	0,75	0,110
SFR	0,024	M	0,5	0,012
SPQ	0,049	H	0,75	0,037
SS	0,246	L	0,25	0,062
ODR	0,124	L	0,25	0,031
PPD	0,025	L	0,25	0,006
DVR	0,026	L	0,25	0,007
	0,009	M	0,5	0,004
BDI				
	0,048	M	0,5	0,024
LO	0,013	L	0,25	0,003
PVC	0,007	L	0,25	0,002
EDA	0,011	L	0,25	0,003
PR	0,003	L	0,25	0,001
CE				
SRR	0,009	M	0,5	0,004
CFF	0,002	M	0,5	0,001
SRM	0,010	L	0,25	0,002
LCC	0,002	M	0,5	0,001

EQR	0,056	M	0,5	0,028
FLR	0,023	M	0,5	0,012
AR	0,009	L	0,25	0,002
ACR	0,072	M	0,5	0,036
COM	0,012	L	0,25	0,003
BCM	0,030	M	0,5	0,015
ISIM	0,022	M	0,5	0,011
ISDM	0,006	L	0,25	0,001
PES	0,003	M	0,5	0,001
KHT	0,002	M	0,5	0,001
IER	0,011	H	0,75	0,008
Year 2016	**1,000**			**0,43**

5. CONCLUSION AND FUTURE RESEARCH

This study aimed to determine the global risk of the SC in automotive sector on the basis of risk issues, by integrating SCRM with AHP technique. Proposed model has shown that different risk issues related with SC can be consolidated with AHP technique. Besides, the proposed model has enabled determination of the global risk for the SC on the basis of risk issues to achieve its aim to minimize them. In this way, it is possible to evaluate from a strategic perspective the global risk according to not only past results but also most important risk issues.

For the case in this research the most important risk issue has been determined as “Single sourcing risk”. The others in Top 3 are “Supplier selection/outsourcing” and “Supply product monitoring/Quality”. The supply chain should find the right mitigation strategies for these risk issues especially. Different mitigation strategies can be evaluated with respect to cost and impact of each strategy. As a result the global risk value 43 % could be reduced.

The model proposed in the scope of this study was related with a production business; however, it can also be adapted to different businesses. Modifications may be required on the proposed system due to two reasons: firstly, the components constituting the analytical structure of the proposed model -namely, main risk fields, risk fields and risk issues respectively- may vary depending on sector in which the SC is operating. Secondly, relationships or relative importance among risk issues may also vary. Modifications and adaptations will enable the use of this model in other SC.

In this study, the main risk fields, risk fields and risk issues were considered as independent and the global risk was determined on this basis. Future studies may expand the model by analysing the inter-dependence of risk fields and risk fields with fuzzy logic combined.

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DETERMINATION AND SELECTION OF LOGISTICS STRATEGIES FOR THE DEVELOPMENT OF MARMARA REGION ORGANIZED INDUSTRIAL ZONES

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Abstract − *Organized Industrial Zones (OIZs) are very important organizations in Turkey for the development of the industry. OIZs allow industries to work together, enable cities to plan their growth and ensure organizations to work in a certain discipline. Most of OIZs in Turkey are located in the Marmara region, which is economically the most advanced area of the country. Logistics is one of the most important processes for OIZs. Increasing the effectiveness of OIZs' logistics can help the development of OIZs by improving performance measures such as production costs, customer satisfaction, supplier relationships and raw material stocks. In this study, literature is reviewed and weaknesses, strengths, threats and opportunities as well as opinions of experts are presented for Marmara Region OIZs by means of SWOT analysis, a commonly used method for strategic planning processes. Secondly, obtained findings are evaluated in a comparative way and priority weights of each SWOT group and each SWOT factor are calculated with AHP (Analytic Hierarchy Process) and alternative logistics strategies are developed. Thirdly, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is used to select the best logistics strategy among the alternatives for the development of Marmara Region OIZs. Findings reveal that "Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries" would be the best strategy for the logistics development of Marmara region OIZs.*

Keywords − *Logistics strategies, Organized industrial zones, SWOT analysis, AHP, TOPSIS*

INTRODUCTION

Organized Industrial Zones (OIZs) allows the construction of the industry in the eligible areas, prevents unplanned industrialization and environmental problems, allows cities to plan their growth and ensure organizations to work in a certain discipline. Organized Industrial Zones are extremely important for the industrial development in Turkey. For OIZ's planned growth, make use of them more effective and efficient and to ensure the sustainable development of the industry in our country, strategic planning work is of great importance [1].

Most of OIZs in Turkey are located in the Marmara region, which is economically the most advanced area of the country. This zones are important areas which has intensive industrial activities that need to be included in the planning process with regards to logistics. Increased competition necessitates organizations to better control in all activities efficiently. In this context, logistics management assists in the management of all material and information flow throughout the manufacturing and distribution processes from raw material supplier to retailers. In OIZs, the lack of transportation facilities, lack of logistics centers, not building of the railway and highway by the government are the major drawbacks for the development. Determining the correct logistics strategies for Marmara region OIZs, will increase customer satisfaction, production efficiency and quality, provides cost advantage and will enable the creation of more efficient stock plan [2].

The aim of this study is to identify the best logistics strategy for Marmara Region OIZs, by analyzing their current situation. The paper is organized as follows: Next section provides a literature survey for OIZs in Turkey. Following section presents calculation procedure of the applied methodologies. In latter, a case study is given and last section concludes the study.

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LITERATURE REVIEW

Based on the literature research, it is observed that several studies have been performed about Organized Industrial Zones. In this section, studies between the years of 2005-2016 has been given about the logistics and Organized Industrial Zones.

Murat [3] determined the importance of Organized Industrial Zones in urban planning with the case study of Kütahya Organized Industrial Zone. In this study, observation and interview techniques has been used. Darby [4] evaluated the logistics facilities of İstanbul by using the SWOT analysis and mentioned the importance of logistics center. Süt and Tutar [5] mentioned the importance of OIZ's as a regional development tool and Sivas and Erzincan OIZ's have been analyzed by using the survey technique. By Istanbul Metropolitan Municipality [6], [7] Istanbul's logistics plan has been created, OIZ's evaluated in terms of logistics and SWOT analyses were performed for industrial sector, logistics, economic structure, trade and service sectors, science and technology. Kök [2] described the development of organized industrial zones to the present, the production efficiency, the companies activities, performances which located in OIZ's, supply chain management and logistics activities, entrepreneurial role of OIZ's. Thus, with every aspects of OIZ's have been examined and by making recommendations, strategies have been developed. Önel and Çetin [8] mentioned the need, aim and importance of the OIZ's in Turkey and analyzed Gebze Organized Industrial Zone. Gülen [9] explained the logistics facilities, the importance and development of logistics in the world and Turkey and competitive strategies has been developed that companies can apply. Çağlar [10] mentioned the importance of OIZ's in Turkey, the incentives provided to OIZ's and the authorities of the OIZ's in Turkey were discussed. By Trakya Development Agency, the industry of Trakya region is discussed, OIZ's were examined and by evaluating the logistics industry proposals were presented [11]. By considering Turkey's economy and industry, for the development of logistics activities which is greater role in increasing the competitiveness of Turkey, logistics strategies and principles are identified by Tanyaş et al. [12]. Bayülken and Kütükoğlu [13] examined OIZ's sectoral distribution by considering locally, urbanization effects and problems of industrial areas, small industrial sites, technoparks have been mentioned and applications and samples of OIZ's in the world analyzed and compared with Turkey. Şahin [14] mentioned the logistics geography by emphasizing the importance of the logistics facility location selection and transportation. Dağlar [1] identified the factors that are necessary to the institutionalization of organized industrial zones and by examining the problems of OIZ's proposals have been developed. Özden [15] analyzed the current situation of Turkey OIZ's and emphasized the importance of incentives, technoparks, location, ease of transport, infrastructure for the OIZ's.

METHODOLOGY

In this study, SWOT analysis digitized by the AHP method in order to determine the weights of factors and criteria’s and alternative strategies are developed. By using the factor and criteria weights, alternative strategies are ranked with TOPSIS method. The proposed approach is described as follows.

SWOT Analysis

Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis is a commonly used method for companies and provides them to examine their internal strengths and internal weaknesses of a product or service and defines the opportunities and threats of the external environment [16]. SWOT analysis helps organizations to define their current situation and allows a long term growth by determining the factors that will ensure growth and eliminating those that will cause failure. The main goal of the SWOT analysis is to develop and select a strategy which will be appropriate between external and internal factors.

Steps of the SWOT analysis are as follows:

Step 1- Determining the SWOT factors of the strengths, weaknesses, opportunities, and threats: In this step, the SWOT factors of OIZ’s considering the logistics facilities are described by benefiting from the literature researches and expert opinions.

Step 2- Developing alternative strategies: In this step, four types of strategies can be developed [17].

1) SO Strategy: Use of the internal strengths to take advantage of the external opportunities
2) WO Strategy: Use of the external opportunities by considering the internal weaknesses
3) ST Strategy: Use of the internal strengths to reduce the threats arising from the external environment
4) WT Strategy: Reducing the external threats by considering the internal weaknesses

AHP Method

Analytical Hierarchy Process (AHP) method is a multi-criteria decision making (MCDM) technique which is developed by T. Saaty [18]. With this method, complex problems can be shown in a hierarchical structure which starts from the main goal to the sub-criteria. This method is used in a lot of different areas in decision-making process such as supplier selection, personnel selection and strategy selection.

Steps of the AHP methodology is given below [18]:

Step 1- The construction of the hierarchical structure of the problem: The hierarchical structure starts with the goal of the decision at the top, factors and criteria at the middle and the alternatives at the lowest level.

Step 2- Creation of the pair-wise comparison matrices and determination of the priorities: The pair-wise comparison matrices acquired after the hierarchical structure of the problem constructed. Equation 1 shows the pair-wise comparison matrices size of nxn.

$$Z=(z_{ij})=\begin{bmatrix} 1 & p_1/p_2 & \dots & p_1/p_n \\ p_2/p_1 & 1 & \dots & p_2/p_n \\ . & & & . \\ . & .... & 1 & . \\ . & & & . \\ p_n/p_1 & p_n/p_2 & \dots & 1 \end{bmatrix} \tag{1}$$

In this matrix, the element z_{ij} = 1/ z_{ij} and thus, when i=j, z_{ij} =1. The value of p_i may range from 1 to 9. At this step, to determine the priorities, the 1-9 scale is used which proposed by Saaty [19].

Step 3- Determination of the eigenvector: To determine the percentage distribution of importance of the factors, the column vectors W=[w_i]$_{nx1}$ should be calculated. The column vector W is obtained from the arithmetic means of row elements.

Step 4- Calculation of consistency rate: To reach the CR value first the largest eigenvalue (λmax) of Z matrix should be calculated. The calculation formulas for consistency rate are shown in the Equations 2-3-4-5.

When i= 1,2,3,…n and j=1,2,3,…n, $D=[p_{ij}]_{nxn}\ x\ [w_i]_{nx1}=[d_i]_{nx1}$ (2)

$$\lambda \max = \frac{\sum_{i=1}^{n}\frac{d_i}{w_i}}{n} \tag{3}$$

After the largest eigenvalue is calculated, an approximation to the consistency index (CI) should be calculated.

$$CI=\frac{\lambda \max - n}{n-1} \tag{4}$$

To provide the consistency of the pair-wise comparison matrix, the consistency judgment must be checked for the suitable value of n by CR, that is,

$$CR = \frac{CI}{RI}$$ where RI is the random consistency index. (5)

Consistency rate is calculated for each pair-wise comparison matrix and it's upper limit is expected to be 0,10. If CR≤0.10, the degree of consistency is satisfactory. If CR>0.10, there are inconsistencies in the decision-making. In this case, the AHP may not give meaningful results and judgments needs to be improved.

TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is proposed by Hwang and Yoon in 1981 [20]. In this method it is considering that the selected alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution [21].

Steps of the TOPSIS method is given below:

Step 1- Decision matrix A_{ij} is normalized by using the Equation 6:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}, \quad r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}$$ where i=*1,2,…,m*; j=*1,2,…,n* (6)

Step 2- Obtaining the weighted normalized decision matrix: It is acquired by multiplying normalized matrix with the weights of the criterias.

$v_{ij} = w_i * r_{ij}$ where i=*1,2,…,m*; j=*1,2,…,n* (7)

Step 3- Determination of the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS):

$A^* = \{v_1^*, v_2^*, \dots, v_n^*\}$ maximum values. (8) $A^- = \{v_1^-, v_2^-, \dots, v_n^-\}$ minimum values. (9)

Step 4- Calculation of the distance of each alternative from PIS and NIS:

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \qquad S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \tag{10}$$

Step 5- Calculation of the closeness coefficient of each alternative (CCi):

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}, \; 0 \le C_i^* \le 1 \tag{11}$$

Step 6- Finally, the ranking of alternatives is determined by comparing CCi values.

CASE STUDY

In this section, a case study is examined in order to implement the proposed approach in the selected area. In this example, by benefiting from the literature research [1]-[15], [22]-[28] and expert opinions, the SWOT factors have been determined for the Marmara region OIZs considering the logistics activities in order to develop and select the best logistics strategy for the development of Marmara region OIZs.

A SWOT matrix can be created and used as basis of goal setting, strategy formulation, and application. The factors and strategies of SWOT analysis are presented in the SWOT matrix as shown in Table 1.

Hierarchical structure of the study has been created in Figure 1. When Figure 1 is analyzed; it is seen that goal is in the top, SWOT groups and related SWOT groups' factors are in the middle. Alternative strategies are in the bottom.

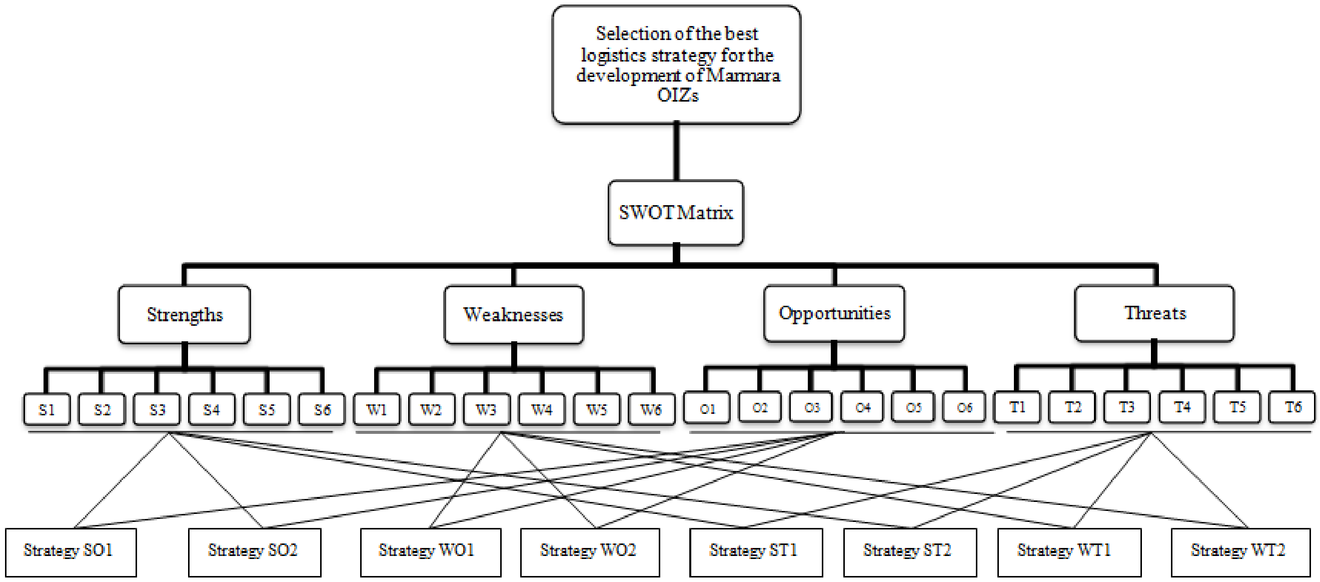

Figure 1. The hierarchical structure of the problem

After the SWOT factors identified, experts were consulted in order to calculate the weights of SWOT groups and factors using AHP method. 1-9 scale proposed by Saaty [18] was used while comparisons were made. After pair-wise comparisons were made between SWOT groups, each factor were compared with each other. The consistency ratio of the SWOT groups and related factors were calculated and observed to be less than 0.10.

As a result of the evaluations, the local and overall weights of all SWOT groups and SWOT factors are shown in Table 2. As shown in Table 2, priority values between SWOT groups appears as weaknesses (0.380), strengths (0.292), opportunities (0.213) and threats (0.115). According to the analysis it is seen that threats group is low compared to the others, weaknesses are weighted higher than the other groups. When creating the best logistics strategy for the development of Marmara Region OIZ's, priorities should be given to the weaknesses, and strengths should be assessed as possible.

Table 1. Internal and External Strategic Factors of Marmara region OIZs

Internal Factors / External Factors	**Strengths (S)** **S1**: The diversity of the sectors in the Marmara region OIZs **S2**: The presence of the free zones in or near the OIZs and border gates to be closer to the production centers **S3**: The presence of qualified people in the region and to be open to learning and innovation **S4**: The presence of advanced universities in terms of research activities **S5**: Ensuring greater efficiency in production due to the advanced technology in the industry of the region **S6**: Low cost of human resources	**Weaknesses (W)** **W1**: The lack of port capacity (ship berthing areas, docks, etc.) and the lack of a sufficient number of entrepot **W2**: Although some of the OIZs in the region are close to the main transportation artery, the lack of a direct connection **W3**: The lack of railway connections in the most of the OIZs **W4**: The high price of land **W5**: Not completed of the infrastructure work in several OIZ's and the lack of full capacity of OIZs **W6**: The high cost of road transport and port costs
Opportunities(O) **O1**: Location of the region that provides transition between Europe and Asia and region to be on the international road routes **O2**: A region has a coast with Marmara sea and the black sea **O3**: The two major ports of Ro-Ro transport of Turkey's (Ambarlı and Haydarpaşa) to be in this region and the presence of the container ports **O4**: Increasing awareness of the logistics village projects **O5**: Establishment of a new OIZ and logistics base project in Yalova that will be one of the most important industrial projects in the Marmara region **O6**: Region to be suitable for the dissemination of the railway network	SO1 Strategy: Giving importance to the logistics village and logistics base projects SO2 Strategy: Increasing the number of free zones for boosting cross-border trade and investment with neighbor countries	WO1 Strategy: Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries WO2 Strategy: Increasing the port capacity and increasing the number of entrepots
Threats (T) **T1**: Some of the exporters prefer not to take part in the OIZs because of distant from the ports **T2**: Reduction of exports to neighboring countries due to the confusion **T3**: Lack of government grants made to the region OIZ's **T4**: Need of intensive capital **T5**: Fluctuations in foreign exchange rates **T6**: Environmental pollution arising from industrial activities	ST1 Strategy: Ensuring the development by ensuring OIZs as an attractive places for qualified population ST2 Strategy: Provide sustainable logistics to minimize environmental pollution	WT1 Strategy: Saving costs by carrying loads of different institutions together WT2 Strategy: Ensuring the development of the railway network to establishment of connection with OIZs and ports

Table 2. Local and Global weight scores of SWOT groups and SWOT factors

SWOT groups	Group weight score	SWOT factors	Local weight score	Overall weight score
Strengths	0.292	S1	0.060	0.017
		S2	0.375	0.110
		S3	0.182	0.053
		S4	0.119	0.035
		S5	0.084	0.025
		S6	0.179	0.052
Weaknessess	0.380	W1	0.126	0.048
		W2	0.292	0.111
		W3	0.230	0.087
		W4	0.063	0.024
		W5	0.183	0.069
		W6	0.107	0.041
Opportunities	0.213	O1	0.091	0.019
		O2	0.075	0.016
		O3	0.244	0.052
		O4	0.169	0.036
		O5	0.120	0.025
		O6	0.301	0.064
Threats	0.115	T1	0.162	0.019
		T2	0.293	0.034
		T3	0.174	0.020
		T4	0.139	0.016
		T5	0.159	0.018
		T6	0.072	0.008

When we look at the local weight scores of the factors, "S2: The presence of the free zones in or near the OIZs and border gates to be closer to the production centers", which is located in the strengths group, seem to be with the highest importance within the SWOT factors. After this factor, "O6: Region to be suitable for the dissemination of the railway network" factor from opportunities group is the second highest factor, "T2: Reduction of exports to neighboring countries due to the confusion" factor from threats group is the third highest factor and "W2: Although some of the OIZs in the region are close to the main transportation artery, the lack of a direct connection" factor from weaknesses group is the fourth highest factor.

When we look at the overall weight scores of the factors, "W2: Although some of the OIZs in the region are close to the main transportation artery, the lack of a direct connection " stand out among the other factors. In the continuation, "S2: The presence of the free zones in or near the OIZs and border gates to be closer to the production centers" factor from strengths group, "O6: Region to be suitable for the dissemination of the railway network" factor from opportunities group and " T2: Reduction of exports to neighboring countries due to the confusion" factor from threats group, respectively. These results show that primarily the elimination of weaknesses is considered to be important by experts when creating logistics strategies for the development of Marmara Region OIZ’s.

Selection of the Best Strategy

After the overall weights of SWOT groups and SWOT factors are calculated, alternative strategies are ordered. For 24 factors connected with 4 main group determined for strategies, strategies are scored from 1 to 10. Importance value of each strategy and distance between negative ideal solution vector and positive ideal solution vector are calculated by using TOPSIS method [20].

Ideal solution values A^+ and A^- are given below.

A^+= { 0.00748; 0.05824; 0.02745; 0.01733; 0.01074; 0.02094; 0.02532; 0.05152; 0.04173; 0.01011; 0.03653; 0.02116; 0.00872; 0.00688; 0.02359; 0.01837; 0.01349; 0.03180; 0.00934; 0.01453; 0.00768; 0.00756; 0.00818; 0.00496}

A^-= { 0.00499; 0.03235; 0.01525; 0.01083; 0.00716; 0.01745; 0.01407; 0.02862; 0.02319; 0.00578; 0.02029; 0.00941; 0.00436; 0.00393; 0.01474; 0.01021; 0.00750; 0.01767; 0.00467; 0.00727; 0.00640; 0.00378; 0.00468; 0,00220}

The distance of each alternative from PIS (S_i^+) and NIS (S_i^-) are as follows:

S_i^+= { 0.033814; 0.033709; 0.032055; 0.041552; 0.048700; 0.051217; 0.042749; 0.036948}

S_i^-= { 0.026410; 0.031061; 0.034057; 0.021816; 0.015641; 0.008073; 0.017236; 0.032362}

The closeness coefficient of each alternative (C_i^+) are given in Table 3.

Table 3. The closeness coefficient of each alternative

Alternatives	C_i^+	Rank
SO1	0.4385	4
SO2	0.4796	2
WO1	0.5151	1
WO2	0.3443	5
ST1	0.2431	7
ST2	0.1362	8
WT1	0.2873	6
WT2	0.4669	3

According to the relative closeness to the ideal solution, the alternatives are ordered with TOPSIS method. As shown in Table 3, “WO1: Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries” strategy become the best strategy among 8 alternative strategies, with the final performance value of 0.5151; while SO2 and WT2 are second and third, SO1 and WO2 are fourth and fifth, WT1, ST1 and ST2 have placed at the sixth, seventh and eighth ranks with 0.4796, 0.4669, 0.4385, 0.3443, 0.2873, 0.2431, 0.1362 as the final performance values, respectively.

CONCLUSION

Organized Industrial Zones have great importance in the development of the economy and industry of our country. Identify the current status of the Marmara Region OIZs and create strategies for the logistics development in order to withstand the challenges of the future, will be important. Only in this way it will be possible to obtain maximum contribution from the logistics activities of the Marmara Region OIZs.

This study suggests logistics strategies for the development of Marmara region OIZs. Based on the literature survey and expert opinions, SWOT matrix is created and a case study is presented. AHP method is used in this study to evaluate the SWOT groups and SWOT factors. Furthermore, TOPSIS method is used to choose the best strategy for the ideal solution of this problem. According to the results, WO1 strategy (Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries) is the best strategy which matches the best with the four groups of S, W, O and T and 24 strategic factors, so WO1 strategy should be chosen for the development of the logistical activities of the Marmara region OIZs.

In this study, the interactions among and between SWOT groups and factors are not considered. One of the perspectives for future work can be to consider the dependence of the criteria, the interaction between the criteria, and to extend our analysis by applying the analytic network process approach [29]. By using different MCDM techniques, further studies could be done to enlarge the assessment and strategy selection process of the Organized Industrial Zones.

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THE CONCEPT OF DRY PORT AND THE SELECTION OF DRY PORT LOCATIONS: THE CASE OF IZMIR

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Abstract – In today's world when it is hard to ignore the effect of global supply chain and logistic systems on global markets, maritime transport confronts us as a type of transport that is chosen considering the amount of load and shipping fares. Ports, playing an essential role in maritime transportation, are places where goods gain added-value. The current port yards cannot be extended for ports having problems due to the increase in the number of containers with each passing day and thus there occur disruptions both in the flow of goods and in other relevant activities. These disruptions can be eliminated through some actions to be taken in dry ports. Within the scope of the present study, the literature about dry ports is reviewed and it is aimed to determine suitable dry port locations for port areas in the coastal region of Turkey by developing criteria for selection of suitable ports.

Keywords *– Dry Port, Facility Location Selection, Logistics*

1. INTRODUCTION

The ever increasing international trade and containerization causes some bottlenecks in ports, thus services in ports such as handling, custom clearance and related activities shifted form actual ports to dry ports in order to decrease the traffic resulted with the transportation of goods. In addition to carrying performance in standard containers for goods, the load volumes in intermodal transport are intended to provide an ever-increasing and steady increase in the daily volume. According to Crainic et al. (2015), with this ongoing increase, specialization together with the different components of the intermodal transport network have led to the efficiency of the logistics systems of the ever-expanding expansion and maritime industry.

As a result of the worldwide increase in container traffic, there is also a growth in ship and employee numbers for maritime logistics. Expansion of port capacities, loading and unloading operations and freight transfer centers located near the port have started to take place in maritime terminology to increase operational efficiency (Crainic et al., 2015). Also, the current activities in maritime logistics involve the consolidation of goods at freight terminals, customer services, and information processing activities, short-term storage and the consolidation of high value-added goods.

Intermodal freight transport involves the transportation of freight in an intermodal container or vehicle, using multiple modes of transportation (rail, ship, and truck), without any handling of the freight itself when changing modes. (Economic Commission for Europe, 2001). According to Hanaoka and Regmi (2011), Transport nodes such as airports, ports, intermodal logistics terminals and land ports need to be developed in order to promote intermodal transport. Dry ports pose a crucial element for the intermodal transport system.

2. LITERATURE REVIEW ON DRY PORTS AND DRY PORT SELECTION CRITERIA

The latest works on dry ports, which are one of the most important parts of multimodal transportation, have aimed to reduce the increasing number of problems in seaports. It is necessary to take significant steps for evaluating and enhancing the performances in order to gain a competitive advantage on international scale.

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Originally, UNCTAD (1982) introduced the dry port concept as an inland terminal that bill of lading and related documentations are issued by shipping lines.

Leveque and Roso (2012) defined the dry port concept as an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport.

Dry ports have been located outside ports to reduce traffic density and so that they can be close to factory centers. They provide services similar to those offered in ports and are in the most suitable locations. These dry ports incorporate all the foreign trade operations and are shaped according to the needs of customers in order to contribute to productivity, efficiency and economy of scale. These values included in each ring of the transportation chain ensure an effective and productive sustainability. Dry ports also play an important role in reducing traffic and costs as well as preventing environmental pollution. Also, the presence of an efficient railway network is one of the factors that provide a competitive advantage in dry ports. In this part, studies on dry ports and the selection of dry port locations contained in the literature are handled, and some criteria are presented for dry ports to be established across Turkey, specifically in the Aegean Region. The relevant criteria and the people introducing them can be seen on Table 1.

Table 1: Criteria considering in the selection of dry port locations

Author	Criteria
Gooley (1998)	• Physical infrastructure • Proximity to customers and suppliers • Political state and tax range • International trade factor
Henttu et al. (2011:13), The conceptual framework for Finland	• The location of city and its attractiveness (Ability to serve top 50 city in Finland) • Preparedness for necessary infrastructure • Accessibility to railway • The efficient use of coastal areas of cities • The availability of ports in cities to intermodal system • Population
Rahimi et al.(2011:16), Qualifications for inner ports	• Adequate demand for intermodal transportation • The local supply for transportation services • Successful public relations management • Contribution of public/private sector
Tamosaityte and Haat (2012:13), Applicable dry port characteristics for Sweden	• Infrastructure • Proximity to suppliers and customers • Tax and political advantages • Serving value added services
Awad-Nunez et al. (2014:45)	• Environmental protection • Noise on natural environment • Noise on urban areas • Hydrology • Land price • Geography • Accessibility to transportation modes • Accessibility to services • Weather • Orography • Geology • Distance to other logistics platforms

Chang et al. (2015:444,448) listed the criteria that are necessary for the selection of a suitable dry port location and the qualities of dry ports in the model proposal they suggested about the dry ports to be established in the Port of Dalian in China in Table 2:

Table 2: Dry Port attributes and selection criteria

	Attribute Detail
Geographical attributes	Linked to a sea or airport.
	Inland – located away from traditional land, air and coastal borders.
Logistics Attributes	High capacity transport link(s).
	More than one transport mode.
	Intermodal transfers.
Warehouse logistics attributes	Temporary storage or warehousing.
	Consolidation and deconsolidation.
International port attributes	International trade involved.
	Customs inspection.
	Other services found in an international sea or airport.
Value-added logistics services	Freight forwarding.
	Information systems.
	Other value-added services.
Criteria	**Critics Detail**
Transportation condition	Traffic capacity
	Regional transportation volume
Regional economy	Development status
	Industrial level
	Commercial level
	Foreign trade
	Social reproduction conditions
	Development potential
Policy environment	Policy orientation
Environmental friendliness	Sustainable development potential

Source: Chang et al. (2015:444,448).

2.1 Detailed Examination of the Selection Criteria Used in the Study

A detailed examination of the selection criteria for dry ports contained in the literature is presented in this part. Information about the criteria used in the present study is provided below.

2.1.1 Environment

The environment perspective of the transportation activities is considered an important pillar for most countries. Especially in European Union, some actions regarding to environmental consciousness are taken. Emission decreasing and taking alternative actions in order to decrease emissions and other harmful gases are considered and with this context, some strategies can be seen by taking taxes form CO2 (European Commission, 2001).

Facilities such as freight villages, industrial zones and dry port yards have some effects to the both urban and natural environment. As Núñez et al., (2013) states that, natural and urban environment might be affected with the noise level from such facilities.

Another consideration about the environment is protected areas and the hydrology. Any construction is forbidden within the areas of special environmental areas, the decision of the location of the facility should not be considered within the areas of protected areas. Rivers, lakes and areas with near to the water courses are also another consideration that Núñez et al., (2014) indicates a flooding risk for such facilities. Furthermore, solid and liquid wastes generated form such facilities also create an environmental risk. Though not exclusively for dry ports, it is required to diminish the unpleasant effects on the environment and to take into account the carbon emission while building such places as storage facilities and logistic villages in the supply chain. Woxenius et al. (2014) indicated that it is important to ensure that the damage caused in the environment is minimum and the congestion in the exchange of loads is eliminated so that the transfer at the ports can be carried out more productively. They also stated that it is essential to provide improved logistic solutions in the port hinterland. Tanyaş et al. (2011) underlined the importance of the following points:

I. Realistic and practical measures should be taken in all logistic activities to protect the environment
II. Fuel usage should be decreased due to the decline of petrol resources and the environmental damage caused due to the increase of prices
III. The use of productive energy should be increased
IV. New systems should be developed to reduce greenhouse gas emission and air pollution
V. The solid waste that can be seen at ports should be removed before they cause any damage to the environment

In the present study, the above-mentioned criteria were taken into account in the case of the dry ports planned to be established after the examination of special environmental protection areas across Izmir. As it can be seen in Figure 1, there is a special environmental area located in Foça, İzmir.

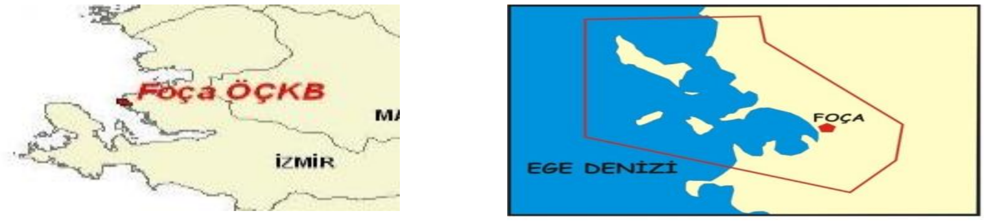

Figure 1: Special environmental protection areas

2.1.2 Land Condition

Land price, infrastructure, orography geology elements were listed in the land condition title. Land price is simply the market value of the possible facility area and the values were gathered form the municipalities. Lv and Li (2009:639) include the use of land resources included cost title.

Infrastructural considerations also an important pillar for such facilities that without proper investigations of related infrastructure elements is going to be decrease the efficiency as well as decreasing the information capability of the dry ports. Here, accessing various communications mediums and the availability of infrastructure elements such as sewage, natural gas lines, electrical circuits etc. might be considered as vital. In this context, Núñez et al., (2013) highlights that accessing supplies and services such as sanitation and other related utilities might affect the selection criteria.

Orography confronts the topographic characteristics of the land. Here, slope and curl characteristics of the land determine the investment decision (Núñez et al., 2014:314). Geology criterion includes various characteristics of the soil. Here, soil term is a technical term which includes various elements such as excavability of the soil, pressure of the soil etc.

2.1.3. Transportation Networks

A freight facility needs to efficiently connect to the transportation network (National Cooperative Freight Research Program Report 13, 2011). There are four transportation modes that affect dry port selection such as railway transport, road transport, air transport and sea transport.

2.1.3.1 Railway Transport

Rodrigue and Noteboom (2012) pointed that geographical characteristics and regional access capacities play a very important role in the establishment of dry ports and shape their development besides railway networks that are also crucial with regards to the utility and productivity of dry ports. They also indicated that every domestic market will require a different transportation system and thus there will not be only one strategy for dry ports. Similarly, Çağlıyan and Yıldız (2013) emphasized that the transportation of raw materials has become very important with mass production and the increase in the number of orders for raw material with each passing day. They added that railway transportation has come to the forefront in the distribution of the raw materials arriving at ports across the inlands although maritime transportation still remains important. With the latest developments in the economy and the technology as well as the increase in the number of regions having a high load potential and which are close or connected to organized industrial sites, railway networks have gained significance in loading and discharging operations carried out in the port hinterland (Turkish State Railways, 2014). In Figure 2, the railway infrastructure can be seen for Izmir area.

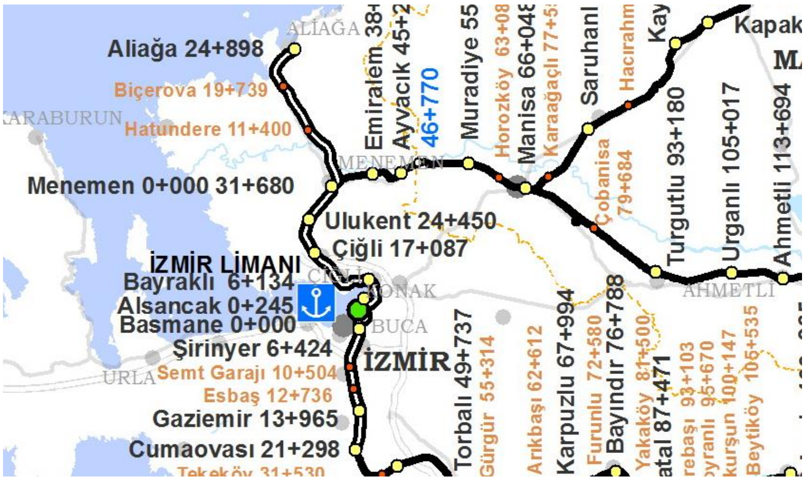

Figure 2: Railway infrastructure for Izmir Zone (TCDD)

2.1.3.2 Road Transport

In the context of transportation modes in Turkey, the most percentage is belongs to road transport with %88.3, sea transport modes is about %5.8, rail transport mode is %5.3 and the air transport is %0.6 (UBAK, 2012:9). Karadayı (2012:26) highlights that road transportation mode has the most advantage compared with the other transportation modes. However, Woxenius et al (2004) states that road transportation mode still dominates traffic mode and involves adverse effects such as emissions, noise and accidents.

2.1.3.3 Air Transport

Although air transport mode constitutes a small percentage in million ton (%0.6), the availability of air cargo transportation increases the competitiveness of the logistics service providers.

2.1.3.4 Sea Transport and Ports

The lack of sites and the congestion in terminal services can be listed among the main problems recently encountered at ports. Direct railway connection to seaports makes transportation to dry ports possible. Woxenius et al. (2004) describes the dry port concept as a seaport directly connected with inland intermodal terminals where goods in intermodal loading units can be turned in as if directly to the seaport. So the further development of hinterland networks under the high-volume development conditions of dry ports and inland terminals is crucial. In Figure 3, the container ports in Turkey were shown.

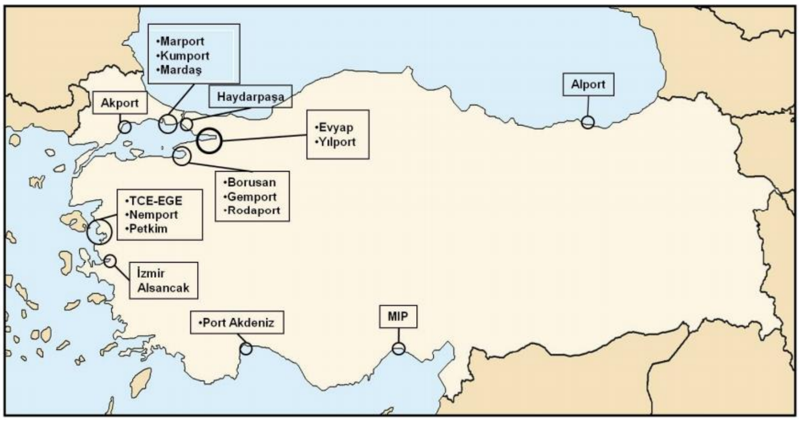

Figure 3: Container ports in Turkey
Source: Türklim, 2010

2.1.4 Population

In the literature, it is pointed that the criteria about population and population density are closely related to the establishment of dry ports and other relevant structures. In the study on the dry ports that could be established in Izmir, Akman (2007; 68) argued that high gross domestic product and population density would affect their sizes. Henttu et al. (2011: 13-14) used the population criteria for the selection of dry port locations in Finland. They indicated that the reason why the selected dry ports are mostly located in the southern part of Finland is the density of the population in this part of the country. In the study where they investigated the effect of dry ports on carbon emission, Lattila et al. (2013:24) indicated that the flow of transportation is based on population. Awad-Nunez et al. (2014: 47) similarly argued that high population density can be regarded as an advantage about the demand for goods stored at dry ports and also about the labor force. The population data used in the present study with regards to the population criteria for the province of Izmir, for Aliağa district of Izmir, and for the province of Manisa are given in Table 3.

Table 3: Population of Izmir, Manisa Cities and Aliağa County for years 2014 -2015

	İzmir(Aliağa)-1128		Bornova		Gaziemir		Kemalpaşa		Yunusemre (Manisa)	
	Population	Percentage	Population	Percentage	Population	Percentage	Population	Percentage	Population	Percentage
2014	83.366	% 2,10	431.149	% 10,41	130.870	% 3,15	99.626	% 2,42	204.436	% 15,29
2015	87.376	% 2,10	435.162	% 10,44	132.365	% 3,18	101.693	% 2,44	211.673	% 15,33

Source: Turkish Statistical Institute

2.3.5 Climate

The climate conditions are also another critic that affects the transportation activities. Henttu (2011:3) state that these two are in connection with each other. Simply, this study determines the climate conditions by considering the weather conditions of cities and counties for selected points.

2.1.5 The Legislation in Turkey

As stated in Annex 4 of the "Regulation on Temporary Storage Facilities" dated 21.03.2014 and numbered 2014/1, it is required for temporary storage areas to be in 10-km distance at most to the Customs Office provided that common routes are followed, in addition to the economic conditions and other conditions relevant to the field. For this purpose, the locations for dry ports that are considered to be temporary storage facilities are evaluated according the current legislation in Turkey.

> *"Paragraph 1 of Article 560 of the Customs Regulation divides the customs offices listed in the official website of the Ministry into two categories being type A and type B customs offices according to their authorities. Type A customs are authorized to perform all kinds of customs operations whereas type B customs are authorized to perform the customs operations determined by the Ministry only as well as the operations about passengers and the freight*

coming along them" (General Directorate of Customs, Accessed on 14.02.2013, Source: http://ggm.gtb.gov.tr/gumruk-idareleri).

In the table given below, the customs and trade offices available in the Aegean Region can be seen.

Table 4: Aegean (Izmir) Regional Directorate of Customs and Trade

Aegean (Izmir) Regional Directorate of Customs and Trade	City	Class
İzmir Customs Office	İzmir	A
Adnan Menderes Customs Office	İzmir	A
Çeşme Customs Office	İzmir	A
Manisa Customs Office	Manisa	A
Aliağa Customs Office	İzmir	A
Ege Free Zone Customs Office	İzmir	A
Uşak Customs Office	Uşak	A
Afyonkarahisar Customs Office	Afyonkarahisar	A
İzmir TIR Customs Office	İzmir	A
İzmir Free Zone Customs Office	İzmir	A
İzmir Passenger Hall Customs Office	İzmir	A
Dikili Customs Office	İzmir	A
Alaşehir Customs Office	Manisa	A
Aydın Customs Office	Aydın	A
Kuşadası Customs Office	Aydın	A
Denizli Customs Office	Denizli	A
Foça Customs Office	İzmir	B

Source: http://ege.gtb.gov.tr/

The areas with a radius of 10 km provided that the customs offices chosen due to their proximity to ports are taken as the center.

3. THE SELECTION OF DRY PORT LOCATIONS: THE CASE OF IZMIR

10 selected points are located Izmir and two selected points are located Manisa. Manisa is neighbor city of Izmir. So, it has an important role in Izmir's logistics system. The selection criteria used in this paper was referenced from the paper of Nunez et al. (2014:45) in Table 5. However, in order to localize these selection criteria, some modifications were applied. The selection criteria are shown below:

- Environmental Protection: In this study there are no selected points in the area of environmental protection. However, if a random point were selected in the protected area, the model automatically eliminates the selected point.

1. Noise on natural environment: for this criterion, the model calculates the distance between the selected point and nearest natural area (i.e. city parks, green areas etc.). Here, points closed to the natural environment area get lower points.

2. Noise on urban environment: for this criterion, the model calculates the distance between the selected point and nearest urban area (i.e. city centers, county-village centers etc.). Here, points closed to the urban environment area get lower points.
3. Hydrology: this criterion concludes the distance between the selected points and the nearest water areas (i.e. sea, river, lake etc.). Regarding hydrological conditions, high scores are obtained for locations far away from surface water courses, no aquifers in the environment and areas without potential risk of flooding.
4. Land price: the land price criterion for this study includes the market value of land and the transportation cost of the C-30 concrete/m³. Regarding land price criterion, high scores are obtained for locations with low land market value and low cost for concrete transportation.
5. Population: this criterion includes the population level and the density of the hosting area. Regarding population criterion, high scores are obtained for locations with high populated areas because; high populated areas are going to create high demand.
6. Accessibility to the rail network: the distance between the selected point and the nearest rail network with handling capability. Regarding this criterion, high scores are obtained for locations close to the rail network.
7. Accessibility to high capacity roads: the distance between the selected point and the nearest rail network with handling capability. Regarding this criterion, high scores are obtained for locations close to the rail network.
8. Accessibility to airports: the distance between the selected point and the nearest. Regarding this criterion, high scores are obtained for locations close to the airport.
9. Accessibility to seaports: the distance between the selected point and the nearest seaport. Regarding this criterion, high scores are obtained for locations close to the seaport.
10. Accessibility to supplies and services: this criterion includes GSM, telephone circuit, fiber, 4.5 G, electric, water, natural gas lines, sewages. Regarding this criterion, (1) correspond the availability of the supply or service, (0) corresponds the unavailability of the supply or service.
11. Weather: this criterion includes the average temperature difference between daily temperatures, total rainy days, average rainfall, number of snowy days, number of minus temperature days and number of days with heavy rainfall. Regarding this criterion, high scores are obtained for locations with low number rainy days, snowy days etc.
12. Orography: orography is used to determine the topographic characteristics of the soil. In this study, the maximum slope and the difference between the selected point's lowest and highest points were included. Regarding this criterion, high scores are obtained with minimum slope and difference between point's highest and lowest points.
13. Geology: Results of the interviews with experts and authorities have concluded that constructing a data set for these areas is very difficult and costly to construct. Separate soil studies are required for each point. For this reason it was removed from the model.
14. Distance to other logistics platforms: In order to calculate the points for this criterion, the distance between selected points and the industrial areas and logistics platforms were taken into consideration. The distances were calculated with statistical methods and classified as very close range, close range, medium range, distant range, very distant range. Getting close to the industrial areas provides more demand potential and creates advantage on the other hand, closing to the logistics platform creates disadvantage by distributing the logistics traffic.

Table 5: Selection criteria for dry port locations

no.	Factor name	Observations
*	Environmental Protection	Binary variable automatically discarded protected areas
1	Noise on natural environment	Noise level measured in dB (A) on the natural environment
2	Noise on urban environment	Noise level measured in dB (A) on the urban environment
3	Hydrology	Presence of vulnerable areas such as rivers, streams or lakes
4	Land price	Measurement of investment to make
5	Hosting municipality range	Considering the size of the municipality, the future development of urban centers and centers nearby and the demographic and economic potential
6	Accessibility to the rail network	Accessibility to freight and passenger transport networks
7	Accessibility to high capacity roads	Accessibility to high-capacity motorway networks
8	Accessibility to airports	Accessibility to air cargo terminals
9	Accessibility to seaport	Connection with one or more Seaports
10	Accessibility to supplies and services	Accessibility to communication networks and the electrical grid and any other necessary utilities such as water, sanitation, etc.
11	Weather	The climates appropriateness for activities in the greatest number of days per year.
12	Orography	The orography is used to understand the topographic relief of the area on which the facility is located. This factor is commonly used to plan infrastructure s.
13	Geology	Mechanical characteristics of the land on which the facility is located
14	Distance to other logistics platforms	Overlap between hinterlands and the agglomeration of industries

Source: Núñez et al. (2014:45)

In the Figure 4, the selected points for dry port locations are demonstrated.

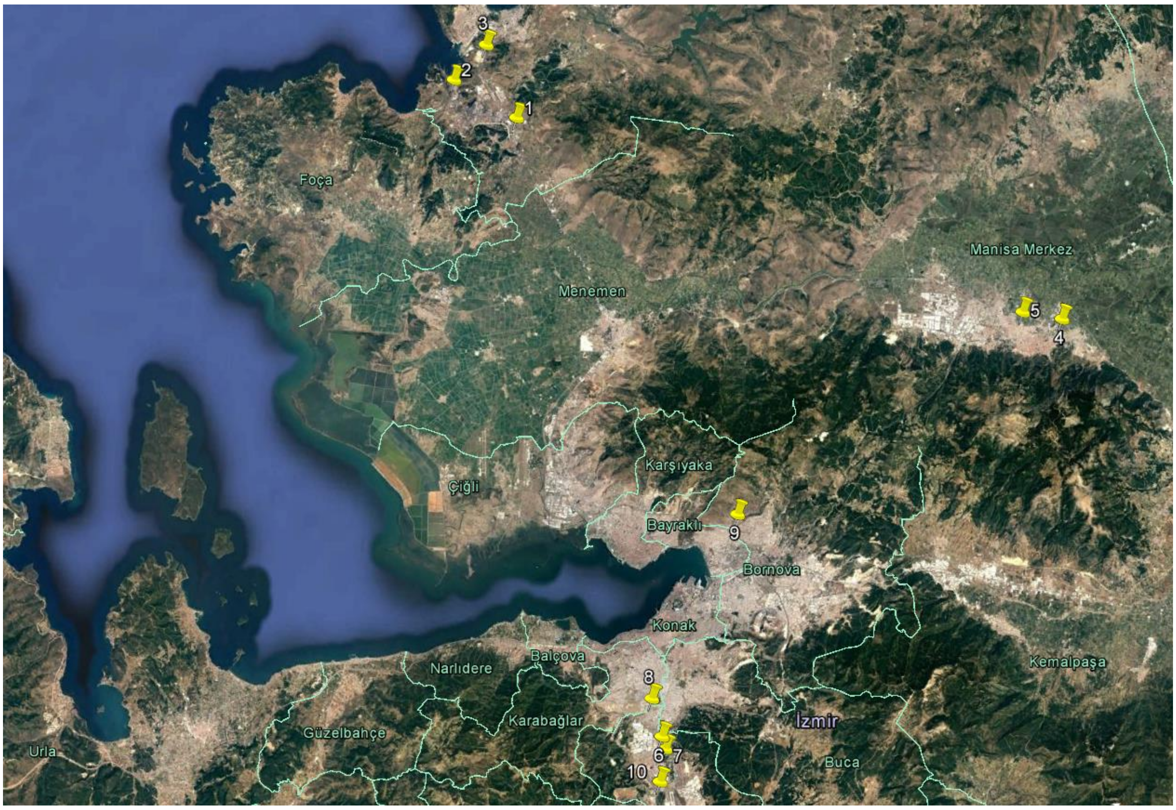

Figure 4: The selected points located in Google Earth Program.

In Table 6, the matrix between factors and locations was shown. According to the assessment of the criteria Location 7 gets the highest score with 71,8. With this score, we can conclude that the location of the dry port should be located in this area with the consideration of 13 factors.

Table 6: Criteria assessment scores of factors and locations

Factors	Weight	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
1	5,00	100,00	77,06	30,21	0,42	4,34	6,43	5,03	0,70	14,55	0,00
2	7,25	0,00	38,98	100,00	36,61	54,24	41,02	42,71	90,85	10,51	17,97
3	6,00	66,47	60,00	51,33	60,00	63,93	80,43	87,57	60,04	59,42	88,36
4	7,00	89,77	100,00	82,48	87,67	81,07	98,57	89,81	89,53	0,00	73,81
5	5,00	45,54	45,54	45,54	67,10	67,10	8,32	8,32	8,32	50,00	8,32
6	10,00	0,00	35,79	74,74	100,00	71,58	91,58	96,84	67,37	40,00	54,74
7	10,00	97,33	0,00	81,11	86,67	72,00	69,56	78,44	100,00	6,67	72,22
8	5,00	0,00	0,00	0,00	0,00	0,00	98,22	99,56	93,56	40,44	100,00
9	10,00	91,64	100,00	100,00	18,22	23,11	78,18	76,20	83,78	96,62	60,00
10	8,00	66,50	70,50	90,00	82,00	100,00	82,00	92,00	82,00	68,00	92,00
11	3,00	54,01	54,01	54,01	87,43	87,43	51,57	51,57	51,57	49,62	51,57
12	5,00	94,24	61,52	100,00	92,94	97,58	69,52	90,52	53,16	0,00	79,93
14	8,00	40,83	33,33	40,83	37,47	50,81	57,47	64,99	64,97	80,00	92,51
SCORE(WITHOUT WEIGHT)		57,4	52,1	65,4	58,2	59,5	64,1	68,0	65,1	39,7	60,9
SCORE(WITH WEIGHT)		57,6	51,7	**70,1**	59,5	59,7	67,7	**71,8**	**70,2**	41,7	63,0
POSITION		8	9	**3**	7	6	4	**1**	**2**	10	5

4. CONCLUSION

This study includes the cities as Izmir and Manisa. Although the title only includes Izmir city, the author of the paper concludes that Manisa is neighbor city of Izmir and have a high impact on both manufacturing and logistics activities of Izmir city. The location selection criteria were referenced and modified and some of the factors were omitted. The criteria structured as (1) protection areas, (2) Effect of noise and other mediums on natural environment, (3) Effect of noise and other mediums on urban environment, (4)Hydrology, (5) Land price, (6) Population, (7) Availability of rail roads, (8) Availability of high capacity roads, (9) Availability of high capacity roads, (10) Availability of airports , (11) Availability of ports, (12) Climate, (13) Connection with industrial zones and logistics platforms. Furthermore, each criterion has its specific score which determined the factors listed above. In this context, the factors calculated above aims to select the best location among the others thus, each selected point has a different advantage on different factors. This application may be a useful decision support system for decision of dry port establishment. In future research, the weights of the factors can be determined by the experts in Turkey by using multi-criteria decision making methods. Scoring methodology is based on the establishment of the relative weight of each factor. New factors and new dry port points can be added to the model to broaden the choice of decision. Although dry port term is a new concept in the context of Turkey, this option should be determined with the freight village options together.

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HOW TO GO GREEN YOUR LOGISTICS AND NEXT MILESTONES: CASE STUDY

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Abstract – *Nowadays firms have to apply more environmental policies as well as decreasing costs. The aim of green logistics is not to damage environment (rapid consumption of sources, pollution, global warming, decrease in biological diversity, distortion in ecological balance) while carrying out logistics activities. Customer preferences for green products and green processes have triggered the logistic firms to review and revise their strategies/implementations. At the same time; social responsibility, legal and governmental pressure, ecologist image have incentive impact on companies about sustaining green processes and products to ensure competitive advantage. In this paper, primarily, in the introduction part, the general information is given about green logistics, its advantages, reasons and problems of it. Secondly, literature research is made about green logistics implementations. Lastly, how a "logistic firm" implement green logistic and what are the future of green logistics have been analyzed with studying the green logistics activities in the sample firm. Data collection will be actualized by case study in a "logistics firm" by face to face meeting method with semi structured interview forms. As a result the researchers aim to come up with some significant results on the clarification of "Green Logistics Applications" and its future.*

Keywords – *Case study, Green Logistics Applications, Logistics*

1. INRODUCTION

Creating a sustainable business processes requires the least possible negative environmental impact. Logistic Firms should be focusing on changing/redefine their business processes to fit the idea of being green. In order to reach such a situation where the whole aspects/functions of Green Logistics is run environmentally friendly, there must be an evaluation step.

The worldwide economic growth of the last century has given rise to a vast consumption of goods while globalization has led to large streams of goods all over the world. The production, transportation, storage and consumption of all these goods, however, have created large environmental problems [1].

Green innovations in logistics services can help improve efficiency and effectiveness across many sectors of the economy [2]. Even, a new approach which was termed as "green logistics approach" had emerged in the early 2000's in response to the ever rising environmental pressures; there is a need to integrate green innovations in logistics [3].

"Customers", "technology", "regulatory compliance" are the main drivers. Accordingly H'Mida (2009), as costumers have the final decision about what they choose to buy, if leading companies act environmentally and create environmental consumer demand, will lead consumers to ask for environmentally friendly products and refuse to buy if the product does not meet this requirement [4]. Only this way, companies will start to compete in terms of environmentally-friendliness, which in turn will benefit every human being, every creature living in the world and the Earth itself. "Technology" alone is not able to help protect environment without consumers' willingness to participate in this mission and their consciousness about the issue.

Environmental issues have become critical issues in the scope of logistics. Zailani *et al*. (2011) describe that globalization and global logistics are destructing the environment unevenly because firms are required to

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maintain high environmental standards in developed countries but can lower these in less developed. Nevertheless, the growing importance of environmental in logistics has become a universal issue and generated a great deal of discussions among the international academic and business communities all around the world to solve the conflicts. The logistics discipline has generally focused on producer-to-consumer movement of products, considering transportation, warehousing and inventory management (forward distribution) but the desire for greenness, led in the early 1990s to the concept of reverse distribution where consumer-to-producer movements become equally important [2].

In this paper, primarily, in the introduction part, the general information is given about green logistics, its advantages, reasons and problems of it. Secondly, literature research is made about green logistics implementations. Lastly, how a "logistic firm" implement green logistic and what are the future of green logistics have been analyzed with studying the green logistics activities in the sample firm. Data collection will be actualized by case study in a "logistics firm" by face to face meeting method with semi structured interview forms. As a result the researchers aim to come up with some significant results on the clarification of "Green Logistics Applications" and its future.

2. LITERATURE SURVEY: GREEN LOGISTICS APPLICATIONS

The costs related with environmental management are in escalating trends and force logistics firms to gain certified environmental management system and to develop innovations that are aimed the environmental performance of their processes and products.

Why Green ?: There is no doubt for the necessity of green logistics. It’s a result of environmental apprehensions. On the other hand, in business view, "green" called the mind extra-costs. The firms were really successful to pretend that they are needed to be green with new mottos: "sustainability", "competitive advantage", "social responsibility", "ecologist image", "stop the depletion of resources" and conversely/surprisingly "reducing the cost of manufacturing via re-production and recycling". Costumers' worries for environment and preference for green products are turned out new add-value services for the firms. So, logistics literature flourished according to "firms' allegations" instead of "to be green to prevent environmental damage".

Studies in logistics literature are inquired the main reasons to be green: macro environmental factors (legal/social/government pressures, urbanization/industrialization), management strategies (customer pressures, image), operational issues (decrease waste, improve profit) or sincerely (rapid consumption of sources, pollution, global warming, decrease in biological diversity, distortion in ecological balance).

How Green?: Environmental management for the logistics industry is now-a-days playing much more important role owing to rapid development of the Green Logistics. According to Zailani *et al.* (2011) greening of supply chain will have an increasing impact on logistics activities such as network design, transport modes used, warehousing, selection of equipment, business processes, behaviors and balance sheets [2].

Regarding main focus of this study some studies in literature focus on “Green Logistic Firms” instead of “Green logistics of the Firms” :

- Lai *et al.* (2013) contributed a validated measurement scale useful for shipping companies to evaluate the strengths and weaknesses of their greening efforts and identify areas for improvement. They develop, refine, and test a six-dimensional measurement scale specifically for evaluating Green Logistics implementation in the sea transportation context [5].

- Zailani *et al.* (2011) aimed to find out as to what extent the logistics managers perceived the green innovation and environmental impact on their logistics activities. The preliminary survey was conducted on logistics companies in Malaysia based on proportionate random sampling. They mention two methods to reduce the environmental impact of industry are to either introduce more energy efficient technology or to organize logistics in a different way [2].

- Rodrigue *et al*. (2001) stated that the logistical operators use the most polluting, least energy efficient and most infrastructure-intensive transportation modes to increase the speed of distribution [6].

- Lin and Ho (2010) analyzed the factors influencing the adoption of green practices in Chinese logistics industry. Research results reveal that relative advantage and compatibility of green practices, organizational support, quality of human resources, regulatory pressure, and governmental support have significantly positive influences on the adoption of green practices for Chinese logistics companies [7].

Nowadays, Governments, NGOs, action groups and companies are asking for measures to counter environmental threats such as rapid consumption of sources, pollution, global warming, decrease in biological diversity, distortion in ecological balance. Also costumers' worries for environment and preference for green products are turned out new add-value services for the firms.

Despite the extensive literature on "green logistics", "green application in Logistic Firms" is quite new.

3. CASE STUDY

Logistic activities include of distribution network design, freight transport, storage, inventory management, material handling, production plan and all the related information in processing. The Authors will not differentiate between green logistics and green supply chain management as in previous studies. The purpose of this study is to give a roadmap of the present and possible actions in logistic firms.

The survey questions are grouped due to research model developed by Dekker et al (2012) as seen in **Fig.1** [1]. The "semi structured review form" updated regarding previous studies (Zailani *et al.* 2011; Lin and Ho 2010; Murphy and Poist, 2003; Lau 2011) [2, 7, 8, 9]. Approximately 70 open ended questions classified regarding "research method". After face to face interview in June 2016 in logistic facilities of the company (ANKARA), the questions are detailed/analyzed via phone call/e-mail traffic. And the study reviewed by the firms "green team" and high level managers (ISTANBUL) in October 2016 to finalize the study.

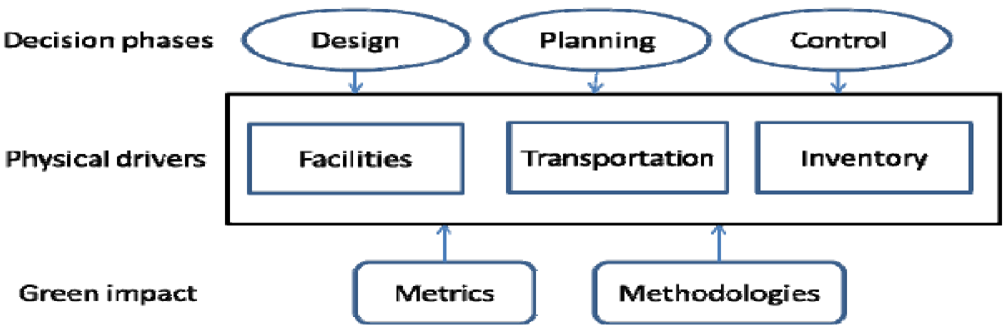

Figure 1. (Source: Dekker et al 2012).

As the aim of this study is to get an understanding of how "green logistics applications" are perceived among logistic firms in the Turkish market, this subject could be researched by the use of a qualitative method to begin with. Then several methods were reviewed in order to determine the most appropriate method for this study; such as in-depth interviews, the Delphi method and focus group studies.

This qualitative research method (case study, face to face interview, semi structured review form) allowed the researchers to go beyond what can be seen in the first glance and examine the green logistic applications. Additionally, the "case study" provided flexibility that cannot be found in quantitative research, as it takes into account the human factor. Another advantage of this method is its ability to capture the unexpressed thoughts or perceptions by observation, allowing the researcher to get a deeper understanding of the "green issue", from the eyes of the subject of this study.

3.1. The Firm:

Each day carrying thousands of containers full of materials, finished products, industrial and consumer goods, **Company A** provides intermodal services to a substantial majority of the best known global companies and brands. At the date of establishment in 1990, **Company A** aim to become a leading brand in Europe (1996 international logistics, 2008 intermodal, 2013 RO-RO). Today; the company has a structure to offer 3PL integrated logistics services globally and tailor made solutions for variety of customer expectations. **Company A** is providing service in Germany, Romania, Italy, Bosnia, France, Greece, Hungary, Spain, Poland, Bulgaria, Czech Republic and Ukraine (28 countries) with its over 750,000 square meters own warehouse. It boasts a fleet of over 5000 vehicles and a multi-national workforce of 6.500 employees.

Company A serves many sectors including automotive, chemical, industrial, health and personal care, e - Commerce, FMCG, textiles, retail, construction and decoration. **Company A** has IATA license, NVOCC Certificate and memberships in HTFN, FIATA, ITCO, and UTIKAD.

Company A provides direct or charter transportation services in a fast and safe manner of many product types from many sectors ranging from general freight to perishable freight, from hazardous material to textile products on hanger, from heavy weight tonnage products within the scope of the transportation project to out of gauge products, from live animals to factory transportation, and special bulk transportations.

Following the implementation of the management systems having international validity, initially some standards have been adopted and then they have been widely taken into operation. The establishment of 16 facilities has been completed; ISO 9001 has started to be implemented in 2004. Passed to the application of OHSAS 18001 in 2005 and to the application of ISO 14001 standards in 2009 and simultaneously, Total Quality Management Philosophy has been adopted in 2004. The Management Systems Development Organization, which has implemented integrated management systems and therefore undertaken the development initiative as integrated with the R&D team, has been formed.

3.2. Design:

Main questions according "**design**" are : "sustainability", "network design", "Multi-objective optimization", "Determination of the type, number and location of facilities", "Explicit Environmental Objectives", "Publicly available missions and values statement", "Determination of production and distribution concepts", "Trade-off between inventories and transportation", "Eco friendlier products", "Combining transports", "C*ross-chain control towers(*sharing transport equipment etc.)", "Compliance with local, regional, national and international laws (Local and EU)", "Provide Environmental Information to Workers", "environmental awareness and training", "Timetable for improvement", "barriers about becoming green", "obtain innovations", "relationships with external stakeholders", "Collaboration with customers and suppliers", "Environmental Cost Identification", "solutions balancing environmental and business concerns", "advantages/motivations of being green", "what consumers are thinking about green issues", "organizational structure", "Size/experienced/tenure of Environmental Staff", "The status of the environmental issues in the company", "Cross-Functional Work Teams", "Problem-Solving Teams", "Habitat improvements", "civil society organizations/ Academic cooperation", "Press releases", "Annual reports", "Roles of new technologies including information technology".

To believe in to be green for “sustainable supply chain network design” is main issue in literature. **Company A** is certified for its operations carried out in accordance with the sustainable service perspective. **Company A** has the GOLD level "Sustainable Logistics Certificate" in conclusion of the audit carried out by relevant institutions. In this context, **Company A** underwent an audit on the basis of environment, energy, occupational health and safety, employee rights, road safety, asset and customer feedback management criteria. **Company A** aims to ever improve its level of performance by accelerating its sustainable development.

Within the framework of the firm’s environment project, documentation was created as per ISO 14001 Environment Management Standards, and applied on pre-determined environment-related targets and trainings of **Company A** personnel and the students of the schools close-by began.

Company A claims that the firm “*aware that protecting the nature and the environment is among its most fundamental and vital duties*”. Corporate Policy for Quality, Health and Safety, Environment - QHSE has been built on three corporate values: Customer Satisfaction, Motivation of Personnel and Operational Perfectness.

Company A published The Code of Ethics & Business Conduct to espouse the ongoing ethical values to its employees, sub-contractors, suppliers and all stakeholders. The Conduct holds a guidance role in internalizing the values among all stakeholders and taking necessary actions in cases where values aren’t being performed in an appropriate manner. The Code of Ethics & Business Conduct Good that **Company A** espoused, mainly focuses on; Observing Social Benefits, Complying with Laws and Other Regulations “Internal and External Communications Policy" is available in website and customers can contact directly with The Ethics Committee Members for questions and further notifications via e-mail.

Company A adopted the motto "logistics for a better world" for its business operations. “Environment” is the one of 5 keywords in **Company A**’s Values. “to be environment-friendly” takes place in Mission of **Company A**. The firm gives support to any effort to raise the public awareness in the nature and the environment via its website.

Company A develops awareness in its employees. Within the framework of the training process the drivers enroll into since day one of their employment at **Company A**, drivers receive regular trainings in key points such as safe and economic driving and defensive driving techniques on a heavy vehicle simulator, as well as other vocational trainings, on-the-job trainings, and trainings on cargo safety. Training activities are on full swing with the support of trainers specialized on various matters such as Advanced Driving Techniques, Economic and Safe Driving Techniques, ADR, Load Safety, RCA - Root Cause Analysis. Also, WWF-Turkey Green Office Program activities focus on improving the awareness of employees. Drivers are able to expand their knowledge with the “drivers' handbook” in which all basic information is illustrated with pictures and most competent drivers are rewarded.

R&D Center aims to implement and maintain systematical, creative, authentic, scientific, experimental and technical works which take environment concerns seriously and provide innovations or substantial improvements/developments in services, processes, systems, organizations, and business practices directly contributing to the competitiveness of the firm and the industry. R&D Center is currently engaged in R&D activities in numerous fields, including fleet optimization and route planning, cargo and network optimization developments incorporating 3D loading models, development of warehouse management, shipment and distribution business models and the design of automation systems, development of flexible product/order preparation and packaging processes, order method software development, demand management system design, and alternative transportation, in cooperation with universities and various institutions.

Throughout the R&D activities, **Company A** R&D Team employs an interdisciplinary methodology making simultaneous use of various qualifications such as Process Development, Optimization, Simulation, Software Development, Quality Systems Management, and Project Management. **Company A** R&D Center is the scene of research on areas such as Vehicle Route Planning, Distribution Network Design, Pricing, Ergonomics, Process Analysis, Quality Management, Capacity Planning, Plant Investment and Investment Planning, with a view to improving basic service types of Transportation, Warehouse Management and Customs Clearance.

Company A employs a "Business Development" team specialized in project management and specific sectors. Team members who work locally in each facility, follow up the operation closely and ensure that processes that are designed with the principle of constant development and the aim of increasing the efficiency and the operational quality are implemented in the field in time and smoothly. **Company A** ensures that environmental risks that may occur during its operations are identified and eliminated in accordance with the legal legislation.

Determination of the type, number and location of facilities is the one of main issues in green logistics literature. **Company A** organizes its processes with environmental awareness via projects. For example, with the project: "*Developing a Real Time, Simulation Based Supply Chain Risk Management Methodology, and Tool for the Multiple Model Transport of Goods between Turkey and Germany*" considering the logistics sector legislation and the need for incentives and support for the transition from land transportation to sea and railway transportation, the planned projects will be focusing on building an advanced transportation infrastructure network between Germany and Turkey, and developing a simulation based decision support system to reduce risks and ensure the smooth functioning of the multiple-module systems between the two countries.

The right selection on "location of facilities" has an increasing impact on green logistics applications. **Company A** intents to add a new logistic node (a sea port in Yalova) to keep approximately 100000 truck away from city traffic jam.

On behalf of business partners, **Company A** has co-operated with NGOs for 3 years in this context for Three "Memory Forest". **Company A** supports civil society organizations working to protect wild life. The revenue derived from Recycling of Scrap Waste was used to support the adoption campaign of World Wildlife Conservation Fund for Turkey (WWF Turkey). **Company A** personnel and the students of the schools close-by receive trainings on environment-related targets (Harmandere High School Project in Turkey).

Company A invites academicians and students from the relevant departments of universities to cooperate in the following fields: SAN-TEZ (Industrial Thesis) Program, TÜBİTAK (Scientific and Technological Research Council of Turkey) - TEYDEB (Technology and Innovation Funding Programs Directorate) Programs, EU Framework Programs, University-Industry Cooperation Programs.

3.3. Planning and Control:

Main questions according "**Planning and Control**" are: "Forecasting system", "ISO Certification", "Environmental performance monitoring system", "Regular Environmental Inspections", "Environmental Audits", "design/monitor the measures", "Penalties for non-compliance", "modal split", "intermodal transportation", "The labeling system", "Reduction of travel times", "Reduce long waitings", "Navigation software(apply sophisticated shortest-path algorithms and reduce the amount of kilometers to be travelled)", "Direct versus hub-and-spoke transportation", "direct trips versus milk runs", "Equipment pooling", "Consolidated in full trucks".

To struggle with Global Climate Change, **Company A** verified the ISO 14064-1 Greenhouse Gas Inventory. Emissions due to all locations and activities of company are included in the scope of the certification. Documentation was created as per ISO 14001.

Environmental performance indicators are described in ISO 14031 (Environmental management-environmental performance evaluation of the ISO 14001 accreditation guidelines). Environmental performance indicators are needed when evaluating the environmental performance of activities, processes, hardware and services. Within the ISO 14000 family of certification requirements and guidelines are environmental performance management guidelines codified as IS0 14031. ISO 14031 focuses on evaluation of environmental performance.

Eco Performance defines the effective integration of ecological, economical and social engagement of a company and its representation of individual responsibility for the realization and sustainability of successful road freight transportation. The term "Eco" combines the words "Economy" and "Ecology". Eco Performance

Award assesses the services of the companies, which will serve as a model for the sustainability in transportation sector. **Company A** with its operations to protect environment is the winner of this award in 2012. European Eco Performance Awards are granted following an assessment of the companies' environmental conscience against the economic business model and measuring the levels of its implementation. The category of large scale corporations was assessed in 3 areas; economical success, environment and social responsibility by the jury. In the scale of economical success that is assessed in terms of effective service and efficient work process; criteria such as operating in various markets, work capacity, international locations and total cost optimization were taken into consideration. On the basis of firms contribution to environment in terms of efficient fleet, use of telematics, intermodal solutions, reduction of carbon dioxide emission, and cooperation with suppliers, advanced tracking devices, fuel consumption and use of Euro 5 compliant vehicles. Also firms approach to social responsibility; have been assessed on the basis of its education, corporate culture, social activities, and motivation and awarding criteria.

Intermodal transportation entails the transportation of a cargo to more than one location, using more than one model of transportation, without any alteration of the product at the times of transfers from one means of transportation to another. Within the framework of intermodal transportation, special trailers that allow the transfer of products from one model of transportation to another without leaving the original trailer are used. "Intermodal transportation" aims to transport cargoes from one location to another, in a most effective, punctual, affordable, and environment-friendly manner. **Company A** uses transportation models used in intermodal transportation, such as trucks, trains, cargo ships, and airplanes. Aiming less diesel consumption, less NOx, CO2 and Particles emission.

Company A is member of the CREAM Consortium (Customer-driven Rail-freight services on an European mega-corridor based on Advanced business and operating Models) established under the 6 Framework Programme of the European Commission.

By ensuring the efficiency of a model dependent on another, **Company A** offers road-railway, maritime-railway, air-maritime services. Premium and guaranteed intermodal services are offered for "time-sensitive cargoes". For commodities with lower value, value pricing is on offer on the basis of "various equipment types and service options". Flexibility of equipments allows customers to choose the most suitable option for the cargo: these options are on offer including 20', 40', 45' containers and trailers; high-cube containers and 13.60 trailers. Contracts with select Drayage providers ensure on-time picking and delivery.

Company A's technology (software: quadro) automatically tracks customers' shipments in order to provide information about current location and status over e-mail, facsimile, or secure internet access. System alerts user if trucks get out of their planned route or if they are late than the Schedule. The system gives off an alarm and warns the center in cases where vehicles have not arrived at the set location on time, have spent unscheduled time in rest stops or have strayed from pre-determined routes.

Experienced service personnel, manages each consignment, in order to provide consistent and reliable performance the customers need for their transportation program. Two projects ongoing are:

- Project 1: **Routing and Load Optimization System for Transportation Solutions.** Routing optimization engine which minimizes margins of error that may arise due to human factors in traditional routing planning and ensures planning with optimum values, Load optimization engine including 3D loading model and network optimization engine, Development of an optimization system to be resolved with fleet source optimization engine and to be integrated to Quadro online management and tracking system
- Project 2: **Development a Decision-Support System for Strategic Fleet Management.** With reference to the fleet composition problem concerning various transportation models on offer by the firm, the development of a computer-assisted decision-support system to provide solutions under uncertain conditions and in line with various scenarios, taking fleet assignments, property purchase/sale decisions, use of external resources, and re-positioning the resources on the logistics network into account in an integrated perspective.

Company A offers sorting and consolidation centers set up for main warehouse and store deliveries in the retail sector, warehouse and store - based complete and partial distribution services, and intermediate transportation services with dedicated vehicles for transportations of raw materials, packaging materials and finished goods between the factories and warehouses of customers together with intercity pre - collection from suppliers.

3.4. Facilities and Warehouses:

Main questions according "**Facilities and Warehouses**" are: "Green buildings", "Zero emission", "Electric equipment", "Energy saving installations, using sophisticated lighting systems and solar cells", "Handling equipment", "Packaging and returnable transport items (like pallets, containers and roll-cages, refillable bottles)", "Discharges to receiving streams and water bodies", "Underground injection on-site".

Joining the WWF-Turkey Green Office Program in 2010, **Company A** took part in the program and awarded Green Office Diploma. Additionally with its LEED(Leadership in Energy and Environmental Design) Facilities (in service in Konya and ongoing project in Sekerpınar) supports green activities.

Company A creates a path to improve the electricity consumption in line with the results based on measurements taken by different electricity measurement devices for each office and prefers to use energy-saving bulbs in its facilities. By carrying 64 servers into virtual environment, energy consumption which previously used to be 32400 Watt reduced to 5400 Watt and 84% less energy was consumed. Energy consumed to cool down the overheated system room was also reduced by one third.

"Handling equipments" is the one of main issues in green logistics. The systems;

- Vertical Lift Systems: This system using the platforms (trays), each of which that can move/be moved freely, as stacking equipments. This system, where the trays are stored vertically by the built - in automated lift systems, places the products to be picked up during the order picking, in front of the operator so the walking distance of the operator is reduced to a minimum.
- Pick to Light Systems: It is a system that shows on a led screen to the staff the address and the quantity of the products to be picked. This system, which does not require the staff to carry any equipments for picking up and sorting out the products, is used within **Company A** for the operations in textile, retail and health sectors that require detailed order picking.
- Automated Sorter Systems: The most resource intensive stage of order preparation and returns handling operations is the sorting of the products in accordance with pre-determined criteria. **Company A** focuses on automated solutions for these processes, which usually are among the most labor-intensive, hence error-prone ones, and makes use of automated sorting systems designed to serve different storage units.
- Product Pick by Voice: These systems enable the person picking the order to receive commands through a headphone and also to give feedback to the system through a microphone. **Company A** uses this system, which enables the staff to free their hands and eyes during order picking process, particularly in the operations of its customers in the fast moving consumer goods industry.
- RF Handheld Terminal: RF Handheld terminal enables the staff to receive work orders from the system in relation to the processes within the warehouse and to inert the results into the system in relation to the completed work. By using these terminals physical activities in the warehouse and the systemic records of these activities are managed simultaneously.

"Waste management" is the one of main issues in green logistics. For instance;

- Food waste: The waste food collected in cafeterias is taken to animal shelters in the vicinity, with an aim to provide food for our animal friends
- Sorting of Food Waste: Through sorting out recyclable wastes among the waste produced in the cafeteria, recycling efforts are supported.
- Recycling of Scrap Waste: The scrap waste created in the facilities were sorted and delivered to relevant recycling firms.
- Paper Consumption: Each ton of paper recycled saves 17 trees, which in turn provide for the oxygen needs of 144 human beings. Identifying paper consumption on the basis of departments, special solutions were created to reduce paper consumption

About “warehouses”, automated storage and retrieval systems in **Company A** are robotic systems, which stock up a load (palette, tray or carton) to pre - determined destinations and unload from shelves, when required. The advantages that ASRS applications provide for customers: Reduction of spaces, Reduction of labor costs, Reduction in throughput cycle times, Reduction of error risks, Address optimization for frequently moved items. The projects ongoing are;

- Project 1: “*Development of an Automated Organization, Storage and Distribution System*”**.** Design of Mechanical Conveyor, Conveyor PLC Software and Integration of Conveyor Storage Software in order to store more products in less space, prepare more orders in a shorter span of time due to increasing the efficiency and the level of operational competency in order to meet future requirements.
- Project 2: **“***Development of Warehouse Management and Delivery Automation Systems*”**.** Developing a software infrastructure required to utilize information to relevant persons and departments, store and report the same in the project which was initiated to store more products in less space, prepare more orders and produce services in a shorter span of time in order to increase the efficiency of warehouse management and delivery systems, and to improve the level of operational competency in order to meet future requirements
- Project 3.: “*Development of Fully Automated Flexible Logistic Warehouse Product Preparation, Matching, and Packaging Process*”**.** Development of a product preparation system which matches and packages products of various sizes, and directs them with reference to the destination delivery areas, by removing the human factor from the equation, and without changing the products. Design of a sorter algorithm which is capable of product selection and direction, in addition to mechatronic design elements, to operate mechanical systems, electronic components, and automated control units in combination.

3.5.Transportation:

Main questions according “**Facilities and Warehouses**” are: “most visible aspects”, “Equipment choice”, “Transportation speed”, “Fuel choice(Modern gasoline, biofuels, minimizing the use of fossil fuels, Electric vehicles)”, “Transportation CO2 emissions”, “NOx, SO2, and PM (particulate matter or fine dust) emissions”.

Another important objective of the **Company A** in this respect is to provide the drivers with required trainings to ensure that they consume the least possible amount of fuel. In addition to its environmentally conscious approach, the efficient use of resources and cost-awareness perspective, **Company A** provides its drivers Safe and Economic Driving Techniques Trainings with heavy vehicle simulator, in addition to professional development trainings.

Within the framework of the “Fleet renewal Project” to minimize the environmental footprint of the vehicles which ensure seamless flow of trade throughout the Europe, **Company A** has replaced all the trucks in its fleet as of the end of 2011, and made the fleet fully compliant with EURO 5 standards. The calculations to determine savings are based on the emission figures of trucks compliant with Euro 5 standards. Within this framework, the average fuel consumption figure for **Company A** vehicles are 0.32 liters of diesel and 1.1 kg of CO_2 emission per kilometer covered with a full trailer. Calculation method was confirmed under ISO 14064-1.

EURO 5/6 norms aim to achieve gradual reductions in NO (Nitrogen oxide), CO (Carbon monoxide), HC (Hydrocarbons) and particle emissions. With a fleet exceeding by a wide margin the EURO 1 standards currently in force in country, **Company A** adopted European norms, and proved its environmental awareness with a total of 2000 Euro-5/6 compliant vehicles(average age of 3).

3.6. Greening Trends in Company A

Company A plans and implements improvements with respect to the savings on Waste Management, Electricity Consumption and Paper Consumption within the framework of the WWF-Turkey Green Office Program. WWF The Green Office program, a savings and improvement program for offices, comes into prominence as a part of the strategic approach of the WWF to reduce human pressure and ecological footprint on natural resources, The Green Office program provides the participating companies with the opportunity to evaluate their office resources systematically, identify their savings criteria and develop their own environmental management systems in their offices.

However seems so detail, **Company A** plans "accumulator charging stations" for its facilities/building for electrical cars which will take part in our life. Also environment protection equipments(canalization covers, absorbents, etc) which are used after accidents needs to be congruent for every case and must be tested in exercises.

Besides intermodal transportation; "Seaway" and "railway" transportation and its greening measures will highlight in the next future. "Sensory lambs", "returnable packs", "electrical equipments" are trend topics in logistics firms. Changes in processes, customer and supplier relations, and knowledge management issues can lead to innovation. Application of the "innovation" will enable firms to improve "green logistic management" effectively.

4. CONCLUSION

As stressed in quato the **Company A**'s website: "*In the world where natural resources are getting exhausted, living spaces are already limited and the harm given by human being to the nature is incrementally increasing every day, companies need to play their roles well in the way to leave a better world to future generations*". As competitive and efficient logistics sector is vital for all economies and is an imperative component of trade logistics management plays a significant role for the firms.

All logistic Firms are need "green ideas"; to reduce the environmental externalities of logistics operations and therefore develop a sustainable balance between economic, environmental and social strategies. The issues of environmentalism on logistics industry are highly imposed on transportation and distribution. And it needs special effort to categorize and welcome these issues.

As recommendations for further researches; If the context of this study was to be applied to other firms (specially more local ones) as well as the ones in other regions and countries, a ground for comparison about perceptions will be created. This comparison opportunity will enable the small firms (in terms of being environmentally friendly) to take example from the more developed ones. Additionally, a cross-sectoral analysis(between 3PL logistic firms and SC of large scale Production Firms) will point out the opportunities for inter-sectoral cooperation and develop the potential of having integrated logistics applications, as it will serve as a framework on being environmentally friendly.

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FUEL LOGISTICS IN THE ANATOLIAN SIDE OF ISTANBUL

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ABSTRACT — *From the point of view of urban logistics planning, urban logistics infrastructure, terminals, equipment and networks occupy a large amount of land in the city. Transport problem is another important issue. Especially the transport problem of Istanbul is getting worse day by day with the increase in population. In this study, the effects of fuel transportation on the Anatolian side of Istanbul were researched and 2045 projections were made. It was determined that the existing infrastructure, road and restrictions on vehicle would be insufficient to meet the fuel transportation. Therefore, alternative methods were searched. Then alternative methods have been evaluated using Ahp and Pugh matrix methods. Railway transportation has come to the forefront among alternatives. Afterwards, the operational cost and CO2 emission of existing method and rail way transportation were calculated and compared.*

Keyword — Urban logistic, Urban transportation, Fuel transportation, Green Logistics, Ahp, Pugh Matrix

1. INTRODUCTION

It is easy to understand why oil is so important in our lives. In fact, our world would almost grind to a halt without oil. However, our working is about oil used in vehicles. Furthermore, how these materials can be delivered to distributors.

Oil is transported via cars, trucks, rail, vessels and through pipelines. Which method is used to move this oil depends on the amount that is being moved and where it is being moved to. The biggest problems with moving this oil are air pollution and urban logistics issue. Crude oil can be transported by sea oil ships, pipelines, tank vehicles and tank trucks. This distance to deliver the product which one to choose is important.

Crude oil converted into a fuel by 4 refineries in Turkey. After refining, the fuel is transported to Istanbul by tanker trucks. This situation causes problems in urban logistics for Istanbul. Urban traffic is negatively affected. As it also causes air pollution, we propose a new transportation model with AHP and Pugh Matrix in this study.

2. FUEL PRODUCTION AND TRANSPORTATION

Oil is a naturally occurring, yellow-to-black liquid found in geological formations beneath the Earth's surface, which is commonly refined into various types of fuels. Components of oil are separated using a technique called fractional distillation. It is divided into petroleum products such as gasoline and kerosene at the refining plants called crude oil refinery. Crude oil can be transported in various shapes. These are as follows:

1. Marine oil tanker and barges can transport this oil all around the world. These vessels are used because of their transportation amount and cost of per barrel. It costs per barrel to move this oil is very cheap.
2. Pipelines are another method used to transport oil from wells to refineries and storage facilities. Pipelines are viewed as the most cost efficient way to move oil on land. However, pipelines can be used the same way to deliver already refined fuels such as gasoline, diesel and even jet fuel from the refinery to distribution facilities or a consumer. These pipelines are not just a solid line of straight pipe, but have various components on the pipeline.

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3. Tank cars are another way to move crude oil across a landmass. The oil is loaded into the tank cars, and are moved by a diesel train across the rails to the refinery or the trains planned destination. Trains can carry a mass amount of this oil by using of multiple tank cars
4. Tank trucks are used a lot like rail cars are, but they will usually transport refined fuel to a fuel station, like a gas station. Trucks are usually used to carry smaller capacities of oil short distances. Like railcars these trucks can carry a whole bunch of different forms of this petroleum, but they do not carry the petroleum in its crude oil form because it would take a lot of trucks to deliver the volume of crude that the refineries demand. These trucks can deliver this fuel to gas stations, or deliver the fuel straight to the consumer. These trucks are used in situations where it would be illogical to use railcars, pipelines and tanker ships.

2.1 Fuel Production and Consumption in Turkey

Turkey is an important link between Europe and Asia and serves as a bridge. In addition, it plays an important energy corridor task.

Turkey has a serious consideration and chance of job opportunity with the existing Baku-Ceyhan, Kerkuk-Ceyhan pipelines, the straits and in the supply of energy to the World market with TANAP Project.

Crude oil is processed and converted into fuel and commercial products (Pitch etc.) through 4 refineries affiliated to TUPRAS. These production facilities are located in Izmir, Izmit, Aliaga and Batman which is from logistics point of view for easy access to raw materials and easy shipping of finished products and in Kırıkkale due to military risk analysis. These refineries and energy corridor are shown in figure 1 below.

Figure 1. Places of Refineries and Energy Corridor in Turkey [4]

These refineries in Turkey have an annual crude oil processing capacity of 28.1 million tons and 6,963 million m³ storage capacity which is shown in table 1 below.

Some fuel distribution companies meet domestic fuel demand by fuel imports from abroad in addition to TÜPRAŞ.

Table 1. Production and Storage Capacity of TUPRAS AŞ. [5]

İzmit Refinery		İzmir (Aliağa) Refinery	
Processing Capacity	11.0 Mn Tonne/ Year	Processing Capacity	11.0 Mn Tonne/ Year
Nelson Complexity	7.78	Nelson Complexity	7.66

Storage Capacity	2.91 mn m^3	Storage Capacity	2.42 mn m^3
Kırıkkale Refinery		**Batman Refinery**	
Processing Capacity	5.0 Mn Tonne/ Year	Processing Capacity	1.1 Mn Tonne/ Year
Nelson Complexity	6.32	Nelson Complexity	1.83
Storage Capacity	1.38 mn m^3	Storage Capacity	253 thousand m^3

Fuel oil which is Refinery processed or imported are sold as different products in the domestic market. As the table 2 below shows, the products sold are gasoline, motor, heating oil, fuel oil and kerosene as well as special jet fuel for the aviation industry.

Table 2. Turkey Fuel Sales Volume [6]

TYPE	2014 DECEMBER AMOUNT	2014 CUMULATİVE AMOUNT	2015 DECEMBER AMOUNT	2015 CUMULATIVE AMOUNT
Total Gasoline (m^3)	**217.032**	**2.605.53**	**233.751**	**2.806.042**
Total Diesel (m^3)	**1.835.768**	**21.274.396**	**2.105.000**	**24.059.270**
Heating Oil (Tonne)	**17.882**	**127.242**	**19.272**	**122.745**
Total Fuel Oil (Tonne)	**48.313**	**563.183**	**70.449**	**611.433**
Kerosine (m^3)	**2.340**	**21.882**	**1.212**	**22.142**
Autogas LPG (Tonne)	**234.755**	**2.925.041**	**248.207**	**3.076.630**

2.2 Fuel Distribution

These fuels which are produced or imported are subjected to marking and contribution by the companies having distribution license by EMRA.

Distribution of fuels should be moved with ADR certified vehicles and drivers having the SRC-5 document According to Regulation on the Transport of Dangerous Goods' No. 26479 dated March 31, 2007.

ADR transport is generally used to minimize the risks of transporting dangerous goods,

- The suitability of the vehicle's technical specifications
- Labeling and marking
- Possibility of intervention in case of risk
- Documentation
- ADR training for drivers

Can be explained Transportation that fulfills the requirements of.

ADR vehicle and document examples are shown in figure 2 below.

Figure 2. ADR Vehicle and Document Examples

Distribution operations are carried out by 3PL companies, vehicles belong to gas stations and Fuel distributors themselves.

3. ANATOLIAN SIDE OF ISTANBUL SPECIAL AN ALTERNATIVE MODEL FOR FUEL DISTRIBUTION

3.1 Process Elements in Fuel Distribution Process

The table 3 below shows the purpose and risks in terms of Urban Logistics each of the members involved in the fuel distribution. If we examine the detailed table, we see that left-hand process elements and right-hand elements are opposite in some substance and separated in some substance. The main reason for this is that the companies are focused on cost and profit.

Table 3. Process Elements in Fuel Distribution Process

	PURPOSE	RISK	PURPOSE	RISK	
PRODUCERS	➢ Porduct sales ➢ Max. Profitability ➢ Lawful work ➢ Low logistics costs ➢ Delivery on time of the customer ➢ Product and environmental safety	➢ Competitors ➢ Work safety and environment ➢ Legal restrictions	➢ Secure Delivery ➢ Min.equipment, personal ➢ Optimization ➢ Max.profitability ➢ Effective fleet management ➢ Joint resource management	➢ Competitors ➢ Traffic intensity ➢ Customer-dedicated filo request	CARRIERS
FU	PURPOSE	RISK	PURPOSE	RISK	UR

	➢ Take product delivery fast ➢ Min.logistics cost ➢ Max.profitability ➢ Max.sales	➢ Competitors ➢ Work safety and environment ➢ Legal restrictions ➢ Risks related to distribution into the city	➢ Low vehicle traffic ➢ Min.carbon emission ➢ Safe living area ➢ Reducing road maintenance costs with removing tonnage Vehicles out of town	➢ Immigration problem ➢ Cluster of industry in a region ➢ Short term planning	

3.2 Fuel Distribution Process in Istanbul Anatolian Approach

Fuel supply to the Anatolian side of Istanbul is provided by the Fuel Distributors located around Tüpraş İzmit Refinery (between Korfez and Dilovası). As you can see on the map below (figure 3), filling facilities for distribution companies were collected between Ankara-Istanbul Railway and D-100 highway on the same line.

Figure 3. Filling Facilities

Filled tankers at filling facilities make entry using the D-100 highway and the E-80 roads to the Anatolian side. Table 4 shows that sent to the Anatolian side shipped fuel and the number of cars entering the Anatolian side according to years.

Table 4. Annual Variation of Fuel Consumption and Population of Istanbul

Year	Number of Vehicles In Istanbul	Population of Istanbul	Fuel Consumption(m3)	Anatolian Side Fuel Consumption (m3)	Trips (with 45 m3 Truck)	The Number Of Daily Trips
2007	2.570.559	12.573.836	3.799.288	1.329.751	29.550	99
2008	2.685.756	12.697.164	3.969.549	1.389.342	30.874	103
2009	2.721.203	12.915.158	4.021.940	1.407.679	31.282	104
2010	2.794.236	13.255.685	4.129.883	1.445.459	32.121	107
2011	2.927.650	13.624.240	4.327.069	1.514.474	33.655	112
2012	3.065.465	13.854.740	4.530.759	1.585.766	35.239	117
2013	3.230.908	14.160.467	4.775.284	1.671.349	37.141	124
2014	3.383.812	14.377.018	5.001.276	1.750.447	38.899	130
2015	3.624.403	14.657.434	5.356.870	1.818.657	40.415	135

Table 4 was calculated according to below data,

According to TUIK value, end of 2015 total number of vehicle was 19.994.472 and 3.624.403(19.9% of vehicle) of them was located in Istanbul. [8]

When we have checked consumption of fuel(fuel+diesel), total consumption was 26.865.312 m³ end of 2015. [6]

If 19.9% of vehicle was located in Istanbul, the fuel consumption would calculated, 19.9% of 26.865.312 m³ as 5.356.870 m³.

The fuel consumption is calculated as 1,478 m³ *year/vehicle (5.356.870/3.624.403) in Istanbul.

Fuel consumption = Number of vehicles in Istanbul*1.478 m³ *year/vehicle

Anatolian side population is 35% of Istanbul. [18] Thus, it is assumed that fuel consumption and number of vehicle are distributed with same ratio.

When we consider the same work as a 30-year Project, in analysis by TUIK, due to the increase in welfare and population growth of 1.9% per annum it is estimated that population of Istanbul will reach 26 million in 2045.

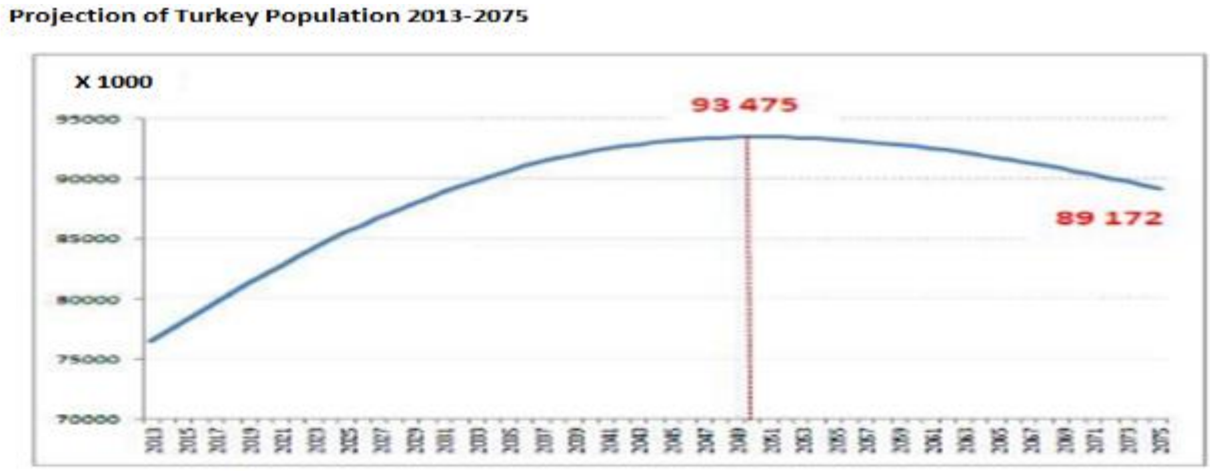

Figure 4. Turkey Population [7]

According to population change fuel demand and daily number of trucks required are given in the table 5 below. Fuel demand in 2015 is 135 truck*trip*day. On the other hand, as of 2045 it is increased by 83% and it has been Daily 247 truck*trip*day.

Projection was calculated according to below data,

- From 2007 to 2015 population increased 1,9% in average each year. So, population is calculated with this ratio from 2016 to 2045.
- According to value of TUIK, 2015 there was 14.657.434 people and 3.624.403 vehicle in Istanbul. It shows us there was 0,25 vehicles/person in Istanbul. [7,8] So, vehicle is calculated with this ratio from 2016 to 2045.
- The fuel consumption is calculated as 1,478 m³ *year/vehicle in Istanbul.

Table 5. 2045 Projection

Year	Number of Vehicles In Istanbul	Population of Istanbul	Fuel Consumption(m3)	Anatolian Side Fuel Consumption (m3)	Trips (with 45 m3 Truck)	The Number Of Daily Trips
2007	2.570.559	12.573.836	3.799.288	1.329.751	29.550	99
2008	2.685.756	12.697.164	3.969.549	1.389.342	30.874	103
2009	2.721.203	12.915.158	4.021.940	1.407.679	31.282	104
2010	2.794.236	13.255.685	4.129.883	1.445.459	32.121	107
2011	2.927.650	13.624.240	4.327.069	1.514.474	33.655	112
2012	3.065.465	13.854.740	4.530.759	1.585.766	35.239	117
2013	3.230.908	14.160.467	4.775.284	1.671.349	37.141	124
2014	3.383.812	14.377.018	5.001.276	1.750.447	38.899	130
2015	3.624.403	14.657.434	5.356.870	1.818.657	40.415	135
2016	3.694.594	14.941.292	5.460.612	1.911.214	42.471	142
2017	3.766.144	15.230.647	5.566.363	1.948.227	43.294	144
2018	3.839.079	15.525.606	5.674.162	1.985.957	44.132	147
2019	3.913.427	15.826.277	5.784.049	2.024.417	44.987	150
2020	3.989.215	16.132.771	5.896.063	2.063.622	45.858	153
2021	4.066.471	16.445.200	6.010.247	2.103.587	46.746	156
2022	4.145.223	16.763.680	6.126.642	2.144.325	47.652	159
2023	4.225.500	17.088.328	6.245.292	2.185.852	48.574	162
2024	4.307.332	17.419.263	6.366.239	2.228.184	49.515	165
2025	4.390.748	17.756.607	6.489.528	2.271.335	50.474	168
2026	4.475.780	18.100.484	6.615.206	2.315.322	51.452	172
2027	4.562.458	18.451.020	6.743.317	2.360.161	52.448	175
2028	4.650.816	18.808.345	6.873.909	2.405.868	53.464	178
2029	4.740.884	19.172.590	7.007.030	2.452.460	54.499	182
2030	4.832.697	19.543.889	7.142.729	2.499.955	55.555	185
2031	4.926.287	19.922.379	7.281.056	2.548.370	56.630	189
2032	5.021.690	20.308.198	7.422.062	2.597.722	57.727	192
2033	5.118.941	20.701.490	7.565.798	2.648.029	58.845	196
2034	5.218.075	21.102.398	7.712.319	2.699.312	59.985	200
2035	5.319.129	21.511.069	7.861.677	2.751.587	61.146	204
2036	5.422.140	21.927.656	8.013.927	2.804.874	62.331	208
2037	5.527.146	22.352.310	8.169.126	2.859.194	63.538	212
2038	5.634.186	22.785.188	8.327.330	2.914.566	64.768	216
2039	5.743.298	23.226.449	8.488.598	2.971.009	66.022	220
2040	5.854.523	23.676.255	8.652.990	3.028.546	67.301	224
2041	5.967.903	24.134.773	8.820.565	3.087.198	68.604	229
2042	6.083.478	24.602.170	8.991.385	3.146.985	69.933	233
2043	6.201.292	25.078.619	9.165.513	3.207.930	71.287	238
2044	6.321.387	25.564.295	9.343.014	3.270.055	72.668	242
2045	6.443.808	26.059.377	9.523.952	3.333.383	74.075	247

** The business volume of gas stations that buy fuel with their own vehicles is included.

** It is assumed that 300 days have been worked excluding Sundays and holidays.

If considering the increasing number of vehicles and the population, existing transportation and infrastructure method will not be able to meet fuel transportation. For this reason, a long-term alternative model for fuel transportation is required.

Alternative fuel transportation methods have been searched. As a result of research Railway&Road, Sea Lane&Road, Pipeline&Road have been identified as an alternative to the existing Road. In order to make the choice between transport methods, a literature search has been conducted. As a result of the literature search, AHP method was used to weight the criteria and the Pugh matrix was used to choose among the alternatives.

The AHP has been used in a wide variety of complex decision making problems, such as the strategic planning of organizational resources [14]. Pugh has proposed a decision making method consisting of evaluation of the systems against the prioritized criteria with a baseline system. The systems are considered better or worse while comparing with the baseline system and given a relative number, finally prioritized summation of the systems column wise gives a score to each system, then the system having the highest score in considered the best system. [15,16].

The study is going to use the AHP matrix for weighting transportation method selection criteria. First, the criteria were set and weighted by the AHP method which is shown in table 6.

Comparing criteria with AHP; the opinions of the personnel in the logistics sector, who are in managerial position, were taken.

In step 1; The hierarchical structure of the problem has been created.

In step 2; Each criterion is compared with other criterion. 1-9 scale was used when making binary comparisons.

In step 3; Normalized ratings of all rows calculated. Each entry in the column is then divided by the column sum to yield its normalized score.

In step 4; The weight of each criterion is calculated by dividing each Normalized Ratings value by the total normalized ratings value. W (Buffer stocking) = 0.43/14=%3

Table 6 AHP Matrix

Criterias 1 Equal importance 3 Moderate importance 6 Strong importance 9 Very Strong importance 2, 4, 5, 8 Values for inverse comparison	Buffer stocking	Handling and loading difficulty	Back haul	Security require-ment	Influence of weather conditions	Initial investment cost	Operating cost	Crisis/Disaster situations in sustainability	Revision possibility	The risk of creating a monopoly	Delivery speed	Legal regulatory& Licensing needs	Load consolidation opportunity	CO2 Emission	Sum of Normalized Ratings	Weight
Buffer stocking	1.0	0.3	0.2	0.3	3.0	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	1.0	0.33	2%
Handling and loading difficulty	3.0	1.0	1.0	0.3	3.0	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	1.0	0.42	3%
Back haul	6.0	1.0	1.0	0.3	3.0	0.2	0.2	0.3	0.3	0.3	1.0	0.3	1.0	0.3	0.54	4%
Security requirement	3.0	3.0	3.0	1.0	6.0	1.0	1.0	1.0	3.0	3.0	0.3	1.0	3.0	3.0	1.50	10%
Influence of weather conditions	0.3	0.3	0.3	0.2	1.0	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.1	0.3	0.20	1%
Initial investment cost	5.0	5.0	5.0	1.0	9.0	1.0	1.0	3.0	3.0	0.3	3.0	3.0	3.0	5.0	1.98	14%
Operating cost	5.0	5.0	5.0	1.0	9.0	1.0	1.0	3.0	3.0	0.3	3.0	3.0	3.0	5.0	1.98	14%
Crisis/Disaster situations in sustainab	3.0	3.0	3.0	1.0	6.0	0.3	0.3	1.0	1.0	3.0	3.0	3.0	3.0	5.0	1.57	11%
Revision possibility	3.0	3.0	3.0	0.3	3.0	0.3	0.3	1.0	1.0	0.3	0.3	1.0	1.0	2.0	0.77	5%
The risk of creating a monopoly	3.0	3.0	3.0	0.3	3.0	3.0	3.0	0.3	3.0	1.0	3.0	1.0	3.0	5.0	1.82	13%
Delivery speed	3.0	3.0	1.0	3.0	3.0	0.3	0.3	0.3	3.0	0.3	1.0	0.3	3.0	1.0	1.05	7%
Legal regulatory&Licensing needs	3.0	3.0	3.0	1.0	3.0	0.3	0.3	0.3	1.0	1.0	3.0	1.0	3.0	5.0	1.15	8%
Load consolidation opportunity	3.0	3.0	1.0	0.3	9.0	0.3	0.3	0.3	1.0	0.3	0.3	0.3	1.0	1.0	0.67	5%
CO2 Emission	1.0	1.0	3.0	0.3	3.0	0.2	0.2	0.2	0.5	0.2	1.0	0.2	1.0	1.0	0.48	3%
Total	42.3	33.7	29.5	10.2	61.0	8.4	8.4	11.5	20.3	11.0	19.0	15.0	24.8	34.7	14.46	100%

Table 7. Pugh Matrix

Criteria	Weight	Road	Railway&Road	Sea Lane&Road	Pipeline&Road
Buffer stocking	2%	0	+	+	++
Handling and loading difficulty	3%	0	-	-	-
Back haul	4%	0	+	+	--
Security requirement	10%	0	+	+	++
Influence of weather conditions	1%	0	++	-	++
Initial investment cost	14%	0	-	-	--
Operating cost	14%	0	-	-	--
Crisis/Disaster situations in sustainability	11%	0	++	+	++
Revision possibility	5%	0	-	-	--
The risk of creating a monopoly	13%	0	0	0	--
Delivery speed	7%	0	-	-	+
Legal regulatory&Licensing needs	8%	0	-	-	-
Load consolidation opportunity	5%	0	++	+	--
CO2 Emission	3%	0	+	+	++

Sum of +			10	6	11
Sum of -			6	7	14
Total			4	-1	-3
Weighted Sum of +			0.535	0.351	0.637
Weighted Sum of -			0.509	0.523	1.182
Total			0.026	-0.172	-0.546

Comparing alternatives with Pugh matrix; the opinions of the personnel in the logistics sector, who are in managerial position, were taken.

After the evaluation made between the alternatives with the Pugh matrix method which is shown in table 7, it was concluded that railway transportation would be a more effective solution. However, it has been found that some legal regulations and restrictions are required.

3.3. Alternative Model

Alternative model components ;Refinery, Fuel Distribution Firms Warehousing and Filling Facility, Railway Hubs, Urban Micro Distribution Fleets, Fuel Stations

The general process flow is as follows;

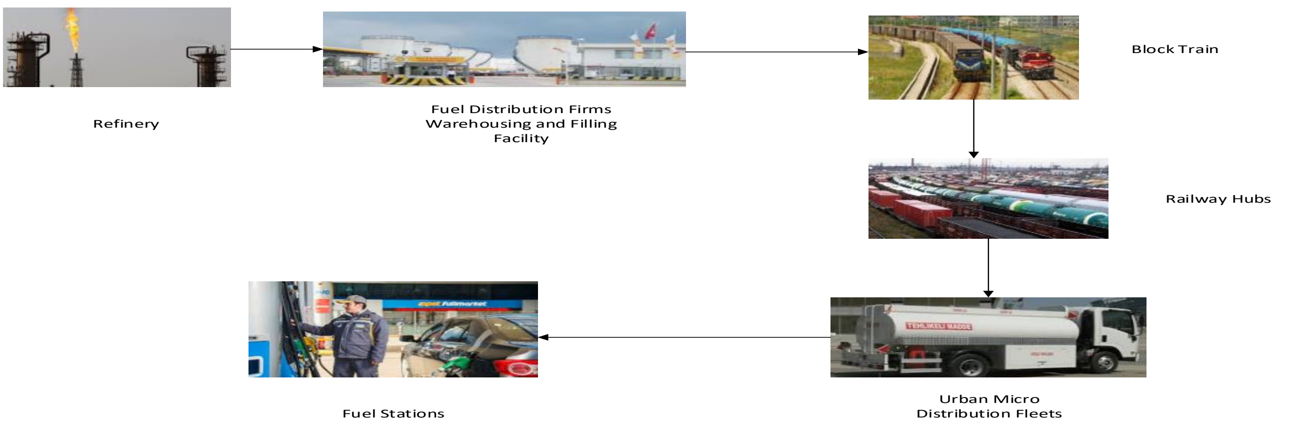

Figure 5. Process Flow

3.3.1 Physical and legal regulations

In this study, a transfer center will be established in Kocaeli-Korfez and Istanbul Pendik Region as a railway hub. These hubs are shown in the figure 6 and 7.

Although these regions are located within the city, central and local governments should centralize the distribution network by expropriating them in order to meet the increasing needs of 20-30-40 year projections.

Figure 6. Korfez Hub

Green: Pipeline from distribution firms

Red : New Korfez Hub and Filling Station

Each distributor firm will establish a pipeline and pump system in connection with its own facilities to the new Korfez Hub.

Figure 7. Pendik Hub

Red: New Pendik Hub and Filling Station

The government should make it obligatory for the distribution firms to use same fleet park that will provide micro distribution between the New Pendik Hub and the fuel stations.

After the liberalization of the TCDD, it is necessary to go to legal arrangements of these areas about renting, registration, operating, using of existing infrastructure and tanker wagons to logistics and distribution firms.

The cost of insfrasture use will be decreased under influence of liberalization and improvements, these improvements will increase the demand of usage of rail way.

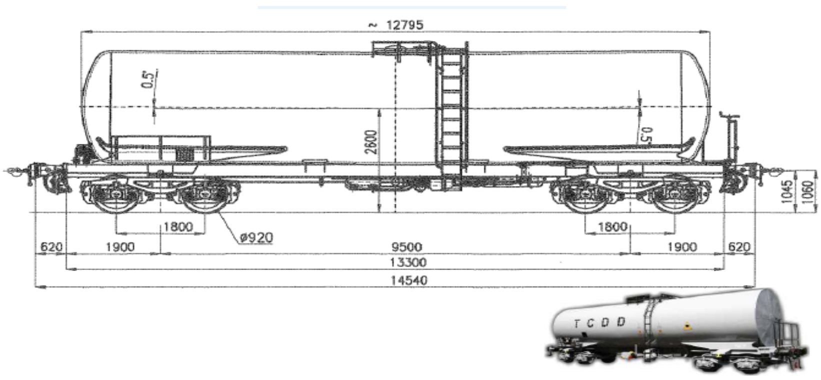

Figure 8. Tank Wagon [10]

3.3.2 Feasibility Study

You may find the calculation details in the table 8 and 9.

Table 8. Current Model (Road)

Curent Model(Road)	
Shipment Qty per day	135
Average Distance(km/ round trip)	110
Tour time(hour)	7
Truck Qty /Day	59
Driver Qty	118
Total Km	14.819
Equipment Cost (per truck)	6.500,00 TL
Driver Cost(per Driver)	3.000,00 TL
Total Equipment Cost	383.097 TL
Total Driver Cost	353.628 TL
Total Fuel Consumption Cost	480.352 TL
Total Monthly Distribution Cost	**1.217.076 TL**

Explanation of calculations;

Shipment Qty per day: From Table 5. 2015 data

Average Distance (km/round trip): From filling facility(Korfez) to Maltepe (central point of Anadolu Side)

Tour Time: Transit time

Truck Qty= (Shipment Qty per day* Tour Time) / Working hour/day (Working hours was assumed 16 hours/day.

Driver Qty/Day= Truck Oty/Day*2 (The drivers have to drive 8 hours/day according to regulations. For daily operation each truck has 2 drivers.)

Total km: Average Distance (km/round trip) * Shipment Qty per day

Total Fuel Consumption Cost = (Total km*ratio of fuel consumption per km (0,36) *fuel cost (per lt)/(1+VAT)) *working day per month

Table 9 Alternative Model

Alternative Model(Railway&Road)	
Transpoaration Cost For Block Train(Per ton)	16 TL
Daily Tonnage	6062
Insurance Cost	21.834 TL
Transportation Cost wh insurance	96.070 TL
Transportaion Cost(per day)	117.904 TL
Transportaion Cost(per month)	2.947.612 TL
Daily Shipment Qty for Micro Dis.	276
Avvarage Distance for Micro Dis.(km/ round trip)	35
Tour time(hour)	3
Lorry Qty /Day	34
Driver Qty	103
Total Km	9644
Equipment Cost (per truck)	5.000 TL
Driver Cost(per Driver)	3.000 TL
Total Equipment Cost (per month)	172.221 TL
Total Driver Cost (per month)	309.998 TL
Total Fuel Consumption Cost (per month)	225.785 TL
Micro Dis. Total Cost (per month)	708.005 TL
Total Montly Distribution Cost (per month)	3.655.617 TL

Explanation of calculations;

Transportation cost for Block Train: It was taken from TCDD Transport Price List [9] as round trip excluding VAT

Daily Tonnage:2015 Anatolian Side Fuel Consumption (m3)/300

Insurance Cost: It was taken from TCDD Transport Price List [10] for per ton.

Transportation Cost wh. Insurence (Per Day) = Transportation cost for Block Train(per ton) * Daily Tonnage

Transportaion Cost(per day) = Transportation Cost wh. Insurance + Insurance Cost

Daily Shipment Qty for Micro Dis.= Daily Tonnage/ 22 m3 (It is assumed that the lorry can carry 22 m3)

Avvarage Distance for Micro Dis.(km/ round trip) =From filling facility(Pendink) to Maltepe (central point of Anadolu Side)

Lorry Qty /Day= (Daily Shipment Qty for Micro Dis.* Tour time(hour)) /24 (Working hours was assumed 24 hours/day)

Driver Qty = Lorry Qty /Day*3 (triple shift for driver)

Total Km = Daily Shipment Qty for Micro Dis.* Avvarage Distance for Micro Dis.(km/ round trip)

Total Equipment Cost = Equipment Cost (per truck)* Lorry Qty /Day

Total Driver Cost = Driver Cost(per Driver)* Driver Qty

Total Fuel Consumption Cost = Total Km*0.26 consumption rate*3.6 Tl/LT*25working days/month

** Figures excluding VAT.

** Calculations were made based on the end of 2015.

**it was assumed that worked over triple shift in table 8 and worked over triple shift in table 9.

** Consumption rate was taken 0.36 for truck and 0.26 for lorry.

** It is assumed that the lorry can carry 22 m3 and truck can carry 45 m3.

**Fuel was taken 3.6 TL/Lt +vat

3.3.3 The New Model Benefits

The most important factor to be considered as a gain in the new process is the decline in the number of vehicles in traffic and carbon emissions. Calculation is shown in table 10.

Table 10. CO2 Emission

	Road	Railway+Road
Shipment Qty	135	276
Avarage Distance(km/ round trip)	110	35
Tour time(hour)	7	3
Truck Qty /Day	59	34
CO2 Emition (kg/km Per Month)	363058	236288
CO2 Emition (ton* Per Month)	363,1	236,3
CO2 Capture&Sequestration Cost	**78.784 TL**	**51.274 TL**

** Exchange rate was taken as 3.5 for euro.

** CO2 Capture&Sequestration Cost/ton was taken 62 euro. [11]

**Co2 value was taken 0.918 kg/km. [12]

Back haul will be possible with a block train application integrated with waste oil collecting associations and organizations such as Petder.

The active use of railways in domestic transportation, especially for meeting urban needs, will increase the importance of railways.

3.3.4 Fields Where Should Be Improved with The New Model

These fields can be listed as follows;

- The government should make serious improvements in the cost of shipment of TCDD and private associations, in order to make the new model feasible. For example, it is impossible to transport these figures when the transportation cost of the Korfez-Pendik-Korfez is 16 TL/ Ton + insurance cost +vat. (Tcdd website)
- In order to reduce the return costs of the block train, inner liner style applications can be use in the container of 40 ', so that different products can be used in domestic transportation.

Figure 8. Inner Liner Set Up

4. CONCLUSIONS and SUGGESTIONS

In these circumstance railway option is expensive because of legal obligations and monopoly of TCDD. If liberalization of rail way system is done, cost will be rational.

The analysis we have done has resulted that CO2 emissions and the reduction in the number of vehicle in traffic can be an advantage.

Long-term strategic advantages can be gained by effective use of railway, government incentive, private sector investments and legal regulation.

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THE RELATIONSHIP BETWEEN GREEN SUPPLY CHAIN MANAGEMENT AND FIRM PERFORMANCE: A STUDY

Burak ÖÇLÜ[1], Murat ERDAL[2]

Abstract - This study analyses the relationship between green supply chain management and business performance. Green supply chain management was handled in context of green purchasing, green design, green production, green marketing, green distribution and reverse logistics. For this purpose, a research has been conducted on 103 companies, which have Izmır Chamber of Commerce membership. This research has quantitative research methods according to environmental applications of companies. Within the main hypothesis, the relationship between green supply chain management and subordinate elements of business performance is also examined.

As a result of this research, significant relations have been found between green supply chain management and firm performance. Also, recommendations concerning green supply chain management have been included in this study.

Keywords - Green supply chain, Firm performance, Sustainability

INTRODUCTION

According to the development in the technology, a natural source, which was spent and will be spent, is measurable. Renewable energy resources' usage is increasing especially after criticizing in fossil resources. Business processes are changing according to conditions. Especially customer demands became center of the production process. Environmentalist approach is also developing with the danger of exhaustion of resources. Green supply chain management activities have environment-oriented transformation in the core. With this perspective supply chain management processes become environmentally sensitive and environmentally friendly. Green purchasing, green design, green production, green marketing, green distribution and reverse logistics are defined as green supply chain management components. Green supply chain management activities are seem especially during physical good shipment and in production process. On the other hand green supply chain has many application areas.

Business' benefit from environmental practices varies market to market. Introducing international markets, developing brand image, aiming for profit are main benefits for international companies mainly earn environmental practices benefits from environmental practices. Examples of success in environmental practices are setting example for local companies. Also they can motivate their selves with the successful examples.

Green supply chain practices are flowed by businesses with variety of reason. Employees, consumers, non-governmental organizations, customer pressures and legal regulations can be defined as main reasons of green supply chain management. Companies, which are applied green supply chain practices, also measure their earnings from these activities. In the literature, financial gain, brand image, new business opportunities and reduced job accidents are counted as benefits.

Environmental practices are seen as increasing trend in the Turkey. But it is inadequate compared to other countries. Legal regulations on environment, environment choices in purchasing preferences and environmental awareness' importance's are increasing over the world. With this perspective, trends in green supply chain management are becoming more important even before. When we compare firms which is applied green supply chain practices and which is not, green supply chain practices can get competitive advantage

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LITERATURE

Quantitative and qualitative studies exist in the literature in order to evaluate the relationship between green supply chain management and business performance. Subrata Mitra and Partha Priya Datta have tried to measure the impact of the scale of green supply chain management on business performance. In doing so, India preferred the manufacturing sector as its application area. A survey was conducted to measure the effectiveness [1]. The main findings of the survey are that the cooperation with suppliers on environmental sustainability has a positive effect on sustainable product, design, logistic activities, competitiveness and economic performance.

Chung-Shan Yang, et al., Conducted an empirical study on the subject in Taiwan. In this study, it is observed that green and in-house green applications have a positive effect on performance and helped to gain competitive advantage [2]. Qinghua Zhu, Joseph Sarkis and Kee-hung Laic have tried to set a model for green supply chain management practices [3]. While environmental management, green procurement, business cooperation with customers, ecological design, return of investment, green supply chain management scales, environmental, economic and operational performance constitute scales of business performance in the direction of their practices in Chinese manufacturing companies. Kenneth W. Green, et al. [4], examining scales and businesses in the US by looking at similar studies in the literature to investigate the effects of green supply chain management practices on business performance.

Daniel C. Esty and Andrew S. Winston have combined qualitative and quantitative research models with green supply chain management and performance in their research [5]. In addition to these, enterprises have carried out their environmental applications by measuring the indicators they have determined and conducting in-depth interviews.

Banu Atrek and Aşkın Özdağoğlu have tried to measure the green supply chain practices of an aluminum mining industry operator. In doing so, they preferred to use an in-depth interview method [6]. The company status has been determined through the variables that make up the green supply chain management. Green supply chain management is not only seen as a new development area, but also the number of outsourced foreign resources is remarkable.

GREEN SUPPLY CHAIN MANAGEMENT, RELATED CONCEPTS AND ACTIVITIES

Green supply chain management can be defined as a whole of green procurement, green production / materials management, green distribution / marketing and reverse logistics processes [7]. Green supply chain management in essence aims to reduce or harmonize non-recyclable wastes that are either unusable or unavailable in the environment, which may or may not occur at any point in the supply chain operations.

One of the main objectives of green supply chain management is to create value in the supply chain. It is envisaged that all relevant stakeholders will be involved in the green supply chain management process. In this context, Patrick Penfield describes the green supply chain management as: "Outputs generated from eco-friendly materials used as inputs in the supply chains are re-evaluated at the end of the process, creating a sustainable supply chain" [8]. Green supply chains are based on applications at every stage where a venture is found. It is important that the supply chain process is sustainable as far as possible with minimal damage to the environment or, if possible, without damage to the environment.

Green supply chain management practices, green procurement practices, ecological design practices, green production practices, green marketing practices, green distribution practices and reverse logistics applications are examined in six sub-chapters.

Green Purchase Applications

Green procurement is included in the literature with terms such as "environmental preferential purchasing", "positive purchasing", "ecological purchasing", "environmental responsible purchasing" [9]. Green purchasing, in its simplest form, means that all of the purchasing activities of businesses are carried out on the periphery

[10]. It is encouraged that an employer adopts the green approach in procurement activities, and the suppliers that work with it go to similar applications. Green procurement activities apply to the entire operator. Raw materials, equipment, etc. necessary for the production of this concept. Including purchasing, as well as in-house purchasing activities.

Ecological Design Practices

Ecological Design In the literal literature, there is also conflicting names such as "green design", "design for environment", "sustainable design", "life cycle design" and so on [11]. Ecological design is called for all environmental influences of a product to be handled and redesigned from the beginning of the production process [12]. This design process should be conducted in coordination with all units.

Two basic activities are taken into account during the eco-design evaluation phase [11]. These are examined in two parts as "Environmental Assessment" and "Environmental Development". Environmental Assessment; The scope of activities for the investigation of the environmental impact of a product. Environmental Development deals with the exploration and implementation of environmentally friendly solutions that can be implemented.

Green Production Applications

The concept of green production in supply chain management is examined from different angles. Green production according to Deif; Design and engineering activities as a sustainable approach based on minimizing the impact on the environment within the scope of product development and production [13]. Activities in green production; Reduction of harmful emissions, elimination of materials that render resources unusable, and recycling activities. In another approach, green production is defined as the ability to use the resulting wastes as re-input [14]. The United Nations Environment Program (UNEP) defines green production as: "Green Production; [15] which results in factors such as overall efficiency, reduced environmental risks, resulting in environmental pollution prevention strategies integrated into processes, products and services. Green production aims that combine life quality with usage of environmental resources and economical growth [16].

Green Marketing Applications

Green marketing, "Sustainable Marketing", "Ecological Marketing" and "Environmental Marketing" concepts are used in the literature to represent environmentalism in marketing [17]. Green marketing can be defined in different ways. The most famous of these is the definition of the American Marketing Association, which first introduced the concept of green marketing in 1975 [14]. In the relevant definition, it is expressed together with the production, packaging, distribution and recovery activities carried out by the enterprises in an environmentally friendly way with ecological concerns. [18]. Grundey and Zaharia argue that green marketing should aim at minimizing the harm to the environment caused by the marketing activities carried out in response to the needs of the customers [19]. Green marketing refers to the practice that is not limited to in-house applications but to include all stakeholders of the business [20].

Green Distribution Applications

The concept of green distribution covers the point transport where the end product will meet the consumer at the end of the production process. The point where the product will meet with the consumer may vary. Today, most of the short and medium distance distribution activities are provided by road. Along with the developing technology, it is envisaged to leave oil to other alternative sources of energy in vehicle fuels. Alternative energy sources are not only needed to reduce environmental risks but also to sustainable environment and economy [21].

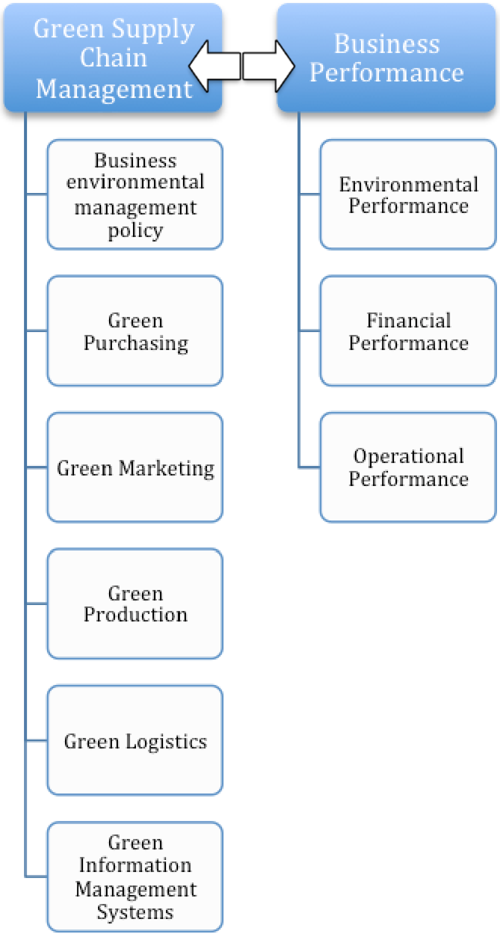
Reverse Logistics Applications

Reverse logistics concept based structured as consumer centered perspective in the literature. This process involves efficient control of the return process to the plant. In this view, within this context, it is aimed to provide savings in the supply of raw materials and to support the in-house inventory. Recycling and disposal processes are the basis of logistics activities [22]. According to the definition of the Logistics Management Council; “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 origin to the point of consumption for the purpose of conforming to customer requirements.” A successful reverse logistics approach provides benefits both within the enterprise and around the enterprise. On the contrary, it is the basis product returns of logistics activities. These product returns occur in five basic ways. These are Product returns, dispenser returns, customer returns, functional returns, product recall of the product [23].

METHODOLOGY

The main cluster of the research is the enterprises with green supply chain management. The size of the main cluster, especially the time and cost, due to the constraints owned by the research, One of the non-random sampling “Sampling according to the quota” method is applied in first stage. In the sampling according to the quota, a unit forming the research universe is chosen by specific features [24]. Quotas were used in the research according to the size of the enterprise. The number of employees is considered as the determining factor. The completion of the quotas is based on volunteerism. It is defined as convenience sampling Time and budget constraints are the decisive factor in choosing this method. In the convenience sampling foresees only accessible people in the research [25]. At least 30 enterprises have been selected for each quota type determined in the completion of the quotas. The numbers of the samples for the respective quota are equal or close to each other. Within the constraints determined in the sampling process, İzmir Chamber of Commerce’s list of member enterprises was used. The descriptive research model is to examine the relationship between specific variables. In addition, the research model has the purpose of realizing definitions for the population [26]. Descriptive research can only be done after sufficient knowledge has been achieved and the hypothesis has been established [25].

Figure 1: Research Model



Survey method is widely used in descriptive research model [26]. The study includes examination between green supply chain management and business performance according to a descriptive research model.

The hypotheses of the research are as follows:

H0: There is no relationship between green supply chain management and business performance.

H1: There is a relationship between green supply chain management and business performance.

Within the main hypothesis, the relationship between green supply chain management and subordinate elements of business performance is also examined. Study, data and information were collected by two different methods. First, in-depth interviews were conducted with 8 people. Through in-depth interviews, managerial levels of knowledge about the subject, perspectives on the subject, and ideas about current and future applications were tried to be revealed. Interviews were held between 22-30 September 2014 at the participant's offices or by phone. Managers from the food, construction, beverage, paper and health sectors participated in the interviews. In addition, an environmental engineer was interviewed to obtain information on current legal regulations and practices. The survey, which was prepared according to interview, applied to 103 participants. It was considered that the participants selected for the survey dominated the topic. The distribution of participants according to company size is shown below.

Table 1: Participants According To Company Size

	Frequency	Percent %
10-49 workers (Small sized company)	36	35
50-49 workers (Medium sized company)	34	33
250 workers and over (Big size company)	33	32
Total	**103**	**100**

Evaluating the information obtained from these interviews and similar studies in the literature formed a questionnaire. Scales were examined according to the research model. The cronbach alpha value of all scales was 0.881 and above.

Table 2: Research Scales, Variable Numbers And Cronbach Alphas

Scale	Variable Numbers	Cronbach Alpha
Business Environment Management Policy	7	,903
Green Purchasing	6	,915
Green Marketing	7	,904
Green Production	5	,859
Green Logistics	4	,890
Green Information Management Systems	4	,894
Environmental Performance	6	,937
Financial Performance	5	,881
Operational Performance	6	,900

The data obtained in the research process were evaluated with the SPSS 21.0 package program. Reliability method, exploratory factor and correlation analysis were used in the analysis of data and information. Reliability analysis of all scale values resulted in 0.88 cronbach alpha coefficient and above.

According to the result of correlation analysis between green supply chain and business performance, at the significance level of 0.000, H0 was rejected and H1 hypothesis was accepted.

RESULT

As a result of the analysis of the correlations made, Environmental management policy, green procurement, green marketing, green production, green logistics and green information systems. There is a positive relationship between environmental, financial, and operational performance. It is expected that the performance of the enterprise will increase as the green supply chain applications increase.

Environmental performance improvements; The amount of waste water, the amount of solid waste, the number of environmental accidents, the decrease in the use of hazardous materials, and the improvement of the environmental condition of the operator in the harmful emissions to the air. Financial performance improvements; The cost of raw materials, energy consumption costs, waste treatment costs, waste disposal costs and penalty costs. Operational performance improvements, on the other hand, Decline in product schedules, stock levels, scrap rates and increase in product quality, product variety and capacity utilization. By going out of the way; It can be argued that businesses that implement green supply chain management can gain competitive advantage by improving overall performance of their operations, thus enterprises that implement green supply chain management are more advantageous than those that do not.

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A QFD APPROACH FOR SUSTAINABLE WAREHOUSE DESIGN

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Abstract − *Sustainable warehouse construction is back on the table after early 2000's. Certain certification programs help designers to achieve sustainable warehouse designs in their environmental efforts. Certifications like LEED guide designers to reduce energy costs, carbon footprint and to have comfortable work space. This research is conducted to explore how such considerations can be integrated into sustainable warehouse design processes. For this purpose, Quality Function Deployment (QFD) approach can be used to translate customer needs into design parameters. A general literature research has been done to identify requirements for a sustainable warehouse. This paper analyzes technical requirements for a sustainable warehouse design, integrates sustainability benefits in existing literature and proposes a QFD-based sustainable warehouse framework for achieving an effective sustainable warehouse structure. The presented approach is then applied in a real case study for a sustainable warehouse design. According to literature reviews, the most important requirement for sustainable warehouse is the location. The case study shows that the first three important technical requirements are; redeveloping vacant building, developing land already contaminated/developed, combination of daylight tubes and photovoltaic panels and prismatic lenses for skylights combines with photocell sensors, all of which can be related to the location.*

Keywords − *Sustainability, Sustainable Warehouse, QFD, Warehouse Design*

INTRODUCTION

The world faced numerous technological achievements, enormous natural resource usage and population growth since the industrial revolution. Nowadays, we start to see the after-effects of this gigantic growth of human species. As a consequence of this effect, awareness for our planet earth has started. Sustainability has entered our lives. Being more sustainable is like the important point in every area. As in other areas, the terms "green", "eco" or "low carbon emission" are not missed in supply chain management. All along, the environmentally sustainable management of logistic activities has become a crucial element of business strategy and competitive advantage [1].

There exists a lot of studies about the impacts of supply chains on environment. Although there are high number of studies, most of them underlined only the transport elements' impacts. Even it is well known that warehouse management is one of the key stones of the supply chain management system, the studies are very few in this area. When the whole system is wanted to be green, so the warehousing must be green at the first step. Reducing the impacts of warehousing will have an extreme effect on supply chain. At this point sustainable warehouse design take its important place in sustainable supply chain design.

Heating, cooling, air conditioning and lighting are the most important causes of warehouse emissions [2]. These causes are related to the location and the size of the warehouse directly. These requirements like location and size are the main steps to start design phase of a warehouse.

The intention of this study is to create new approach with Quality Function Deployment (QFD) technic to a sustainable warehouse design. To accomplish this intention, first important requirements for a sustainable building are defined with a deep literature research on sustainable warehouse. According to that requirements and with a deep literature search technical requirements for a sustainable warehouse are detected. Normally, the QFD approach is a way to gain insight about customer expectations to uncover the positive quality requirements for the product, but in this case it will be used to design a warehouse. For this case sustainability requirements will be like the design parameters for a product. On the other hand, technical requirements, same as the product,

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will be technical parameters to accomplish to have a sustainable warehouse. The aim of this paper is to create a QFD based model to initialize technical requirements while designing a sustainable warehouse building.

This paper is organized as follows: Next section is a literature survey about sustainable building notion and especially sustainable warehouse. Following section will be a brief explanation about the technic used; latter will be a real case study application of a proposed technic for a sustainable warehouse design.

LITERATURE SURVEY

In this paper literature survey has two different parts. First one will be about the sustainable building notion, due to the fact that; many applications for a sustainable warehouse is sustainable building based. Then the second one will be about the studies recently done about the sustainable warehouse design.

Sustainable Building

Sustainable Building (SB) notion is very important to reveal the idea of sustainable warehouse design. In the literature, the concept of SB is a part of studies that deal with sustainable materials for the design, as in [3] in 2005. Another field is eco-cities, such as [4] in 2005. Through the following years, studies about material selection have been an important part of SB literature [5] [6] [7] [8]. Subsequently, mobile rating systems have started in related research, where rating systems are introduced to standardize SB design. These rating systems also play a crucial role in sustainable warehouse design. Well known models in this genre can be described as 'private governance' initiatives. Some of the widely recognized examples of these SB design systems are the Building Research Establishment Environmental Assessment Model (BREEAM), the Leadership in Energy and Environmental Design (LEED), ASHRAE Green Guide, GreenCalc, Green Star and GB Tool [9]. SB which is the basis of sustainable warehouse, is a widely open area, with different tools available to researchers and practitioners alike.

Sustainable Warehouse

Sustainable supply chain management is the "Management of raw materials and services from suppliers to manufacturer/service provider to customer back with improvement of the social and environmental impacts explicitly considered." [10] Since the warehouse is one of the fundamental part of a supply chain it has an important role in it. A little part of the warehousing and transportation companies have necessary regard for environmental effects of their actions. Generally, they consider factors such as cost effectiveness and customer satisfaction as the main performance indicators [10]. Due to that situation, studies about warehousing is about these subjects like [11] in 2014 and [12] in 2008. Also, a lot of studies are about general idea of supply chain. Within the supply chain literature; studies have been done about economic advantages about green supply chain [13], inventory centralization [14], environmental criteria for supplier selection [15], impacts of logistics on environment [16]. Despite the existence of high number of studies about the supply chain, still it exists works to be done about on sustainable warehousing subject. Here Table 1 shows the resume of the studies done about sustainable warehousing.

Table 1. Works about sustainable warehouse

Year	Writer	Aim of the study

-	T. W. Amjed, N. J. Harrison [17]	Develop a sustainable warehouse model
-	K.S Tan et al. [10]	Explore the application of sustainability principles in the context of warehouse storage and distribution
2010	Jinxiang Gu et al. [18]	Comprehensive review of the state-of-art of warehouse research
2012	M.J. Pesch et al. [19]	Case about company to show how sustainable business practices and increased profitability can go hand in hand.
2014	W. Żuchowski [20]	Detailed investigation and a review about sustainable warehousing
2015	J. Fichtinger et al [21]	Investigate environmental impact of warehousing
2015	E. Tappia et al. [22]	Propose a model to evaluate the energy consumption and environmental impact of automated warehousing solutions
2015	A.Meneghetti and L. Monti [23]	Propose an optimization model for the sustainable design of refrigerated automated storage and retrieval systems

METHODOLOGY

In this study QFD model is proposed to prioritize technical requirements for a sustainable warehouse. For this propose first, the most important sustainability requirements are detected for a design requirement.

QFD was first introduced by Shigeru Mizuno and Yoji Akao at the end of 60’s. Then Kiyotoka Oshiumi made the first detailed application for Bridgestone in 1966. Later in 1972, Mitsubishi Company had started to use this technique in their businesses. In 1984 this technique became an accepted and useful approach all around the world. In Turkey, Arçelik Company was first to use QFD in 1994 to design a dish washing machine.

House of quality (HOQ) is the main part of the QFD where consumer requirements and technical requirements evaluate together in a common matrix.

In the field for consumer requirements (CR), QFD is a famous approach [24]. Various studies discussed QFD and its applications in different areas. The main idea of QFD approach is how to balance CR. Prearranging CR is the main and first step for QFD and Analytical Hierarchy Process (AHP) is the most commune way to it. Various approaches are proposed for this step in existing literature as in [25], [26], [27].

CASE STUDY: SUSTAINABLE WAREHOUSE DESIGN

The design and construction phases constitute the most important stages in a sustainable building’s life cycle. Problems that occur during the construction phase can lead to significant corrective measures, in particular when environmental damages are concerned [28]. Examination of variables at an earlier stage permits earlier recognition of potential complications in projects. QFD is based on a matrix known as the house of quality (HOQ) that determines the CR of the project and then defines the priorities of these design requirements [29] Today, like other sectors supply chain sector is also on a sustainability road to be able to survive in the competitive area. As mentioned before, warehousing is the main part in the supply chain so, it is important to evolve it in a sustainable way.

Creating a House of Quality Model for Sustainable Warehouse Design

HOQ is founded on the idea of quality charts with two main elements: a set of Demand Qualities (or customer requirements) and a set of Quality Elements (or technical requirements**)** [28]. In the case of sustainable warehouse design, sustainability criteria become demand qualities. A matrix is developed for complying with demand qualities that allows users to incorporate technical requirements in the evaluation. In this approach, columns are ranked according to the sums at the bottom. The highest scoring item is then prioritized for further improvement.

In our study, all the demand qualities or sustainability requirements are evaluated with an extensive literature research about sustainable warehousing and its daily trends in sector. Then technical requirements detected according to demand qualities. Table 2 shows the detailed list of sustainability requirements and their technical requirements.

As the first step in the QFD, importance of demand qualities must be detected. To decide on their importance levels, some research is conducted about SB requirements and their importance in the sustainability rating systems [30, 31].

LEED, an SB system, is one of the very well-known, widely used certificates for green building standards. A rating system is developed for this certificate and different ratings are assigned for different levels of certificates, which are; “Certified”, “Silver”, “Gold” and “Platinum”. The highest level is the Platinum certification, the lowest being simply called ‘Certified’. Points to be achieved under these different levels differ, where each and every qualification for the building has its own score, determined in the LEED score card [32].

For our case study, these scores also present a good way to determine qualification’s importance. To determine their importance in QFD, qualification’s scores for LEED is evaluated, then demand qualities are scored from 1 to 9 according to their ratings, where 1 is the lowest and 9 is the highest importance.

Table 2. List of sustainability requirements and their technical requirements

LOCATION [33, 34, 35]	Optimizing vehicle capacity
	More efficient distribution network
	Redeveloping vacant building
	Developing a land already contaminated/developed
	Site Planning
LIGHTING [33, 35]	Fixed Light Windows for Skylight
	Motion Sensors
	Combination of daylight tubes and photovoltaic panels
	Energy efficient fluorescent fixtures with daylight sensor
	Prismatic lenses for skylights combines with photocell sensors
	Clear story glass
WATER EFFICIENCY [33]	Low flush toilettes
	Low flush fixtures on all faucets
	Rain water management
RECYCLING [36]	Redeveloping vacant building
	Developing a land already contaminated/developed
	Site planning
	Use steel with high-recycled content
	Precast concrete
	Locally sourced renewable materials
GOING NET-ZERO [37]	Optimizing vehicle capacity
	More efficient distribution network
	Redeveloping vacant building
	Site planning
	Combination of daylight tubes and photovoltaic panels
	Energy efficient fluorescent fixtures with daylight sensor
	Renewable energy
	Prismatic lenses for skylights combines with photocell sensors
INDOOR AIR QUALITY [38]	HVLS Fans
	Passive night time air circulation with natural ventilation
WORKPLACE/ THERMAL CONFORT [39]	Fixed light windows for skylight
	Clear story glass

	Passive night time air circulation with natural ventilation
	Radiant flooring
	Localized active cooling or heating systems

How's / Whats's	Importance (1-9)	Optimizing vehicle capacity	More efficient distribution network	Redeveloping vacant building	Fixed Light Windows for Skylight	Developing a land already contaminated/developed	Site Planning	Motion Sensors	Combination of daylight tubes and photovoltaic panels	Energy efficient fluorescent fixtures with daylight sensor	Clear story glass	Low flush toilettes	Low flush fixtures on all faucets	Rain water management	Use steel with high-recycled content	Precast concrete	Locally sources renewable materials	Renewable energy	HVLS fans	Passive night time air circulation with natural ventilation	Radiant flooring	Localized active cooling or heating systems	Prismatic lenses for skylights combines with photocell sensors
LOCATION	9	○	△	□		□	○																
LIGHTING	8				□			△	□	□	△												□
WATER EFFICIENCY	7											□	□	△									
RECYCLING	8			□		□	○								□	□	△						
GOING NET-ZERO	9	○	○	○			○		△	○								□					△
INDOOR AIR QUALITY	5																		□	□			
WORKPLACE/ THERMAL COMFORT	4				△						○									△	□	□	

																							TOTAL
Technical İmportance	18	36	162	84	153	26	24	99	81	28	63	63	21	72	72	24	81	45	57	36	36	99	1380
Normalized values (%)	1,304	2,609	11,739	6,087	11,087	1,884	1,739	7,174	5,870	2,029	4,565	4,565	1,522	5,217	5,217	1,739	5,870	3,261	4,130	2,609	2,609	7,174	100,000
RANKING	14	10	1	4	2	12	13	3	5	11	7	7	14	6	6	13	5	9	8	10	10	3	

□	Strong relation (9)
△	Medium relation (3)
○	Low relation (1)

Figure 1. Quality Function Deployment for sustainable warehouse design

Based on some research and an evaluation of LEED scores, the criteria of "Location", "Going Net-Zero" are chosen as the most important demand qualities due to their high scores on related areas in the LEED system v4 design for warehouses. Other importance points are listed in the QFD in Figure 1.

RESULTS AND DISCUSSIONS

According to the findings from QFD, "Redeveloping a vacant building", "Developing a land already contaminated/developed" are the two most important technical requirements for a sustainable warehouse design. After them, "Combination of daylight tubes and photovoltaic panels" and "Prismatic lenses for skylights combines with photocell sensors" shares the third place in ranking for technical requirements. In accordance with results of QFD, these four technical requirements must be well met in order to achieve a sufficiently sustainable warehouse design.

The results from QFD matrix is also consistent with the research which was done to gather all the information for a sustainable warehouse design. During the research, it was firstly noticed that the most important requirement which affects the sustainability of a warehouse is its location [33, 34, 35]. In the QFD application also, the first two important requirements are strongly related to location factor.

Although the ranking is obtained from HOQ, for further results, the interrelations of technical requirements must be evaluated to decide which one to prioritize or eliminate in the designing phase. A roof matrix for HOQ is a best way to see all these relations between the technical requirements. This roof matrix is shown in the Figure 2.

Following the QFD results, a roof matrix of a HOQ is evaluated and the correlations between technical requirements are detected with another literature research.

According to these correlations, the most important technical requirements "Redeveloping vacant building" (11,74%) has a strong relation with "Site planning" (1,88%), that means they should be evaluated together carefully while designing phase for a sustainable warehouse even though the site planning's percentage is very low from the others. The second important technical requirement which is "Developing a land already contaminated/developed" (11,09%) has also strong relation with "Site planning". These requirements should also be evaluated together for the design phase.

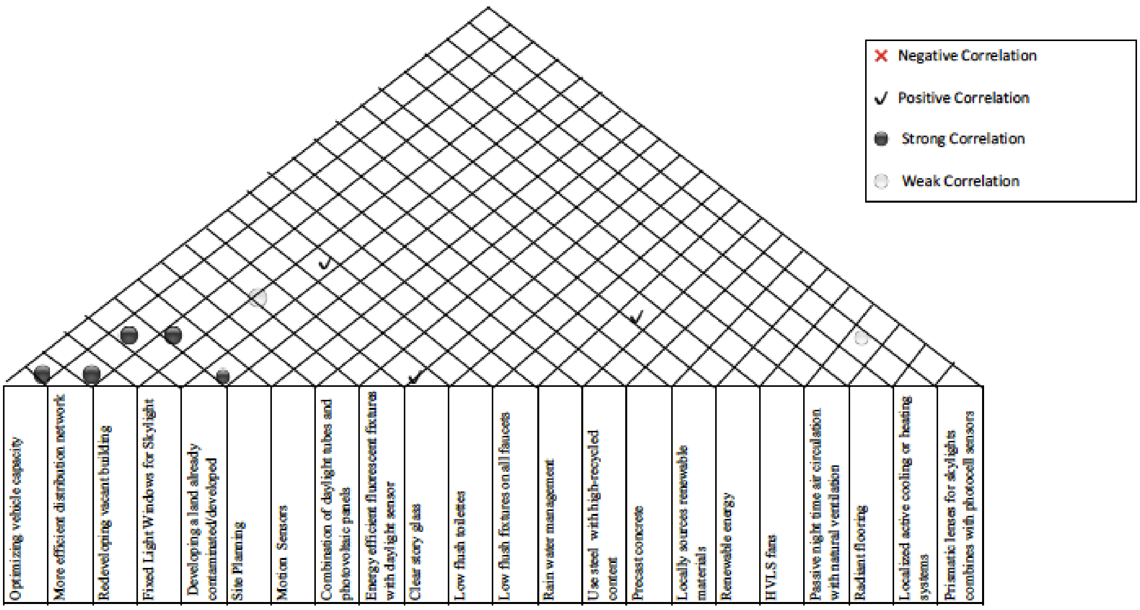

Figure 2. Roof matrix for the house of quality

CONCLUSION

Today it is well known that future of the business is passing through sustainability; and sustainability will be very critical competitive advantage for business. It is not always easy to be compatible with sustainability requirements for business. This QFD approach is proposed to address these difficulties for supply chain management. Warehousing is the key point in a supply chain; having a sustainable warehouse will be a good advantage in the market for the firms.

In this case study, all the sustainability requirements are gathered from a waste research on sustainable warehousing trends and literature research. Then, technical requirements are detected according to sustainability requirements for warehouses. Later their importance is evaluated by their scores according to their importance with respect to LEED v4 warehouse design and construction. Consequently, their relations with technical requirements are determined with a detailed literature research.

After applying QFD and HOQ for the data, results show that the most important technical requirement is “Redeveloping vacant building” according to sustainability requirements.

In this study, the requirements are determined with a literature research and with the help of the LEED rating system. The QFD approach is used for ranking the technical requirements.

Considering the complexity of sustainability related issues, many companies make use of a group of decision makers (DMs-experts) instead of a single DM to accomplish the given tasks successfully. The group decision making (GDM) consists of multiple individuals interacting to reach a decision. Each DM may have unique motivations or goals and may approach the decision process from a different angle, but have a common interest in reaching eventual agreement on selecting the “best” option(s). One of the perspectives for future work can be to consider the GDM approach for evaluation process. In general, sustainability problems adhere to uncertain and imprecise evaluation data. In order to model this kind of uncertainty in human preferences, fuzzy logic [40] is applied very successfully. Thus, concerning as a second perspective, evaluation procedures will be performed under fuzzy environment.

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ANALYSIS OF FACTORS THAT AFFECT SUSTAINABLE PRODUCTION BY USING FUZZY QFD METHOD

Arif Yiğit Akkoyun[1], Doğan Özgen [2]

Abstract – *In the 19th century industrial revolution taking place in Europe has led to many dramatic changes in our world and in our lives. In the 20th century, the industrialization had spread almost all of Europe, and today it has spread all over the world. However, some environmental problems have occurred as side effects in this process. Today, the concept of sustainability begins to occur against those side effects and the companies are trying to meet expectations in this respect. In this study, preventions and solutions have been identified against several challenges in order to achieve cleaner production and environmental problems caused by industrial enterprises. For this purpose, Quality Function Deployment (QFD) method is used. Consumer expectations that inputs of house of quality have been considered as obstacles to sustainable production strategies on businesses and various technical requirements have been proposed to eliminate these barriers. The uncertainties in the data obtained by the survey that used in practice are eliminated by using fuzzy logic. Proposed fuzzy QFD method was used in practice.*

Keywords – *Barriers to sustainable production, fuzzy logic, sustainability, QFD*

1- INTRODUCTION

From the 19th century, when the industrial revolution took place, mankind and the world have experienced many striking changes. The urban population has increased, rising of production, developing technologies and science have gradually increased the welfare level of humanity. Increasing industrial production along with the growing population has also brought some problems with it in centuries. Probably the most important problem is environmental pollution and related problems.

Towards the end of the 20th century, the concept of sustainability has begun to be developed against the environmental problems that have arisen and the industrial enterprises have begun to renew their production processes in order to meet these expectations.

In this study, the challenges and the solution proposals presented for the enterprises to achieve clean and sustainable production are presented. For this purpose, Quality Function Deployment (QFD) method is used.

Consumer expectations that constitute the inputs of the house of quality are considered as the obstacles against sustainable production strategies and technical requirements have been determined against these obstacles. Relations between the obstacles and the solution proposals have been put forward to enable appropriate strategies to be determined.

2- SUSTAINABLE PRODUCTION

Sustainability in a report called "Our Common Future", also known as the Brundtland report, prepared by the United Nations Commission on Environment and Development in 1987, which was included in most of the studies, was described as "providing the needs of the present without compromising the ability of future generations to meet their own needs" [1]. This definition has been included in the literature as the most known and most explicit expression.

In the Brundtland Report's proposal for the concept of sustainable development, it has been proposed to balance the two needs, "today's needs and expectations" and "the needs and expectations of future generations" on two levels of balance. The basic principle is that it does not give up the possibilities of realization of the other in order to meet one of the requirements [2].

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According to Lowell Sustainable Production Center sustainable production is; non-polluting, protecting energy and natural resources, economically feasible, healthy and safe for employees, consumers and communities, rewarding all employees socially and creatively, processes and systems used to produce products and services [3].

Sustainability aims to reduce raw materials and energy consumption as well as to prevent the generation of waste. In order to fulfill these requirements; cost and time efficiency, product and process quality, efficiency, raw material and energy use should be considered.

Sustainable production; as can be seen in Figure 1, from product design to material recovery, all stages in the product chain mean the process in which the specified conditions are considered.

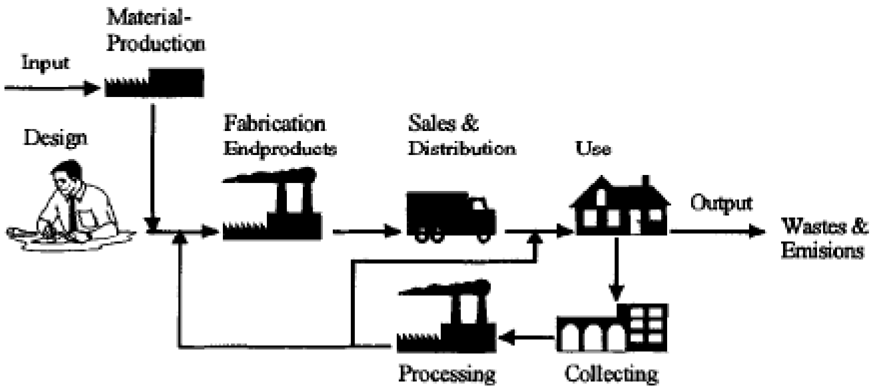

Figure 1. The Various Stages in the Supply Chain [4]

3- QUALITY FUNCTION DEPLOYMENT

Quality Function Deployment (QFD); is a systematic approach that supports the presentation of demand and expectation by adding to the design and production processes of products and services in order to be able to respond quickly and accurately to the competitive environment of the customers' changing demands and expectations.

According to Akao [5] QFD is a method aimed at meeting consumers' wishes and being an important quality assurance of these demands, aiming at improving the design quality for the final product, which needs to be used at every point of production.

Prof. Mizuno and Prof. Akao's objective was to develop a quality assurance method that could include customer satisfaction into the product without being produced. Previous quality control methods were usually approaches to solve the problem during production. QFD has emerged as a method or concept under the dome of Total Quality Control for new product development in this environment [6].

3.1- House of Quality and Fuzzy House of Quality Approach

The quality of the house comes out as an application method of QFD. House of quality is a matrix system that sets out the relationship between the technical requirements and quality characteristics determined to meet them with the needs and desires of the customers.

The house of quality is basically based on customer demands and the design of the appropriate product or service is targeted accordingly. It is essential that customer requests be reflected throughout the process from the design process to the formation of the final product. Thus, house of quality practices force different units within the enterprise to work in harmony with each other and form a common purpose and language.

The creation of a house of quality with a fuzzy logic approach is often used to overcome uncertainties in consumer demand. The data obtained from the consumers constitute the inputs of the house of quality and these data are converted to fuzzy numbers and the processing steps are continued.

Basically, in the practice with the house of quality, which consists of six parts, different operations are carried out in each part and then these parts are combined. In Figure 2 below, the parts of the house of quality are shown and explained.

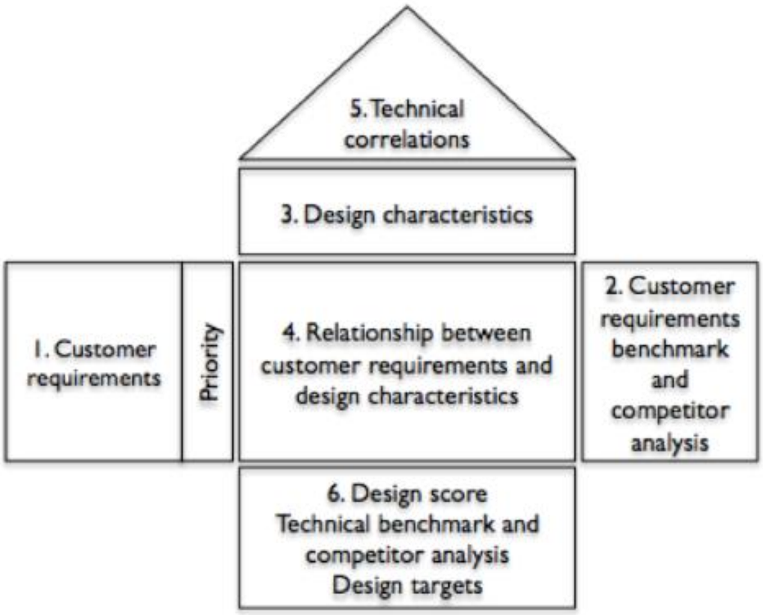

Figure 2. Parts of House of Quality

3.2- Creation and Application of House of Quality

Stage 1: Determination of consumer demands

The "What" section of the quality house is created. First, the target market is identified and its characteristics are examined. The mass addressed by the target market is identified and the wishes and needs are revealed. This process, which is also expressed as the voice of the customer, constitutes the input of the house of quality.

The customer requests generated are summarized and the requests and needs are identified and prioritized by the performed studies. Various numerical scales can be used when determining the significance level. The importance ratings are calculated by taking the average of the answers given by the customers.

Stage 2: Determination of consumer satisfaction

Determining the importance and satisfaction ratings from customers' viewpoint is not enough to make realistic planning for the development of a product or service. At the same time, the condition of the product or service and the condition of the competing products must be investigated. If customer requests are met, it must be determined how it affects product sales and how much improvement is needed on the product [7].

This helps in the use of some of the following variables in determining consumer requests.

Improvement rate: According to consumer expectations, how good is the target of the new product or system compared to the old one.

Advantage of sale: Determines the effect of the improvement made on the product.

The formulas given below can be used in calculations made at this stage.

$$\text{Improvement rate} = \frac{\text{Planned quality level}}{\text{Satisfaction level of the company}} \tag{1}$$

$$\text{Absolute weight} = (\text{Importance value}) * (\text{Improvement rate}) * (\text{Sale advantage}) \tag{2}$$

The data obtained with all these calculations are placed in the relevant parts on the right side of the house of quality.

It is also necessary to obtain the clear result that the resulting fuzzy results are converted to crisp values. The following basic formula is frequently used in the literature to confirm the triangular fuzzy numbers used in this study. For a triangular fuzzy number; a is lower bound, c is upper bound, b is the largest membership value;

$$\text{Crisp value} = \frac{a + 2b + c}{4} \tag{3}$$

Stage 3: Determination of technical requirements

At this stage, customer considerations are transformed into technical requirements. Technical specifications are identified for meeting specified consumer requirements. These constitute the "How" part of the house of quality. It is important to establish a direct relationship with the customers voice while creating technical requirements.

Stage 4: Creation of correlation matrix

It is at this stage that the relationship between consumer demands and technical requirements is revealed. The degree to which the technical requirements meet the consumer demands, so "How" and "What" relations, are determined. The values obtained are placed in the cells of the matrix. These relationships are often classified as weak, moderate and strong, or there may be no relationship. Various numerical scales can be used to define relations, and value sets of 1-5-9 or 1-3-9 are used, respectively.

Stage 5: Determination of relations between technical requirements

In this part of the roof of the house of quality, the bilateral relations between technical requirements are defined. The aim here is to observe the positive or negative effects of technical improvements on other technical requirements.

Four options are usually used when determining relationships. They are strongly positive and positive for positive relationships, and strongly negative and negative for negative relationships. The specified relationships are placed on the roof of the quality house, and if there is no relation, the related cells are left empty.

Stage 6: Determine the importance of technical requirements

At this stage, the ability of technical requirements to meet consumer demands is measured individually. For this, the absolute importance level in each column is calculated. As a result, the technical requirements of high absolute importance will guide the strategies to be determined. The absolute significance level is calculated by the following formula.

$$\text{Absolute importance} = \Sigma(\text{Absolute weight}) * (\text{Correlation value in the related row}) \tag{4}$$

4- CASE STUDY

The case study was made in a factory that manufactures wood panel industry located at Gebze. The structure of the house of quality related to the elimination of obstacles against sustainable production strategies of this study is composed of 6 parts as shown in the previous section and the implementation steps are carried out taking these parts into consideration.

4.1- Determination of Consumer Requirements

In the classical house of quality approach, consumer expectations create inputs of house of quality. In this study, the removal of obstacles in front of the sustainable production strategies, which are the expectations of the business, was accepted as input. With this assumption made, the expectation of the company will be tried to be met. In order to determine the expectations, academic researches on obstacles against sustainability and opinions of expert staff in company have been examined. These expectations are listed and explained below.

1. Risks, uncertainties of new technologies
2. Missing resources and high installation costs
3. Bureaucratic obstacle, lack of legislation
4. Irresponsibility, insensitivity and ignorance
5. Lack of openness to newness and qualified workers
6. Scarcity of renewable energy sources
7. Damage to nature in the use of raw materials and in production

4.2 - Determination of Consumer Satisfaction

The application was made only within the factory area. Therefore, this section does not include competitiveness analysis of competitors and their products or services.

The membership functions of the triangular fuzzy numbers used to determine the degree of importance and the degree of prevention are shown in Figure 3.

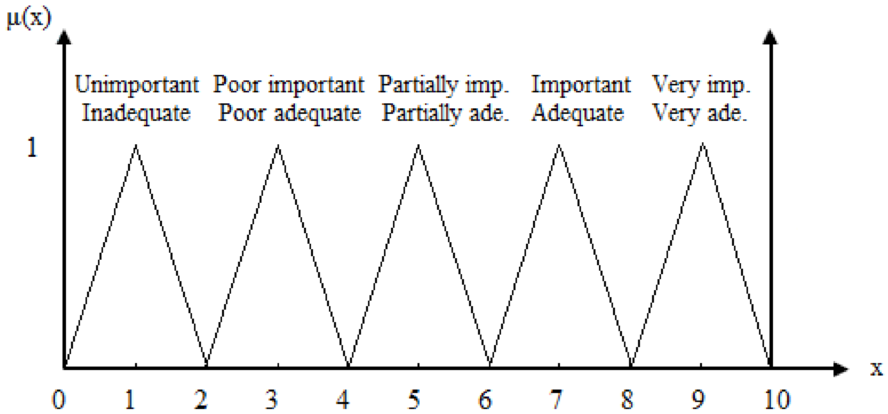

Figure 3. The Membership Functions for Importance and Prevention Levels

First, the importance of the obstacles in front of sustainable production strategies has been determined. Then the adequacy of the prevention taken against barriers to sustainable production strategy has been measured. A total of 21 participants' answers were converted to fuzzy numbers and arithmetic averages were taken. The membership grades shown in Figure 3 are used for this. The determined importance and prevention degrees are listed in Table 1.

The rate of improvement required for the determination of consumer satisfaction must be calculated for each item. In the previous section it was shown that the improvement rate is the ratio of the planned quality level to company satisfaction with QFD work. In this application, it is assumed that the planned quality level is equivalent to the degree of importance given to the barriers by the employees. Similarly, it is assumed that the satisfaction level of the company is equivalent to the adequacy of the preventions against the barriers. As a result, the ratio of the target value of the improvement rate to the present value, that is, the ratio of the degree of importance to adequacy of the degree of preventions will be used. Transactions were made by translating fuzzy numbers into crisp values. The results are shown in Table 1.

Appropriate sale advantage values have been determined for each barrier following the calculation of the improvement rates. The sale advantage determines how the elimination of barriers against sustainable production strategies will affect production or products. For this reason, a survey was made to the expert group of 5 people about the subject in the factory. The answers given by the engineers in the expert group were converted to individual fuzzy numbers and the arithmetic average was calculated. The membership degrees shown in Figure 4 have been used to translate sale advantage values into fuzzy numbers.

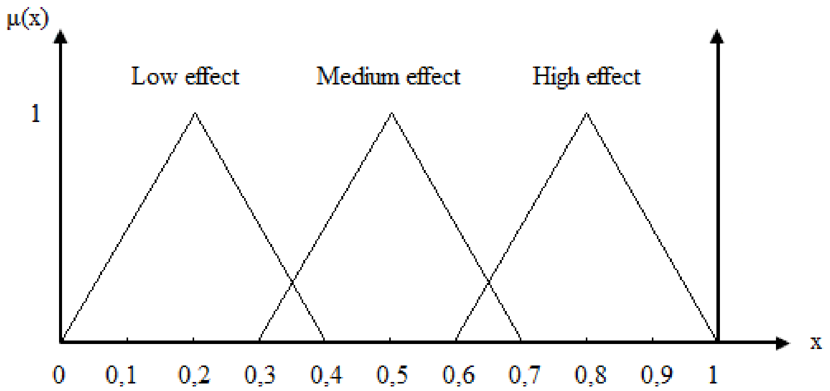

Figure 4. The Membership Function for Sale Advantage Values [6]

Absolute weight values of the barriers against sustainable production strategies are obtained by multiplying the calculated importance value, improvement rate and sale advantage values. The final value obtained by the multiplication of the fuzzy numbers is converted to the crisp number and the process is terminated. The results obtained are given in Table 1.

Table 1. Assuming the Absolute Weight of Consumer Demands

Demands	Degree of importance	Degree of prevention	Improvement rate	Sales advantage	Fuzzy absolute weight	Absolute weight
1	(4,10; 5,10; 6,10)	(2,95; 3,95; 4,95)	1,29	(0,24; 0,44; 0,64)	(1,27; 2,89; 5,04)	3,02
2	(5,62; 6,62; 7,62)	(3,71; 4,71; 5,71)	1,41	(0,24; 0,44; 0,64)	(1,90; 4,11; 6,88)	4,25
3	(4,95; 5,95; 6,95)	(3,33; 4,33; 5,33)	1,37	(0,42; 0,62; 0,82)	(2,85; 5,05; 7,81)	5,19
4	(4,76; 5,76; 6,76)	(3,52; 4,52; 5,52)	1,27	(0,42; 0,62; 0,82)	(2,54; 4,54; 7,04)	4,67
5	(6,76; 7,76; 8,76)	(3,24; 4,24; 5,24)	1,83	(0,48; 0,68; 0,88)	(5,94; 9,66; 14,11)	9,84
6	(4,76; 5,76; 6,76)	(2,67; 3,67; 4,67)	1,57	(0,36; 0,56; 0,76)	(2,69; 5,06; 8,07)	5,22
7	(5,14; 6,14; 7,14)	(3,14; 4,14; 5,14)	1,48	(0,48; 0,68; 0,88)	(3,65; 6,18; 9,30)	6,33

4.3- Determination of Technical Requirements

The technical requirements that form the part of "How" of house of quality were created to meet the expectation of the customers. The technical requirements put forward for the elimination of obstacles in front of sustainable production strategies have been created with the support of various academic publications and expert personnel in the factory. The technical requirements classified as economic, environmental, social and managerial according to their areas are listed below.

1. Increase the lifetime of the product
2. R&D studies and investments
3. Reduction of investment return period
4. Installation of recycling systems
5. The amount of carbon produced per unit of product
6. Waste management (treatment and disposal systems)
7. Increase the ratio of green energy used
8. Worker safety and health
9. Staff training
10. Job opportunities
11. Compulsive legislation and action plan
12. Government support for sustainable production, incentives, credit facilities
13. Sector-focused approaches, setting sector priorities

4.4- Creating the Correlations Matrix

In the literature studies, various scales such as (1,3,5,7,9), (1,3,9), (1,5,9) were used to construct the correlation matrix. In this study (1,5,9) scale was preferred. 0 indicates no relationship, 1 indicates little relationship, 5 indicates medium relationship, 9 indicates strong relationship. The membership grades of the triangular fuzzy numbers are shown in Figure 5.

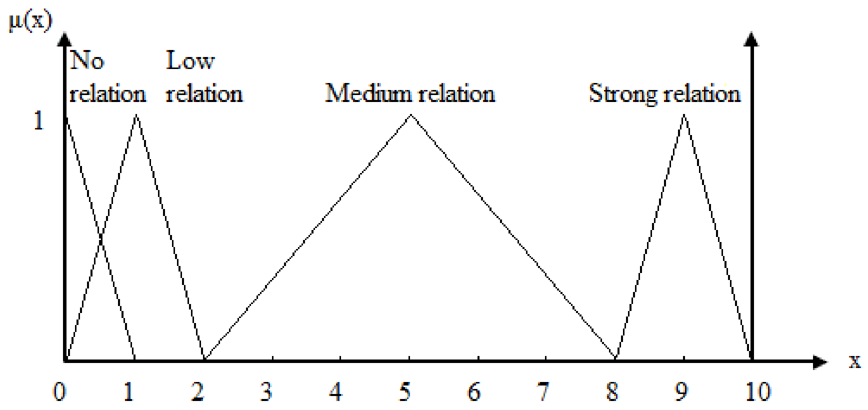

Figure 5. The Membership Function for Correlation Values

The values obtained from the views of 5 expert personnel were translated into fuzzy numbers according to the membership grades shown and their arithmetic average was taken. The fuzzy values in the relation matrix obtained according to these operations are shown in Table 2 below.

4.5- Determination of Relations between Technical Requirements

The common views of the same 5 person expert group were used to determine the relationships between technical requirements. Numerical expressions were used to determine relationships at four levels. The values respectively shown as; strong positive relationship 2, positive relationship 1, strong negative relationship -2, negative relationship -1. Relations between technical requirements are shown in Figure 6.

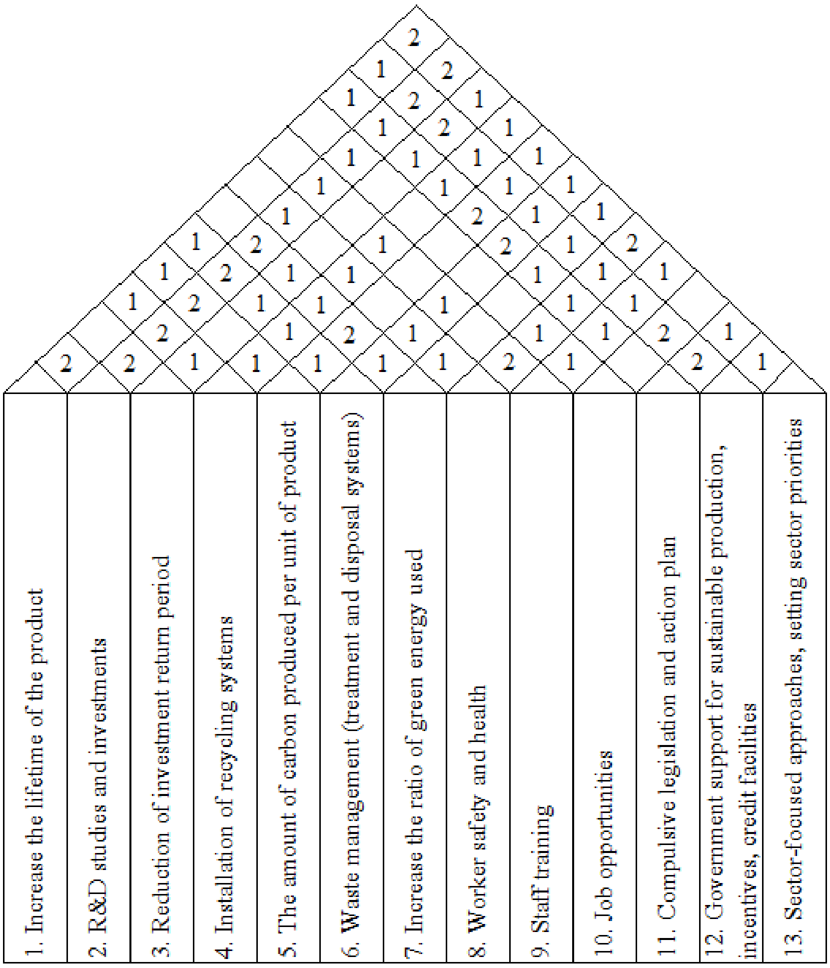

Figure 6. Relations Between Technical Requirements

4.6- Determination of the Importance of Technical Requirements

Following the formation of the correlation matrix, the degree of importance of each technical requirement is found by summing the products of the previously calculated fuzzy absolute weight values with the fuzzy correlation values in each column. Absolute importance ratings are obtained by confirming the obtained fuzzy numbers. The calculations made and the results are shown in Table 2.

Table 2. Importance of Technical Requirements

	Economical Technical Requirements			Environmental Technical Requirements				Social Technical Requirements			Managerial Technical Requirements			
Demands	1. Increase the lifetime of the product	2. R&D studies and investments	3. Reduction of investment return period	4. Installation of recycling systems	5. The amount of carbon produced per unit of product	6. Waste management (treatment and disposal systems)	7. Increase the ratio of green energy used	8. Worker safety and health	9. Staff training	10. Job opportunities	11. Compulsive legislation and action plan	12. Government support for sustainable production, incentives, credit facilities	13. Sector-focused approaches, setting sector priorities	Fuzzy absolute weights
1	(3,2; 4; 5)	(6,8; 8,2; 9,6)	(4; 5,8; 7,6)	(5,2; 6,6; 8)	(6,4; 7,4; 8,4)	(5,2; 6,6; 8)	(5,6; 7,4; 9,2)	(2,8; 5; 7,2)	(2,4; 4,2; 6)	(0; 1; 2)	(4; 5,8; 7,6)	(6,8; 8,2; 9,6)	(5,6; 7,4; 9,2)	(1,27; 2,89; 5,04)
2	(2; 3; 4,4)	(2; 5; 8)	(6,8; 8,2; 9,6)	(4; 5,8; 7,6)	(4,4; 6,6; 8,8)	(4; 5,8; 7,6)	(5,6; 7,4; 9,2)	(0,8; 2,2; 4)	(0,4; 1,4; 2,8)	(0; 0,6; 1,6)	(0,4; 1,8; 3,2)	(6,4; 7,4; 8,4)	(3,2; 5,8; 8,4)	(1,90; 4,11; 6,88)
3	(1,6; 2; 3)	(1,6; 2,4; 3,4)	(1,6; 2,4; 3,4)	(2,4; 4,2; 6)	(4; 5,8; 7,6)	(5,6; 7,4; 9,2)	(5,6; 7,4; 9,2)	(0,8; 2,4; 4,2)	(2,4; 4,2; 6)	(0,8; 2,4; 4,2)	(5,6; 7,4; 9,2)	(6,8; 8,2; 9,6)	(3,6; 5; 6,4)	(2,85; 5,05; 7,81)
4	(2; 3,2; 4,6)	(3,6; 5; 6,4)	(4,8; 5,6; 6,6)	(2,8; 5; 7,2)	(4,4; 6,6; 8,8)	(4,4; 6,6; 8,8)	(4,4; 6,6; 8,8)	(5,2; 6,6; 8)	(6,4; 7,4; 8,4)	(1,2; 3,4; 5,6)	(3,2; 5,8; 8,4)	(4; 5,8; 7,6)	(5,2; 6,6; 8)	(2,54; 4,54; 7,04)
5	(0,4; 1,6; 3)	(5,6; 7,4; 9,2)	(2; 3,2; 4,6)	(1,2; 3,2; 5,4)	(1,6; 4; 6,6)	(2,8; 4,8; 7)	(1,6; 4; 6,6)	(4; 5,8; 7,6)	(6,4; 7,4; 8,4)	(5,2; 6,6; 8)	(2; 3,4; 4,8)	(3,6; 5; 6,4)	(3,6; 4,8; 6,2)	(5,94; 9,66; 14,11)
6	(0,4; 1,4; 2,4)	(2; 3,2; 4,6)	(0,4; 1,6; 3)	(3,6; 5; 6,4)	(4,4; 6,6; 8,8)	(2,4; 4; 5,8)	(5,6; 7,4; 9,2)	(0; 0,8; 1,8)	(0; 0,6; 1,6)	(0; 0,6; 1,6)	(1,6; 4,2; 6,8)	(4; 5,8; 7,6)	(4; 5,8; 7,6)	(2,69; 5,06; 8,07)
7	(3,2; 3,8; 4,8)	(4,8; 5,6; 6,6)	(2; 3,2; 4,6)	(8; 9; 10)	(6,4; 7,4; 8,4)	(5,6; 7,4; 9,2)	(5,2; 6,4; 7,8)	(1,2; 3; 5,2)	(2,8; 4,8; 7)	(1,6; 2,4; 3,4)	(5,6; 7,4; 9,2)	(4; 5,6; 7,4)	(4,8; 5,6; 6,6)	(3,65; 6,18; 9,30)
	32,64	82,3	55	74,17	83,76	80,31	83,88	48,7	75,14	42,06	66,55	97,08	86,32	a — Fuzzy absolute importance
	94,54	201,35	146,79	198,65	225,53	214,51	226,69	144,19	176,88	114,54	187,69	234,11	210,76	b — Fuzzy absolute importance
	217,62	403,35	309,27	411	466,45	445,05	470,88	323,05	352,04	250,73	399,47	455,11	420,66	c — Fuzzy absolute importance
	109,84	222,09	164,46	220,62	250,32	238,59	252,03	165,04	195,24	130,46	210,35	255,1	232,13	Absolute importance
	0,04150748	0,083925677	0,062147853	0,083370178	0,094593522	0,090160868	0,095239715	0,06236703	0,07377932	0,04929958	0,079489243	0,096399838	0,087719696	Relative importance
	13	6	11	7	3	4	2	10	9	12	8	1	5	Sequence

5- CONCLUSION

For the wood panel industry, in our study, the barriers against sustainable production strategies have been identified as basic and various solution proposals have been presented in order to eliminate these obstacles. The priorities of these obstacles and solution proposals have been determined through a questionnaire survey conducted with the participation of personnel working in the field of business. In this way, it is possible to determine the suitable strategies for the business in order to achieve the sustainable production targets.

For this purpose, the QFD method and the house of quality approach have been used. This is because the house of quality method is frequently and successfully applied in order to reflect consumer demands on products in industrial enterprises. However, fuzzy logic has been used so that the ambiguities and inconsistencies in the responses of the respondents can be removed. The application was implemented with the fuzzy quality house approach proposed for the solution, and the results obtained supported the operation of the enterprise on the path of sustainable production.

Absolute weights of the barriers against sustainable production strategies that form the expectations of the business have been determined. Accordingly, 3 of the most important absolute weights of the business expectations are listed below in order of magnitude.

5. Lack of openness to new ideas and qualified workers

7. Damage to nature in the use of raw materials and in production

6. Scarcity of renewable energy sources

The absolute importance ratings of the technical requirements of the solution proposal prepared to meet the expectations of the operator are listed below in order of magnitude.

12. Government support for sustainable production, incentives, credit facilities

7. Increase the ratio of green energy used

5. The amount of carbon produced per unit of product

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A SYSTEMATIC LITERATURE REVIEW FOR MEASURING SUSTAINABLE TRANSPORT

Ebru SÜRÜCÜ[1], Mehmet DOYMUŞ[2], D. Ali DEVECİ[3]

Abstract – *The concept of sustainability in transportation sector has been one of the most popular topics for both countries and researchers over two decades. Shareholders, who are countries, and non-governmental organizations (NGOs), are constituted different types of index and indices to measure logistics firms' and/or sectors' sustainability performance according to their policies. However, since each of the shareholder developed different types of indicators for different purposes, there is no common sense. To create a common sense, a systematic literature review is held for sustainability indicators, which are developed by countries and NGOs. Paper provides an overview various sustainability index, indices, and measurement tools, which are created for transportation sector. At the end, study findings as well as limitations of the study and directions for future research are offered.*

Keywords – *Index, Measurement Tools, Sustainability Performance, Sustainable Development, Transport*

INTRODUCTION

In recent years, many firms have begun to strive to be more 'green' in their business. The main reason for this change is the pressures coming from external sources such as increased regulation and changes in consumer preferences and from internal forces such as the values of the firms' leadership. For example, drivers in the U.S. prefer to drive smaller and more environmental-friendly hybrid vehicles instead of large SUVs [43]. Companies, governments, and citizens now understand the importance of green and want more than green and started to think about sustainability. Sustainability is defined as *"meet the needs of the present without compromising the ability of future generations to meet their own needs"* [54]. Increased importance of sustainability makes the measurement of environmental effects of transportation systems more important. Because one-fifth of the carbon dioxide (CO_2), one third of chlorofluorocarbons (CFCs), and half of nitrogen oxides (NO_x) in the atmosphere related to transport activities [32]. Transportation has significant economic, social and environmental impacts and is an important factor in sustainability. Moreover, growing importance on environmental issues such as environmental pollution [40], decrease in raw material resources, increased amount of waste and high level of pollution [45] and pressures come from government regulations, changing consumer demands and the development of international certification standards [50] raised sustainability concept in transportation. Because of these reasons, there is a growing tendency in board of directors and managers to show stakeholders` company's environmental and social activities [14].

Sustainable transport is defined as *"a system that allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations, is affordable, operates efficiently, offers choice of transport mode, supports a vibrant economy, limits emissions and waste within the planet's ability to absorb then, minimizes consumption of non-renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise"* [10].

The purpose of sustainability assessment is to ensure decision-makers with a consideration of global to local integrated nature-society systems in short and long-term perspectives to help them to determine which actions should or should not be approved to attempt to make society sustainable [24]. Sustainability measurement for transportation has been oriented around cost, time, and accuracy. However, due to the increases in pressure

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comes from customers and governments, organizations are now coming under increased scrutiny. Thus, the importance of measuring sustainability becomes more important. In the literature, Ness et.al. (2007) study puts a general framework for sustainability assessment tools [31]. According to this study, sustainability assessment tools can be gathered in three main groups, which are indicators/indices, product-related assessment tools and integrated assessment tools (Figure 1). In the literature, there are some studies related to measure sustainable transportation but these studies only cover special geographic area or special transportation mode, meaning that there is no index for measuring sustainable transport that can be used for all over the world.

The purpose of this paper is to overview and discuss on the measuring sustainable transportation literature which are formed by NGOs and governments. For this purpose, all sustainability indices, European Union projects and indices are examined. After the examination period, sustainability indices are grouped according to similarity of their topic. Moreover, indices, which directly or indirectly measure sustainable transportation, will be examined.

The paper is organized as follows. Second part discusses the research design and the activities carried out. Third part review the relevant literature on indices and European Union projects related to measuring sustainable transportation. Fourth part draws some conclusions and provides some insights for future research.

METHODOLOGY

This paper focuses on sustainable transportation measurement framework considering indices, which are prepared by NGOs and countries, and projects that are developed by European Unions. For this purpose, a literature review made from a wide-array of sources. The objective was to review the literature within each area, identify gaps among them.

Literature Review

In the literature, there are two distinct methodologies to make sustainability assessment. Generally, economists prefer to use monetary aggregation method; while, scientists and researchers prefers to use physical indicators. Greening GDP, resource accounting based on their functions, sustainable growth modelling and defining weak and strong sustainability conditions are some of the economic approaches that economists use. The main idea behind economists use these tools is assuming sustainable growth is a part of sustainable development of the economy [41]. Ness et.al. (2007) developed a holistic framework for sustainability assessment tool [31]. According to this study, sustainability assessment tools can be gathered in three main groups, which are indicators/indices, product-related assessment tools and integrated assessment tools (Figure 1). Also, there is an overarching category at the bottom of the figure used when non-marketing values are needed in three categories. Tools are formed on a time continuum based on if they look back in time (retrospective) or if they are forward looking (prospective, forecasting) tools.

First group of sustainability assessment tool is indicators and indices. Indicators are simple measures, rottenly quantitative that represent economic, environmental, and social developments. An indicator should have simplicity, a wide scope, quantifiable, allows trends to be determined, tools that are sensitive to change and allow timely identification of trends [18]. According to Ness et al. (2007) indicators/ indices separated into three groups, which are non-integrated, regional flow indicators and integrated [31]. Non-integrated group don’t integrate with nature-society parameters like Environmental Pressure Indicators (EPIs) and UNCSD 58. Integrated group aggregate the different dimensions like Sustainable National Income (SNI), Adjusted Net Savings, Environmental Sustainability Index. Regional flow indicators analyze inefficiencies in a system within material and energy flows allows an overview of the structure of resource flows. Economy –Wide Material Flow Analysis; Input-Output Energy Analysis and Regional Exergy Analysis are example of regional flow indicators.

Indicators are commonly recognized as a useful tool for policy making and public communication in transferring information on countries’ environmental, economy, society, technological development performances. Indıcators comprise of value and they create values [28]. The most important characteristic of indicators is their ability to summarize, focus and intensify enormous complex data to a manageable amount of meaningful information [15]. Indicators help to visualize and highlight trends and enables complex and complicated information to simplify, quantify, analyze and communicate [53].

Second assessment tool is product-related assessment tools. These tools are examined under four main topics, which are life-cycle assessment, life cycle costing, product material, flow analysis and product energy analysis. These tools focus on flows in connection with production and consumption of goods and services. They are related to regional flow indicators [2] however, these tools focus on evaluating different flows in relation to various products or services instead of regions [31]. Product-related assessment tools evaluate resource use and environmental impacts considering production chain or through lıfe cycle of a product. Moreover, these tools allow both retrospective and prospective assessment that support decision-making.

Lastly, third assessment tool is integrated assessment tools which are conceptual modeling, system dynamics, multi-criteria analysis, risk analysis, uncertainty analysis, vulnerability analysis, cost benefit analysis and impact assessment. These tools used for supporting decisions related to a policy or a project in a specific region. Policy related tools are used for local to global scale assessment; while, project related tools focus on local scale assessments [31]. Moreover, these tools have an expected focus and usually performed in the form of scenarios.

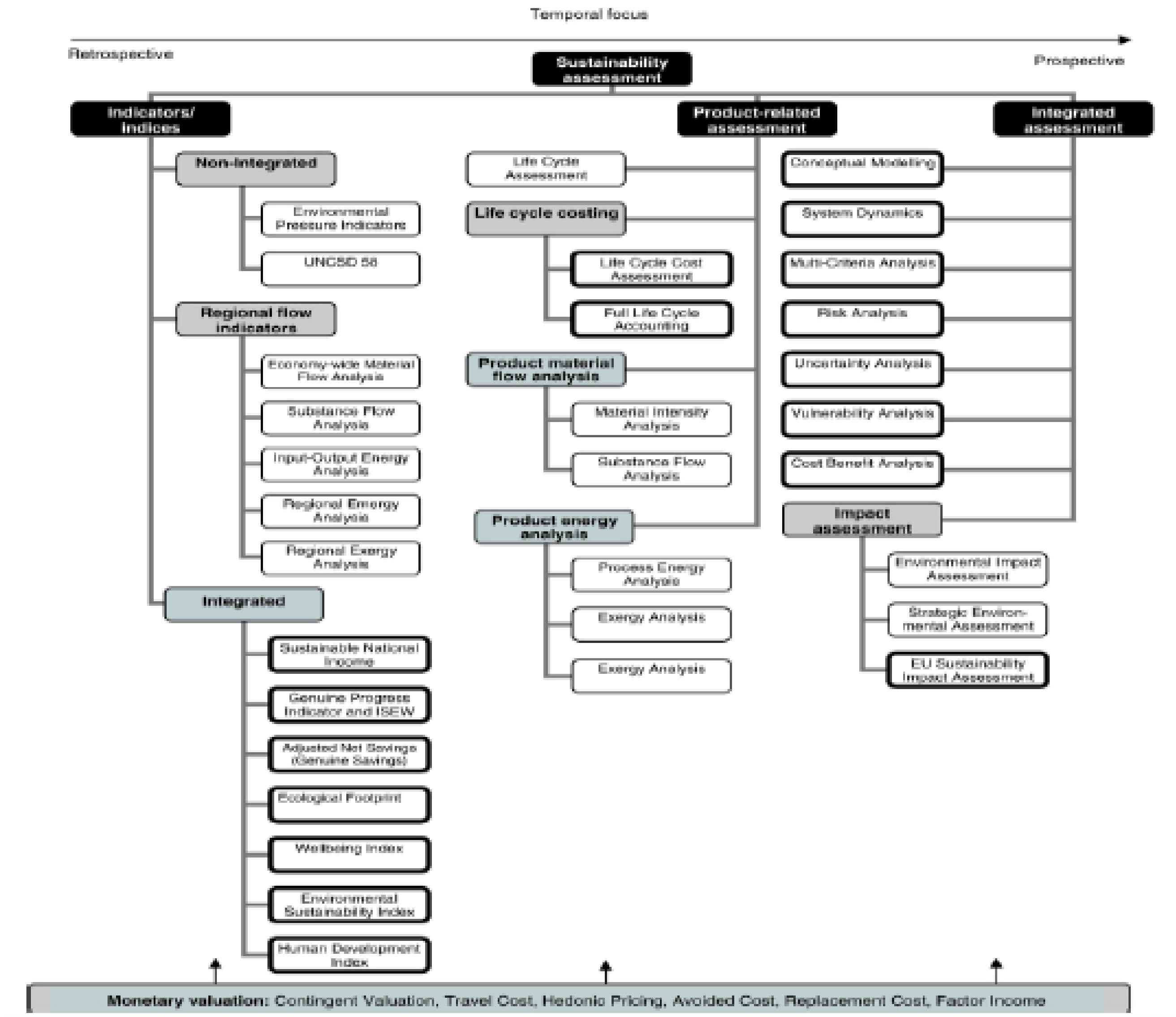

Figure 1: Framework for Sustainability Assessment Tools

From Ness et. al. (2007) shows that indicator/indices are prepared and used mostly for sustainability performance measurement [31]. In the literature, the criteria for selecting appropriate indices have been widely discussed [4] - [20]. Main requirements include [8]:

i. The rigorous connection to the definitions of sustainability [34].
ii. The selection of meaningful indicators representing holistic fields [11].
iii. Reliability and availability of data for quantification over longer time horizons [37] - [47].
iv. Process oriented indicator selection [8].
v. The possibility of deriving political (sub) objectives [13].

According to Bohringer and Jochem (2007) requirements, indices related with sustainability assessment can be grouped into twelve [8]. Figure 2 shows the groups.

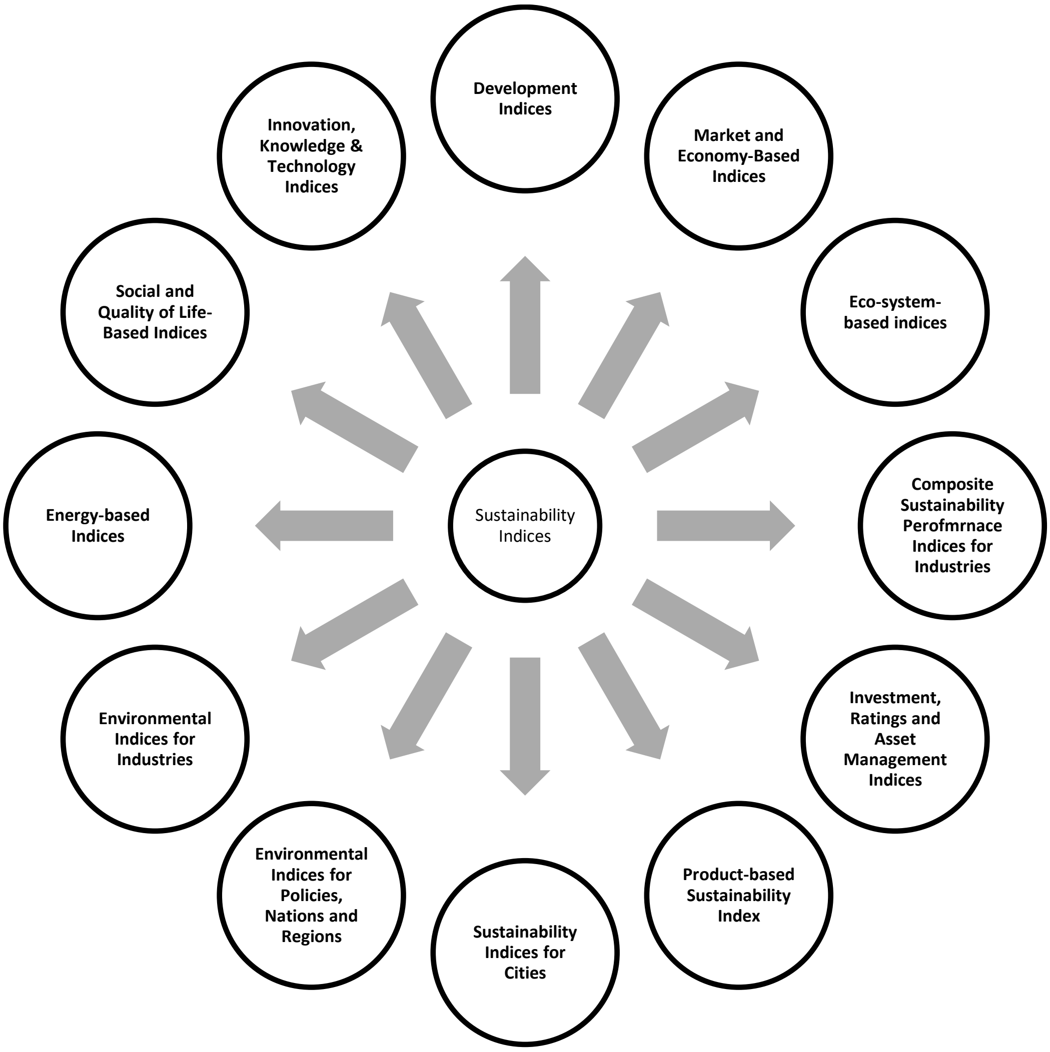

Figure 2: Overview of Sustainability Indices

After dividing sustainability indicators into 12 groups, it is examined that which of those groups related with transportation and used transportation in its measurement items. All related sustainability indicator categories and their indexes are examined according to their used factors and calculation methods. Table 1,2,3,4,5,6,7,8,9 show that indices are used for environmental performance while in subcategories these indicators use sustainable transportation indicators.

Table 1: Used Indicators and Calculation Method for Composite Sustainability Performance Indices for Industries

Category	Index Name	Indicators Used & Calculation
Composite Sustainability Performance Indices for Industries	Composite Sustainable Development Index	A composite sustainable development index (ICSD) in order to track integrated information on economic, environmental, and social performance of the company with time. Normalized indicators were associated into three sustainability sub-indices and finally composed into an overall indicator of a company performance. This was applied by determining the impact of individual indicator to the overall sustainability of a company using the concept of analytic hierarchy process.
	Composite Sustainability Performance Index	The calculation of CSPI is a step-by-step procedure of grouping various basic indicators into the sustainability sub-index for each group of sustainability indicators. Sub-indices then subsequently derived in the form of aggregated index. Weights are derived using AHP methodology.
	ITT Flygt Sustainability Index	The index is calculated by aggregating some 40 sustainability-indicators. These indicators are individual to each company and are designed to measure the significant sustainability aspects of the company
	G Score Method	• Environmental management (GEM), • Input, • Process, • Output, • Outcome Calculated by aggregating the points of the five-categories

Resource: [22] - [27] - [41]

Table 2: Used Indicators and Calculation Method for Environmental Indices for Policies, Nations and Regions

Category	Index Name	Indicators Used & Calculation
Environmental Indices for Policies, Nations and Regions	Environmental Sustainability Index	Based upon a set of 68 basic indicators. These are then aggregated to construct 21 core indicators. For every variable in our data set we created a normalized range and scaled values from 0 (low sustainability) to 100 (high sustainability).
	Environmental Quality Index	Main environmental factors are selected and defined on the basis of the multi attribute-utility theory and a numerical evaluation carried out by applying the Analytic Hierarchy Process (AHP) methodology. A weighted sum of all environmental factors forms the so-called environmental quality index (EQI), which gives an estimate of the overall environmental impact of each alternative. Each environmental factor is interpreted as a linear utility function, which assumes values in the range 0–10. The utility functions are given the weights according to the importance of each environmental factor, and the weighted sum is the environmental quality index for which a maximum is sought.
	Concern About Environmental Problems	Eleven indicators are considered, four related to air problems (nitrogen oxides, sulphur dioxide, carbon dioxide and particulates), two indicators associated with

		water problems (bathing and fertilizers) and five landscape-related indicators (population change, new dwellings, tourism, traffic and waste).
	Environmental Policy Performance Indicator	Six theme indicators (composed of several simple indicators) are combined, including: (a) change of climate, (b) acidification, (c) eutrophication, (d) dispersion of toxic substances, (e) disposal of solid waste, and (f) odor and noise disturbance.
	Environmental Performance Index	The EPI focuses on current on-the-ground outcomes across a core set of environmental issues tracked through six policy categories for which all governments are being held accountable' All variables are normalized in a scale from 0 to 100. The maximum value of 100 is linked to the target; the minimum value of 0 characterizes the worst competitor in the field. Weights are drawn from statistical mechanisms or by consulting experts. Finally, the six policy categories are aggregated to the ESI taking the weighted sum.
	Environmental Vulnerability Index	EVI compromises 32 indicators of hazards, 8 indicators of resistance, and 10 indicators that measure damage The EVI scale for normalization ranges between a value of 1 (indicating high resilience/low vulnerability) and 7 (indicating low resilience/ high vulnerability). The 50 indicators are given equal weights and then aggregated by an arithmetic mea
	Two "synthetic environmental indices"	Twenty-two sub-indicators for environment are combined into two synthetic indices, structural, and a functional one.

Resource: [1] - [7] - [13] - [21] - [33] -[36] -[55]

Table 3: Used Indicators and Calculation Method for Environmental Indices for Industries

Category	**Index Name**	**Indicators Used & Calculation**
Environmental Indices for Industries	Eco-points	LCA: production, distribution, use and end-of-life
	Eco-compass	Water Use, Energy Use, Global warming contribution, Ozone Depleting Substances, Waste, Financial indicators
	Eco-indicator 99	1-Human health, 2- eco system quality, 3-resources, minerals and fosil fuels Weighting is selected by a panel of experts
	Environmental Assessment for Cleaner Production Technologies	Raw material, energy, waste, product and packing profiles
	COPMLIMENT – Environment Performance Index for Industries	EPIs basis on LCA Weighting, aggregation, AHP

Resource: [16] - [17] - [19] - [35]

Table 4: Used Indicators and Calculation Method for Energy Based Indices

Category	**Index Name**	**Indicators Used & Calculation**
Energy Based Indices	Sustainability Assessment Toll for Energy System	The rehabilitation of a 110 MWThermal Power Unit is compared with other options: gas tribunes, hydropower, solar energy

	Energy Indicators for Tracking Sustainability in Developed Countries	Poverty: Total household expenditure, education level of the head of the household, calorie intake, source of drinking water, sanitation, house condition, dwelling area size, dwelling construction type, land possession Energy: Primary, useful, an access-adjusted useful energy-per capita

Resource: [5] - [25]

Table 5: Used Indicators and Calculation Method for Eco-System-Based Indices

Category	Index Name	Indicators Used & Calculation
Eco-System-Based Indices	Sustainability Performance Index	Evaluation is the calculation of the area needed to embed a process completely into the biosphere. This comprises the area required for production of raw material, process energy and provided installations as well as the area required for the staff and for the accumulation of products and by-products within the available area.
	Eco-Index Methodology	Utilizes a 'component' or bottom-up approach to perform EF analysis. It is compatible with the 'compound' top-down approach, which uses international trade statistics as a starting point. In the eco-index methodology full life cycle impact data is used to derive EF conversion factors wherever possible for key component. The ecological footprint (as measured using global average yields) is normalized by the application of equivalence factors.
	Ecological Footprint (EF)	Based on the quantitative land and water requirements to sustain a (national) living standard into infinity thereby assuming certain efficiency improvements. The ratio of required resources to available resources is interpreted as a measure of ecological sustainability: ratios exceeding one are seen as unsustainable, i.e. contemporary living standards would violate the principles of sustainable development. Calculation of the EF is based on data from national consumption statistics. The EF primarily relies on normalisation (as any consumption is converted in land use). Weighting is rather implicit in the conversion parameter and adding up all land and water requirements does aggregation.

Resource: [9] - [30] - [52]

Table 6: Used Indicators and Calculation Method for Social and Quality of Life-Based Indices

Category	Index Name	Indicators Used & Calculation
Social and Quality of Life-Based Indices	Index for Sustainable Society	Comprise of 22 different indices at five different categories, mathematic formula used for each indices and categories equally evaluated and summated. Personal Development (Healthy Life, Sufficient Food, Sufficient to Drink, Safe Sanitation, Education Opportunities and Gender Equality). Clean Environment (Air Quality, Surface Water Quality and Land Quality). Well-balanced Society (Good Governance, Unemployment, Population Growth, Income Distribution and Public Debt). Sustainable Use of Resources (Waste Recycling, Use of Renewable Water Resources and Consumption of Renewable Energy). Sustainable World (Forest Area, Preservation of Biodiversity, Emission of Greenhouse Gases, Ecological Footprint and International Cooperation).
	Well - Being Assessment (Well- Being Index)	Arithmetic mean of Human Well-being Index and Ecosystem Well-being index. HWI consist of five dimensions: health and population, welfare, knowledge, culture and society, equity. EWI consist of land, water, air, species, genes and resource deployment dimensions. HWI and EWI based on 36 and 51 indicators respectively. Dimensions are aggregated by weighted arithmetic mean of sub-indices. Proximity-to-target approach are used to normalize these sub-indices.

Resource: [8] - [42]

Table 7: Used Indicators and Calculation Method for Market and Economy-Based Indices

Category	Index Name	Indicators Used & Calculation
Market and Economy-Based Indices	Business Climate Indicator	Consists of five indicators: production trends at recent past, order books, export order books, stocks, production trends. Each indicator scaled -100 to 100according to surveys. Weighting is made by PCA (Principle Component Analysis) and Factor Analysis. One principle component adopted as composite indicator.
	Internal Market Index	Consists of nineteen sub indicators, including growth in per-capita, long term unemployment, price dispersion, growth in intra EU trade, prices of utilities service, energy intensity, greenhouse gas emissions. Indices were weighted with PCA and aggregation is carried out by synthesis of indices using PCA.

Resource: [23] - [38] - [42]

Table 8: Used Indicators and Calculation Method for Investment, Rating and Asset Management Indices

Category	Index Name	Indicators Used & Calculation
Investment, Rating and Asset Management Indices	OEKOM Environment Rating	Consist of three rating area: environmental management, products and services an environmental bench-marks. Each rating area scaled from A+ to D- based on ecologic activities within specific industry. Three area are weighted and separate grades are constituted to form overall rating.
	FTSE Good Index	That measures compliance of companies to global corporate responsibility standards. Market consultation process is being used and the criteria are regularly updated in order to provide standards of responsible business.
	Storebrand Scudder Environmental Value Fund, Oslo, Norway	The Storebrand sustainability index is calculated from 8 sub-indices: global warming, ozone depletion, material efficiency, toxic releases, energy intensity, water use, environmental reliability, environmental management quality. The index measures the environmental dividend –difference between market average and fund's performance; however, social dimension is missing.
	Bovespa Corporate Sustainability Index	Bovespa Sustainability Index measures economic, financial, corporate governance, environmental and social performance of companies. Three dimensions - economic-financial, social, and environmental are divided into four criteria: policies (commitment indicators); management (indicating plans, programs, goals, and monitoring); performance; and legal compliance (with environmental and consumer regulation, among others).

Resource: [42]

Table 9: Used Indicators and Calculation Method for Product-Based Sustainability Index

Category	Index Name	Indicators Used & Calculation
Product – Based Sustainability Index	Life Cycle Index	Life cycle indexing consist of four different variables: environmental, cost, technology, socio-political. Index includes 21 sub-indices and scaled with linear and non-linear functions. Analytic hierarchy process (AHP) is used for weighting of indices. Aggregation is calculated basis on geometric mean of indices.
	Ford of Europe's Product Sustainability Index	Consist of eight indicators that reflect environment: Life Cycle Global Warming Potential, Life Cycle Air Quality Potential, Sustainable Materials, Restricted Substances, Drive-by-Exteriore Noise, Social (Mobility Capability, Safety) and Economic (Life Cycle Cost of Ownership). Scaled by life cycle assessment.

Resource: [26] - [39] -Schmidt, 2007 ; Khan et.al. 2004

The initiatives of transport sustainability indicators in the EU mainly relate to the indicator sets established by the European Commission (EC), Eurostat, and the European Environmental Agency [12]. In 2006, 'renewed' EU Sustainable Development Strategy (SDS) calls for the European Commission to monitor the progress of the EU against the challenges laid out in the strategy and specifically to draw up a comprehensive set of Sustainable Development Indicators (SDIs). It specifies that these SDIs *are to be developed at the appropriate level of detail to ensure proper assessment of the situation with regard to each particular challenge*.

Five assessment tools, which are used by European Union for sustainable transportation, and their details is given Table 10. Besides, several of the European Union FP funded research projects either focus on sustainable development indicators explicitly or develop indicators sets which covers a number of different aspects of sustainable development. The most notable research projects are TRANSFORM, REFIT, TRANS-TOOLS, BEST, TRANS-TALK and STELLA. Seven projects are included in the sustainable transport theme. These projects and their details are shown in Table 11.

Table 10: European Union – Assessment Tools for Sustainable Transportation

Category	Index Name	Methodology	Results
EU – Assessment Tools	ARTEMIS (Assessment of Road Transport Emission Models and Inventory Systems)	ARTEMIS develops a harmonized emission model with road, rail, air and ship transport modes at regional, national and international level. It was designed for three main applications: 1- classical emission applications, 2-scenario calculation for assessing the impacts of alternative measures, 3- inputs for air quality models for assessing local and temporal impacts on the environment. Tools were structured at five approaches: 1- fleet modeling at three scenarios- enables calculation in number of vehicles and volume, 2- emission data set, 3- emission factor processor –enables computing all relevant emission factors, 4-traffic data set module – combines traffic scenarios with application, 5- emission computation module.	Provides significant progress for test procedures of emission measurement; develop tools to enable the estimation of the vehicle fleets and their emissions, and constitute a powerful platform for emission estimation exercise; collects national and European statistics to coherent assumptions regarding traffic characteristics, includes all means of transportation and provides renewed and improved tools.
	STAIRRS (Strategies and Tool to Assess and Implement Noise Reducing Measures for Railway Systems)	The project consists of three technical work packages: first one provide cost benefit software tool and analysis noise mitigation strategies, second one provides measurement methodologies provide assistance to designers of rolling stock and infrastructure and identify, for specific situations, where noise mitigation could most effectively be applied; third packages develop consensus between stakeholders policy makers, railway operators, railway infrastructure, community and environmental consideration as well as cost of implementation	STAIRRS provide techniques for the separate wheel and truck noises. Tool consists of noise prediction, cost - effectiveness analysis, extrapolation. Resulted with successful and optimization modules.
	SPOTLIGHTS (TN) (Supporting European Policy Makers Assembling Information and Bridging Models Towards European Policy Decision Support System)	Spotlights TN is a scientific forum that enables to develop transport models. For end users and policy makers. Spotlight TN's preparatory phase that end up with two deliverables: 1-website and communication procedures, 2- draft version for all deliverables- Dcod ,Mdir, GTF and LT.	There are different software solutions to interface advanced model through Internet and Intranet. Interactive communication must be provided between users and models in order to validate user's intuitions and presumptions.

	SUMMA (Sustainable Mobility, Policy Measures and Assessment)	SUMMA project provides a consistent tool for policy makers to evaluate environmental, economic and social dimensions of sustainability. SUMMA implements two step approaches. At the first step, analyses the problem and draw a conceptual design for monitoring and modelling sustainable transport. However, at this stage feasibility of implementation is not taken into account comprehensively. The second step is to implement conceptual design, given the limitations of data information, as much as possible and then used to evaluate the contribution of several policies to promoting and realizing sustainable transport.	SUMMA create tools for policy makers. Enable to user easily estimate impact of policy measures on all outcome indicators that combines demand generation and policy assessment capabilities in one tool. Collects the data across the Europe, however quality of the data is not same at all countries. Missing data were estimated from similar countries that reduce effectiveness of the tool.
	MOST (Mobility Management Strategies for the Next Decades)	MOST is a demand-oriented approach that creates new partnerships to provide quality mobility services. MOST comprises two steps. At first step collects impact assessment data in order to assess changes in mobility awareness and behavior. The second step is to investigate Mobility Management implementation process. This methodology consists of 4 work-packages: 1-Definition of the conceptual framework, 2-Policy and implementation framework 3-Monitoring and evaluation, 4-Dissemination, training.	The MOST provide toolkit to assess methods, objectives and levels. In order to The MOST project developed the MOST Monitoring and Evaluation Toolkit, providing different assessment methods, objectives and levels as well as successful strategies for the planning, implementation and evaluation of Mobility Management. The MOST is the first tool that undertakes a structured analysis of European, national, regional and local frameworks. The MOST also proved that city or regional administrators can implements Mobility Management.

Resources: [3] - [29] - [44] - [46] - [49]

Table 10: European Union – Sustainable Transport Projects

Category	Index Name	Indicators Used	Results
EU – Sustainable Transport Projects	TRANSFORUM	Indicators developed include: • Expenditures on transport • Number of fatalities in transport • GHG emissions by transport mode. • Emissions affecting local air pollution and share of substitute fuels. • People exposed to noise • Share of substitute fuels • Passenger and vehicle kilometres per mode and freight tonne kilometres per mode • Energy consumption of transport • GDP per zone, year	Sustainable development in itself not key driver but rather an auxiliary target to that of enhancing coherence and efficiency of transport policy. However, project develops ındicators for other projects and provide synthesis with other projects.

		• Trade and tonnes of freight per zone, year • Income (GDP/Population)	
	REFIT	REFIT offers a quantitative tool to evaluate transport policies. Indices include: • Freight transport costs • Car ownership rate • Passenger transport costs • Total emissions of NOx/SO2/CO2/CO/PM • Emissions of NOx/SO2/CO2/CO/PM from road, rail, air, inland waterways traffic • Population exposure to PM emissions • Population exposure to noise	Developed indices to evaluate sustainability of transportation. Provides quantitative tools for policy makers to measure sustainability of the transport.
	TRANS-TOOLS	Indices cover below items • Accident rates for the year • Emission factors (g/vkm) for the transport mode (car, train, bus…): • Supplier Operating Costs public transport:	Focus on sustainable transport but not sustainable development. Built on existing data and con not provide practical tools for policy makers.
	BEST (Thematic Network on Benchmarking in Transport)	BEST conferences provided five types of benchmarking related with policy: • Policy on benchmarking; • Benchmarking into policy; • Benchmarking for policy; • Benchmarking of policy; and • Benchmarking of policy making	BEST - Thematic network on benchmarking in transport consists of series of six conference over three years. Each conference has different headline that address different theme relating to transport benchmarking. Basis on conference presentations and discussions, the network produces recommendations and provide practical tool to assist European Commission and related parties in order to implement sustainable and competitive transport policies in Europe
	TRANS-TALK (Thematic Network on Policy and Project Evaluation Methodologies)	TRANS-TALK consists of three workshops: conceptual, empirical, policy relevant. At the conceptual part realized that conventional methods such as cost-benefit analysis are not adequate for current challenges. Empirical level reflects problems of choice among a multitude of methodologies and of measurement and comparison. At third level- policy relevant, instead of short term direct inputs, there is over-demand for evaluation that looks at the long term outcomes of policy. TT also implied literature reviews, publication of conferences, and the publishing-synthesis of each workshops conclusions.	EU's transport impact evaluation is basis on cost-benefit analysis and multi criteria analysis. However, environmental impacts, noise and local air pollution are included in appraisal across EU Member States but only half of them are valued in monetary terms. Due to lack of harmonized, integrated transport data, forecast, models and scenarios.

	STELLA (Sustainable Transport in Europe and Links and Liaisons with America)	STELLA creates a platform to exchange, data, knowledge and experience between North America and EU transportation experts. Creating Focus groups, organizing meetings within groups and cross groups, formulation of a policy research agenda and a future Transatlantic research cooperation plan.	Novel policy issues explored and identified; new policy research direction for Transatlantic was determined. Results were grouped under three main research area: strategic policy issues, social well-being and human behavior issues, and policy handles and policy research.

Resource: [6] - [21] -[49] - [51]

CONCLUSION

This paper covers an overview of various transportation sustainability indices and tools which are practically implemented to measure sustainable development. It has been tried to compile the information about how index were created by using which sub-factors and calculation methodologies. According to these information, it can be understood that most of the indices have same policy practice to measure sustainability, which are normalization, weighting and aggregation. Especially in normalization and weighting procedure mostly subjective judgment methods are employed. These methods are analytical hierarchy process (AHP), life cycle analysis (LCA), principal component analysis (PCA). Thus, indices have been subject to subjectivity despite the relative objectivity of the methods employed in measuring. For the aggregation, there are scientific rules that guarantee consistency and meaningfulness of the indices.

Moreover, when factors that are used in indices to measure sustainability are examined it is seen that resource-related factors, environment-related factors, economy-related factors and human-related factors mostly used factors. Table 12 shows factors sub-factors.

Table 12: Factors used in Indices

Factors	**Sub -factors**
Resource-related factors	Waste recycling Energy intensity Water consumption
Environment-related factors	Emission of greenhouse gases Air quality Ecological footprint Global warming Ozone depletion Toxic releases Noise
Economy-related factors	Growth in per-capita Unemployment
Human-related factors	Healthy life Sufficient food & drink

Source: Compiled by Authors

Although there are various international efforts on measuring transportation sustainability most of the indices, tools and projects only focuses one aspect of the sustainability. Creating an index which covers three aspects of the sustainability can be a future research idea by using factors that are explained below or any other type of factors. Moreover, a comprehensive literature review about measuring transportation sustainability should be made for academic literature to see what type of measurement tools has been prepared for measuring transportation sustainability.

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TRAIN SCHEDULING PROBLEM - PHASE III: SIMULATION INTEGRATED HYBRID GENETIC ALGORITHMS

Özgür Yalçınkaya[1]

Abstract − In [3] a feasible timetable generator stochastic simulation modeling framework for the train scheduling problem was developed to obtain a train timetable which includes train arrival and departure times at all visited stations and calculated average train travel time for all trains in the system. The framework can be used for both train scheduling/timetabling and rescheduling/dispatching problems. In [4], the framework is integrated with a genetic algorithm (GA) to get an optimal or suboptimal feasible train timetable with minimum average train travel time. In this study, the GA is hybridized with problem specific local searches in order to improve its searching capability and then each hybrid GA is integrated with the simulation framework. The proposed solution algorithms can be used for both train scheduling/timetabling and rescheduling/dispatching problems.

Keywords − Train scheduling, train rescheduling, hybrid genetic algorithms, optimization

INTRODUCTION

Train scheduling problem is the problem of determining a timetable for a set of trains that do not violate track capacities and satisfies some operational constraints. A general train scheduling problem in the literature considers a single track linking two major stations with a number of intermediate stations in between [1]. In [2] the main studies dealing with the problem are surveyed.

In the first phase [3] a feasible timetable generator stochastic simulation modeling framework for the train scheduling problem was developed to obtain a train timetable that includes train arrival and departure times at all visited stations and calculated average train travel time for all trains in the system. The inputs, random variables and output of the simulation model are exhibited in Figure 1 in a black-box shape. The framework can be used for both the train scheduling/timetabling and the rescheduling/dispatching problems.

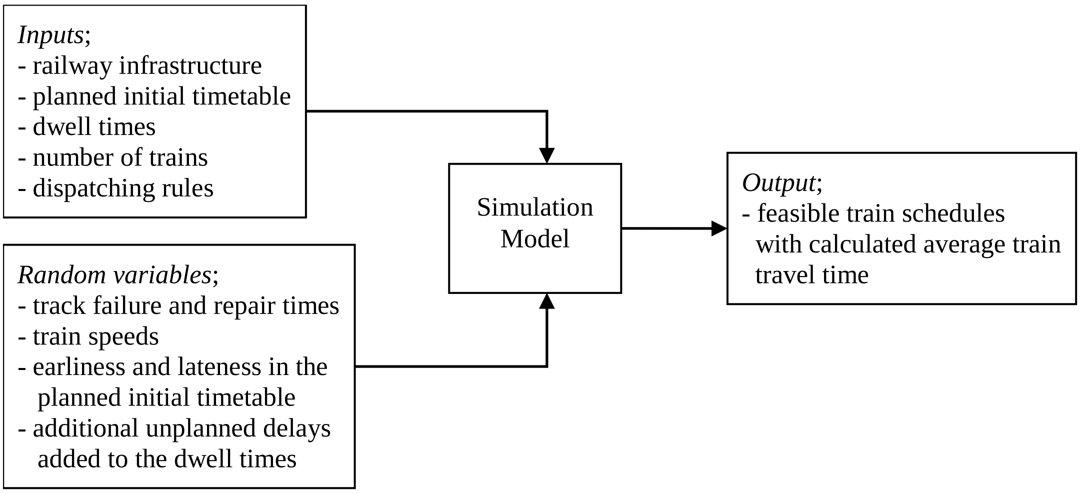

Figure 10. Black-box of the simulation model

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In the second phase [4], the framework is integrated with a GA (*SimGA*) to get an optimal or suboptimal feasible train timetable with minimum average train travel time. The framework of the developed *SimGA* is briefly exhibited Table 1.

In this Phase III, *SimGA* is hybridized with problem specific local searches in order to improve its searching capability and then each hybrid GA is integrated with the simulation framework. The proposed solution algorithms can be used for both the train scheduling/timetabling and the rescheduling/dispatching problems.

Table 1. Framework of the *SimGA* [4]

Begin *SimGA*
Generate INITIAL POPULATION (Sub steps are given in Table 2 in [4])
Rank the initial population
Rank the initial population according to the fitness values of the chromosomes
Select best of the initial population
Record the best fitness value and related chromosome
GN; generation number
maxGN; maximum generation number
From GN = 1 to GN = maxGN
CROSSOVER (Sub steps are given in Table 3 in [4])
MUTATION (Sub steps are given in Table 4 in [4])
Rank the population
The current population includes; individuals from the previous generation population, children and mutated child(ren)
Select best of the population
Record the best fitness value and related chromosome
Check TERMINATION CRITERIA (Sub steps are given in Table 5 in [4])
Form the population of the next generation
Form by using the ranked population adhered to the **PS**
Next GN
Stop *SimGA*

SIMULATION INTEGRATED HYBRID GA

Although *SimGA* [4] itself is a hybrid of the simulation model with GA, in this phase it is hybridized with problem specific local searches in order to improve its search capability and then each hybrid GA is integrated with the previously developed simulation framework in [3].

Three LS algorithms are used for hybridization:

(1) Local search on the best (*SimGAb*),
(2) Local search on the first and the second best (*SimGAfs*), and
(3) Local search on the best and the worst (*SimGAbw*).

Simulation integrated *GAb* (*SimGAb*)

While implementing GA, after the best chromosome in the new generation is found, some problem specific neighbors of it are searched via *SimGAb*. The framework is given in Table 2.

Table 2. Framework of the *SimGAb*

Begin *SimGAb*
Generate INITIAL POPULATION (Table 2 in [4])
Rank the initial population
Select best of the initial population
GN; generation number
maxGN; maximum generation number
From GN = 1 to GN = maxGN
CROSSOVER (Table 3 in [4])
MUTATION (Table 4 in [4])
Rank the population
The current population includes; individuals from the previous generation population, children and mutated child(ren)
Select best of the population

LOCAL SEARCH on the best
Search neighbours of the best chromosome
bChr(GN); the best chromosome in the current generation
bChr(GN) = [i_1, i_2, i_3, i_4, i_5, i_6, i_7, i_8, i_9]
From p =1 to p = 9
$\boldsymbol{i_p}$; the gene related with p^{th} decision point
If i_p = 1 change the value to 2
If i_p = 2 change the value to 1
If i_p = 3 change the value to 4
If i_p = 4 change the value to 3
If i_p = 5 change the value to 6
If i_p = 6 change the value to 5
nbChr(GN, *p*); p^{th} neighbour of the best chromosome
Rearrange the simulation model (Table 2 in [4])
Run the rearranged simulation model (Table 2 in [4])
Calculate the fitness value
Next p
Rank the population
The current population includes; individuals from the previous generation population, children, mutated child(ren) and nine neighbours of the best chromosome
Select best of the population
Check TERMINATION CRITERIA (Table 5 in [4])
Form the population of the next generation
Next GN
Stop *SimGAb*

Verbally to obtain a problem specific neighbour, every time only one gene of the best chromosome is changed using the *opposite pair* rule [4]. For instance, if the dispatching rule on use is FCFS, it is altered to LCFS, or if it is ShrCTT it is altered to LngCTT, or if it is ShrRTP it is altered to LngRTP. Each time only one gene is changed, and thus for each generation nine neighbours are obtained by the local search on the best algorithm. The simulation model is rearranged and run for 20 replications for the each neighbour, and the average train travel time value is noted to be the fitness value of the neighbour.

Simulation integrated *GAfs* (*SimGAfs*)

After the first and the second best chromosomes in the new generation are found, some problem specific neighbours of them are searched with the local search on the first and the second best algorithm depicted in Table 3.

Table 3. Framework of the *SimGAfs*

Begin *SimGAfs*
Generate INITIAL POPULATION (Table 2 in [4])
Rank the initial population
Select best of the initial population
GN; generation number
maxGN; maximum generation number
From GN = 1 to GN = maxGN
CROSSOVER (Table 3 in [4])
MUTATION (Table 4 in [4])
Rank the population
The current population includes; individuals from the previous generation population, children and mutated child(ren)
Select best of the population
LOCAL SEARCH on the best (Table 2 in this study)
Select the second best of the population
Record the second best fitness value and related chromosome
LOCAL SEARCH on the second best
Search neighbours of the second best chromosome
sbChr(GN); the second best chromosome in the current generation
sbChr(GN) = [i_1, i_2, i_3, i_4, i_5, i_6, i_7, i_8, i_9]
From p =1 to p = 9
$\boldsymbol{i_p}$; the gene related with p^{th} decision point
If i_p = 1 change the value to 2
If i_p = 2 change the value to 1
If i_p = 3 change the value to 4

If i_p = 4 change the value to 3 If i_p = 5 change the value to 6 If i_p = 6 change the value to 5 **nsbChr(GN, *p*)**; p^{th} neighbour of the second best chromosome **Rearrange the simulation model** (Table 2 in [4]) **Run the rearranged simulation model** (Table 2 in [4]) **Calculate the fitness value** Next *p* **Rank the population** The current population includes; individuals from the previous generation population, children, mutated child(ren), nine neighbours of the best chromosome, and nine neighbours of the second best chromosome **Select best of the population** **Check TERMINATION CRITERIA** (Table 5 in Yalçınkaya [4]) **Form the population of the next generation** Next GN **Stop *SimGAfs***

Simulation integrated *GAbw* (*SimGAbw*)

After the best and the worst chromosomes in the new generation are found, their problem specific some neighbours are searched with the local search on the best and the worst algorithm exhibited in Table 4.

Table 4. Framework of the *SimGAbw*

Begin *SimGAbw* **Generate INITIAL POPULATION** (Table 2 in [4]) **Rank the initial population** **Select best of the initial population** **GN**; generation number **maxGN**; maximum generation number From GN = 1 to GN = maxGN **CROSSOVER** (Table 3 in [4]) **MUTATION** (Table 4 in [4]) **Rank the population** The current population includes; individuals from the previous generation population, children and mutated child(ren) **Select best of the population** **LOCAL SEARCH on the best** (Table 2 in this study) **Select the worst of the population** Record the worst fitness value and related chromosome **LOCAL SEARCH on the worst** **Search neighbours of the worst chromosome** **wChr(GN)**; the worst chromosome in the current generation **wChr(GN)** = [i_1, i_2, i_3, i_4, i_5, i_6, i_7, i_8, i_9] From *p* =1 to *p* = 9 $\boldsymbol{i_p}$; the gene related with p^{th} decision point If i_p = 1 change the value to 2 If i_p = 2 change the value to 1 If i_p = 3 change the value to 4 If i_p = 4 change the value to 3 If i_p = 5 change the value to 6 If i_p = 6 change the value to 5 **nwChr(GN, *p*)**; p^{th} neighbour of the worst chromosome **Rearrange the simulation model** (Table 2 in [4]) **Run the rearranged simulation model** (Table 2 in [4]) **Calculate the fitness value** Next *p* **Rank the population** The current population includes; individuals from the previous generation population, children, mutated child(ren), nine neighbours of the best chromosome, and nine neighbours of the worst chromosome **Select best of the population** **Check TERMINATION CRITERIA** (Table 5 in [4]) **Form the population of the next generation** Next GN **Stop *SimGAbw***

DISCUSSION OF THE RESULTS

The algorithms are run for each *Population Size (PS) / Crossover Rate (CR) / Mutation Rate (MR)* combination. The first conducted algorithm is *SimGA* and the results were discussed in [4]. The second conducted algorithm is *SimGAb*. With this algorithm in all PS/CR/MR combinations the best value is reached, the earliest generation number is three, in the combinations 30/0.4/0.3 and 30/0.6/0.2, and the latest generation number is 56 in 10/0.4/0.1.

The third conducted algorithm is *SimGAfs*. With it, the best value is reached in all PS/CR/MR combinations. The earliest generation number is two in 10/0.4/0.1 and it is noted that *SimGAfs* has the minimum generation number among the presented algorithms. The latest generation number is 34 and the combination is 10/0.6/0.1.

The fourth conducted algorithm is *SimGAbw*. Except the combination of 10/0.8/0.1, all the other PS/CR/MR has the best value with this algorithm. The earliest generation number is three and appeared in combinations 10/0.4/0.1, 20/0.8/0.2 and 30/0.4/0.3. Although *SimGAbw* is run for 100 generations for 10/0.8/0.1 the best fitness value cannot be approached, but it gets very close to the best and it is the only combination in which the best value cannot be arrived. The reached average train travel time is 20753.02 seconds that is only 10.09 seconds (0.049%) more than the best (20742.93 seconds). In 10/0.8/0.1 the algorithm trapped in a local optimum just in the second generation, and cannot get out.

Only one combination in 108 PS/CR/MR combinations gets trapped in a local optimum. Although some of the other combinations visited a local optimum, they were able to get out. To see the variation in fitness values some combinations are discussed in below parts.

At first, the results of **10/0.4/MR** combinations are discussed. Here, while the parameter MR takes the values 10%, 20% or 30%, PS and CR are set to be 10 and 40%, respectively. The earliest generation number belongs to *SimGAfs* and is equal to two, the latest generation number (56) appears in *SimGAb* both in 10/0.4/0.1.

For combination of **10/0.4/0.1** it is seen that:

(a1) *SimGA* reached the best in 25th generation in six steps.

(a2) *SimGAb* reached the best in 56th generation in three steps

(a3) *SimGAfs* reached the best in 2nd generation, which is the best generation number, in two steps.

(a4) *SimGAbw* reached the best in 3rd generation in three steps.

Although all algorithms reached the best *SimGAfs* and *SimGAbw* arrived very fast.

On the other hand, in combination **10/0.4/0.2** it is seen that:

(a5) *SimGA* reached the best in 16th generation in five steps.

(a6) *SimGAb* and *SimGAfs* reached the best in the same 29th generation in the same four steps.

(a7) *SimGAbw* reached the best in 20th generation in five steps.

All algorithms reached the best, the fastest is *SimGA*.

And for **10/0.4/0.3** combination it is seen that:

(a8) *SimGA* reached the best at 13th generation in six steps.

(a9) *SimGAb*, *SimGAfs* and *SimGAbw* reached the best in the same generation, 28th generation, in the same four steps.

Here, the fastest is *SimGA*, the others show same pattern.

Secondly the results of **20/CR/0.2** combinations are looked. Here, while the CR takes the values 40%, 60% or 80%, the PS and MR are set to be 20 and 20%, respectively. The earliest generation number belongs to *SimGAbw* and is equal to three, in 20/0.8/0.2. The latest generation number (19) appears in *SimGAb* in 20/0.4/0.2.

In combination **20/0.4/0.2** it is seen that:

(b1) *SimGA* reached the best in 12th generation in five steps. The fitness value reached in 5th generation, 20743.05 seconds, is a local optimum and it is very close to the reached optimum, it is the nearest local. It is only 0.12 seconds more that the best that is 20742.93 seconds.

(b2) *SimGAb* reached the best in 19th generation in three steps.

(b3) *SimGAfs* reached the best in 6th generation in three steps, and it is seen that it reached to the nearest local in an early (2nd) generation.

(b4) *SimGAbw* reached the best in 6th generation in four steps, with reaching to the nearest local in 3rd generation.

SimGAfs and *SimGAbw* reached the best fast. Except *SimGAb*, all algorithms visited the nearest local in early generations but they had the ability to escape from it.

For **20/0.6/0.2** combination it is seen that:

(b5) *SimGA* reached the best in 15th generation in five steps.

(b6) *SimGAb* and *SimGAbw* reached the best in the same 7th generation in the same four steps, and both reached to the nearest local in 3rd generation.

(b7) *SimGAfs* has nearly the same pattern with *SimGAb* and *SimGAbw*, but reached the best in 6th generation in four steps, again the nearest local reached in 3rd generation.

Except *SimGA*, the others reached the best in early generations and also visited the nearest local, and achieved to escape.

On the other hand, in **20/0.8/0.2** combination it is seen that:

(b8) *SimGA* reached the best in 17th generation in eight steps.

(b9) Both *SimGAb* and *SimGAfs* reached the best in the same 8th generation in the same four steps, in addition they both reached to the nearest local in 3rd generation.

(b10) *SimGAbw* reached the best very fast in 3rd generation in three steps.

Except *SimGA*, the others reached the best in early generations and also visited the nearest local, and achieved to escape.

Lastly, the results of **PS/0.8/0.1** combinations are discussed; here while the PS takes the values 10, 20 or 30, the CR and MR are set to 80% and 10%, respectively. The earliest generation number belongs to *SimGA* and is equal to six, in 30/0.8/0.1. Although *SimGAbw* is run for 100 generations, the best fitness value cannot be reached in 10/0.8/0.1 combination, in this combination, in an early (2nd) generation it trapped in one of a local and cannot get away from it.

For **10/0.8/0.1** combination it is seen that:

(c1) *SimGA* reached the best in 31st generation in five steps.

(c2) *SimGAb* and *SimGAfs* both reached the best in the same 14th generation in the same four steps.

(c3) *SimGAbw* trapped in a local in 2nd generation and cannot get away in additional 98 generations.

Except *SimGAbw*, the other algorithms reached the best.

In combination **20/0.8/0.1** it is seen that:

(c4) *SimGA* reached the best in 10th generation in five steps.

(c5) *SimGAb* reached the best in 16th generation in four steps, with the nearest local reached in an early (3rd) generation.

(c6) Both *SimGAfs* and *SimGAbw* reached the best in the same 7th generation in the same four steps, and it is seen that the fitness value reached at the 3rd generation is the nearest local.

Here, except *SimGA*, the others visited the nearest local.

For the **30/0.8/0.1** combination it is seen that:

(c7) *SimGA* reached the best in 6^{th} generation in six.

(c8) *SimGAb* reached the best in 10^{th} generation in four steps, and the nearest local reached in 3^{rd} generation.

(c9) *SimGAfs* reached the best in 10^{th} generation in five steps and also visited the nearest local in 5^{th} generation.

(c10) *SimGAbw* reached the best in a late generation (38^{th}) in four steps although it reached the nearest local in an early (just 3^{rd}) generation.

Except *SimGA*, the others visited the nearest local.

After giving this information as a result it can be said that all algorithms have an ability to escape from a very near local point and reach the best, but generally *SimGAb*, *SimGAfs* and *SimGAbw* visit the nearest local in early generations.

CONCLUSION

In this study, the previously developed *SimGA* [3] is hybridized with problem specific local searches in order to improve its searching capability and then each hybrid GA is integrated with the simulation framework [4].

The presented algorithms are run for each PS/CR/MR combination, and the obtained results are discussed. It is seen that the developed algorithms have an ability to escape from a very near local point and reach the best.

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A HYBRID GENETIC ALGORITHM APPROACH FOR OPTIMIZING A CLOSED LOOP SUPPLY CHAIN NETWORK INSPIRED BY AUTOMOTIVE RECYCLING

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Abstract – *Closed-loop supply chain management has gained more attention in the last decade because of the environmental laws in industry, global warming, customer awareness and economical competition. Moreover, companies can achieve a significant profit on original equipment manufacturing, transportation and raw material costs with the help of optimal collection, dismantling, refurbishing and reproduction activities. This paper presents a mixed integer linear programming model which inspired from an automotive industry that consist of raw material suppliers, suppliers, plants, distribution centers, customers, collection centers, dismantler centers and refurbishing centers. In this study, a new constraint that provides both product basis and piece basis flows simultaneously inside the system is proposed. The main objective of this model is to minimize the transportation, purchasing and refurbishing costs while satisfying the demands of customers. When the present's model tested with different solution sets, computational times grew exponentially so we proposed a novel Hybrid Genetic Algorithm approach which aimed to achieve better results in less time by scanning specific area rather than a whole solution space. The solution shows that the proposed approach performs very well in terms of both computational time and quality of solution.*

Keywords - Hybrid Genetic Algorithm, Closed-Loop Supply Chain, Reverse Logistics, Mixed Integer Linear Programming

INTRODUCTION

In the classical sense, the supply chain is described as; the process including the purchasing of raw materials by plants and transporting the products to the distributors and then to the customers after the realization of the production. However, there is only a single and forward flow in the classic supply chains. A new supply chain structure emerges where the reverse flow also occurs because of adding some recycling activities as disassembly, re-use, refurbishment, disposal in an environmentally sound manner as a result of environmental problems faced today and legal obligations and this situation is called as Closed Loop Supply Chain (CLSC) in literature. CLSC could be described as the integrated network structures where the forward and reverse flow occurs [9]. The automotive industry that is one of the most important sectors in our country came to the fore while there is searched an answer for the question that on which sectors the CLSC network design model can primarily provide positive feedbacks and show the impact of it. The CLSC applications became compulsory for the vehicles whose lifetime ended as a result of gradual reduction of resources in automotive industry and increasing need for recycled products.

In this study, a mixed integer linear programming model is suggested for CLSC network design by using Turkey's automotive sector as a base and, the solution is searched by suggesting a hybrid genetic approach for the solution of large-scale problems because of the NP hard of the model. The remaining part of the paper is organized as follows: The introduction section presents a literature review regarding to genetic algorithm and related studies on CLSC, than describes the problem, introduces the proposed multi-level model for the CLSC and mathematical formulation and proposed hybrid genetic algorithm

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approach. Computational results are presented to show and validate the applicability of the model and finally some concluding remarks are given in conclusion section.

LITERATURE REVIEW

In this section, the studies where CLSCs and genetic algorithm approach are discussed together are scrutinized and it is targeted to reach the findings which will direct the study accordingly.

Sakawa and Nishizaki [11], [12] proposed the interactive fuzzy programming for multilevel 0-1 integer programming problems by using the genetic algorithm. In the study, there has been shown that the intuitive methods could also be applied in case the fuzzy parameters exist in interactive programming. Sakawa and Nishizaki [13] formulated interactive fuzzy programming by using the genetic algorithm for two-level nonlinear programming problems which include fuzzy parameters. In the study, Zhou et al. [21] proposed a nonlinear KTP model where distribution problems and forward and reverse logistics network are discussed simultaneously for determining the number and place of recycling plants and they used the genetic algorithm approach as a solution method.

Ko and Evans [8] developed a multi-period, multi-stage, multi-product and capacity general network structure. The system coordinates the forward/reverse flows simultaneously. They formulated with MINLP method and got the results of the solution with the genetic algorithm. The purpose is getting the result which ameliorates the cost in the best way. Haikou [5] discussed a reverse logistics network problems where customers, collection centers, repair centers and fabrics exist. An intuitive model based on the genetic algorithm has been developed for the model which was designed for minimizing all costs and, there was determined with the scenario analysis performed that the model gave a better result in comparison with the other models in terms of processing time and finding the most suitable solution. Keskin and Uster [7] proposed a hybrid messy search algorithm approach for the model that they developed for the location of authorized transfer centers. At the end of the study, there was specified that the initial search parameters affected the performance and the values of messy search algorithm decreased the total solution time and a significant increase in the quality of solution were determined as well.

Tang and Xie [16] discussed a reverse logistics network problems which include customers, collection centers, repair centers and fabrics. An intuitive model based on the genetic algorithm has been developed for the model which was designed for minimizing all costs and, there was determined with the scenario analysis performed that the model gave a better result in comparison with the other models in terms of processing time and finding the most suitable solution. Shi et al. [14] developed a reverse logistics network design for medical waste which includes collection centers, facilities and processing center inside. They developed KTDP model in their study for minimizing the total costs consisting of fixed costs, operating costs and transportation costs of the facilities which exist in reverse logistics network and they used genetic algorithm method as a solution method.

Altıparmak et al. [1] proposed the stable genetic algorithm approach that is a solution procedure based and has a new coding structure for a multi-product, multi-level and single-source supply chain network design. In this solution approach, a hybrid method has been developed by using the genetic method and linear programming together for forward supply chain network design. Kannan et al. [6] developed a multi-stage, multi-period, multi-product KDTZ model which discuss the producing, distributing, recycling and disposal of waste batteries and they solved it with the help of a genetic algorithm-based intuitive. The authors compared the solutions obtained from the algorithm that they developed for small scale problems with the best solutions obtained from GAMS software package. Qin and Ji [17] mentioned that the uncertainties lived in the process also made the situation even more complicated as well as in their study where they specified that designing the product recycling networks is one of the most important and difficult problems of reverse supply chains. Three (3) kinds of optimization model have been proposed also in the study based on different criteria and they also proposed a hybrid algorithm consisting of the combination of genetic algorithms and fuzzy simulation. In conclusion, they have also made some numerical analysis for showing the validity of the model

Zarei [20] discussed new product distribution network and recycling network together in his study where he emphasized the importance of the methods chosen for re-collecting and reprocessing for end-of-life vehicles (ELV) and he developed an integrated network design for this purpose. A model which aims to minimize the costs of transport and network design was proposed in the study where the new product distributors are supposed to be responsible also for collecting of ELVs. The genetic algorithm solution approach has been used as a solution method because of the complexity and size of the model. Wang and Hsu [18] formulated a general CLSC network design problem by using the DLP method. At the same time, an NP which would provide the minimum cost for the decision of choosing the place of the facilities located on CLSC model was developed and genetic algorithm based on spanning tree algorithm was used for the solution of this model. Soleimani et al. [15] developed a multi-stage, multi-product, multi-period CLCS network model. They used CPLEX software and genetic algorithm for the solution of the model. This is a multi-product network design where intuitive models are used.

Demirel et al. [3] proposed KTDP for a multi-product and multi-purpose CLCS network design which approaches financial incentive policies and secondhand price policy in their study. The fuzzy goals have been added to the developed model in order to answer the uncertainties in CLCS and later on, the genetic algorithm approach was proposed in order to be used on a life-sized application. A hybrid solution method was presented in proposed solution approach where the genetic algorithm was used. In their study, Roghanian and Pazhoheshfar [10] proposed probabilistic KTDP mode for a reverse logistics network where the uncertainties about the demand, capacity, and product quantity are considered. This model which has been turned into the equivalent deterministic model later also aims to provide satisfaction on demand while it minimizes the fixed opening costs and total cost of transport under unclear circumstances. The priority-based genetic algorithm was proposed for the solution of the model developed for this purpose and the study was tested by experimental analysis.

At it is seen, although there are not the significant number of studies for genetic algorithm approaches to CLCS models and the solutions of them in literature, the number of studies for which the solution is searched by the hybrid genetic algorithm approach quite limited. This study presented in this regard will have the feature to be a pioneering publication. The proposed mathematical model will be explained in the last section.

PROBLEM DEFINITION AND MODEL FORMULATION

Problem Definition

In this section basic model the network begins with the purchase of raw materials over the tonnage in specific proportions from the raw material suppliers to be used in suppliers. Converting raw materials into usable parts processed by suppliers then parts are delivered to the plants ready to be assembled for use in productions. The obtained products are delivered to distribution centers. Finally, the products are delivered to customers through distribution centers. Reverse flow starts with the collection of used products from collection centers and customers. According to the developed model; it is assumed that all the products used by customers are transferred to the collection centers after one period usage and then transported to the dismantler centers. The products at the dismantler centers are evaluated in four different categories according to their structures and qualifications.

Further assumptions about the problem as follows:

- The demand for each product is for multi-periods, is deterministic, and must be fully satisfied.
- The cost of transportation, purchasing, refurbishing, and opening facilities, are fixed and deterministic.
- Transportation, purchasing, refurbishing, and fixed costs are deterministic and known a priori.
- Collection, disposal, and disassembly rates are known a priori.
- No waste assumed during the part production from raw material.
- Each reversed product (car) weight assumed 1 ton.
- There is no difference between the original parts sent from suppliers to plants and used parts renewed by refurbishing centers.

- Sum of the percentage of parts to sending from dismantler centre to the other centers such as refurbishing centre, raw material suppliers, customers, disposal are equal to 1. So $\eta+\kappa+\lambda+\mu = 1$.
- Transportation costs are not change by part/component size and type.
- The capacities of all facilities both forward and reverse are limited and fixed.
- Inventory and shortages are not allowed.

Model Formulation

The sets, parameters, decision variables and mixed-integer mathematical model, which provides all of the above-mentioned decisions and assumptions, are presented below:

Sets

r	set of raw material suppliers,
i	set of suppliers,
j	set of plants,
k	set of retailers,
l	set of customers,
m	set of collection centers,
h	set of dismantler centers,
q	set of refurbishing centers,
c	set of parts,
p	set of periods,
w	set of raw materials,

Parameters

v_{rwp}	capacity of raw material supplier r for raw material w in period p (ton),
a_{icp}	capacity of supplier i for part c in period p (ton),
b_{jp}	capacity of plant j in period p (ton),
c_{kp}	capacity of retailer k in period p (ton),
d_{lp}	demand of customer l in period p (ton),
d_{lcp}	demand of customer l for part c in period p (ton),
e_{mp}	capacity of collection centre m in period p (ton),
f_{hp}	capacity of dismantler centre h in period p (ton),
g_{qcp}	capacity of refurbishing centre q for part c in period p (ton),
Δ_{ri}	distance between raw material supplier r and supplier i (km),
Δ_{ij}	distance between supplier i and plant j (km),
Δ_{jk}	distance between plant j and retailer k (km),
Δ_{kl}	distance between retailer k and customer l (km),
Δ_{lm}	distance between customer l and collection centre m (km),
Δ_{mh}	distance between collection centre m and dismantler centre h (km),
Δ_{hl}	distance between dismantler centre h and customer l (km),
Δ_{hq}	distance between dismantler centre h and refurbishing centre q (km),
Δ_{hr}	distance between dismantler centre h and raw material supplier r (km),
Δ_{h}	distance between dismantler centre h and disposal (km),
Δ_{qj}	distance between refurbishing centre q and plant j (km),
Δ_{il}	distance between supplier i and customer l (km),
rw_{c}	the weight ratio of one part c in final product,
α_{jp}	the fixed opening cost for plant j in period p (\$),
β_{kp}	the fixed opening cost for retailer k in period p (\$),
γ_{mp}	the fixed opening cost for collection centre m in period p (\$),
θ_{hp}	the fixed opening cost for dismantler centre h in period p (\$),
t	unit cost of shipping (\$/ton*km),
poe_{ic}	price of original spare parts (\$/ton),
pue_{hc}	price of second hand (used) spare parts (\$/ton),

π_{ic} unit cost of purchasing of supplier *i* for part *c* ($/ton),
ρ_{qc} unit cost of refurbishing of refurbishing centre *q* for part *c* ($/ton),
rde_c revenue from each part which is sent from dismantler centre to customers ($/ton),
rre_c revenue from each part which is sent from dismantler centre to refurbishing centre ($/ton),
rbm revenue from bulk material which is sent from dismantler centre to raw material supplier ($/ton),
c_d disposal cost ($/ton),
H_p maximum available number of plants in period *p* (quantity),
G_p maximum available number of retailers in period *p* (quantity),
M_p maximum available number of collection centers in period *p* (quantity),
N_p maximum available number of dismantler centers in period *p* (quantity),
η percentage of part which is sent from dismantler centre to customer,
κ percentage of part which is sent from dismantler centre to refurbishing centre,
λ percentage of part which is sent from dismantler centre to raw material supplier,
μ percentage of part which is sent from dismantler centre to disposal.

Decision variables

A_{riwp} amount shipped from raw material supplier *r* to supplier *i* for raw material w in period *p* (ton),
X_{ijcp} amount shipped from supplier *i* to plant *j* for part *c* in period *p* (ton),
Y_{jkp} amount shipped from plant *j* to retailer *k* in period *p* (ton),
Z_{klp} amount shipped from retailer *k* to customer *l* in period *p* (ton),
W_{lmp} amount shipped from customer *l* to collection centre *m* in period *p* (ton),
L_{mhp} amount shipped from collection centre *m* to dismantler centre *h* in period *p* (ton),
R_{hlcp} amount shipped from dismantler centre *h* to customer *l* for part *c* in period *p* (ton),
U_{hqcp} amount shipped from dismantler centre *h* to refurbishing centre *q* for part *c* in period *p* (ton),
F_{hrwp} amount shipped from dismantler centre *h* to raw material supplier *r* for raw material *w* in period *p* (ton),
D_{hwp} amount shipped from dismantler centre *h* to disposal for raw material *w* in period *p* (ton),
I_{qjcp} amount shipped from refurbishing centre *q* to plant *j* for part *c* in period *p* (ton),
S_{ilcp} amount shipped from supplier *i* to customer *l* for part *c* in period *p* (ton),
H_{jp} If plant *j* is open in period *p*, 1; otherwise, 0,
G_{kp} If retailer *k* is open in period *p*, 1; otherwise, 0,
M_{mp} If collections center *m* is open in period *p*, 1; otherwise, 0,
N_{hp} If dismantler center *h* is open in period *p*, 1; otherwise, 0.

Objective Function

Minimize

$$t.\,(\sum_r\sum_i\sum_w\sum_p A_{riwp}.\Delta_{ri} + \sum_i\sum_j\sum_c\sum_p X_{ijcp}.\Delta_{ij} + \sum_j\sum_k\sum_p Y_{jkp}.\Delta_{jk} + \sum_k\sum_l\sum_p Z_{klp}.\Delta_{kl} + \sum_l\sum_m\sum_p W_{lmp}.\Delta_{lm} + \sum_m\sum_h\sum_p L_{mhp}.\Delta_{mh} + \sum_h\sum_l\sum_c\sum_p R_{hlcp}.\Delta_{hl} + \sum_h\sum_q\sum_c\sum_p U_{hqcp}.\Delta_{hq} + \sum_h\sum_r\sum_w\sum_p F_{hrwp}.\Delta_{hr} + \sum_h\sum_w\sum_p D_{hwp}.\Delta_{h} + \sum_q\sum_j\sum_c\sum_p I_{qjcp}.\Delta_{qj} + \sum_i\sum_l\sum_c\sum_p S_{ilcp}.\Delta_{il}) + \quad (1)$$

$$\sum_i\sum_j\sum_c\sum_p X_{ijcp}.\pi_{ic} + \quad (2)$$

$$\sum_q\sum_j\sum_c\sum_p I_{qjcp}.\rho_{qc} + \quad (3)$$

$$\sum_j\sum_p H_{jp}.\alpha_{jp} + \sum_k\sum_p G_{kp}.\beta_{kp} + \sum_m\sum_p M_{mp}.\gamma_{mp} + \sum_h\sum_p N_{hp}.\theta_{hp} \quad (4)$$

Constraints

$\sum_i A_{riwp} \leq v_{rwp}$ $\forall_{r,w,p}$ (5)

$\sum_l S_{ilcp} + \sum_j X_{ijcp} \leq a_{icp}$ $\forall_{i,c,p}$ (6)

$\sum_k Y_{jkp} \leq b_{jp}.H_{jp}$ $\forall_{j,p}$ (7)

$\sum_l Z_{klp} \leq c_{kp}.G_{kp}$ $\forall_{k,p}$ (8)

$\sum_h L_{mhp} \leq e_{mp}.M_{mp}$ $\forall_{m,p}$ (9)

$D_{hwp} + \sum_l R_{hlcp} + \sum_q U_{hqcp} + \sum_r F_{hrwp} \leq f_{hp}.N_{hp}$ $\forall_{h,c,w,p}$ (10)

$\sum_j I_{qjcp} \leq g_{qcp}$ $\forall_{q,c,p}$ (11)

$\sum_k Z_{klp} \geq d_{lp}$ $\forall_{l,p}$ (12)

$\sum_h R_{hlcp} + \sum_i S_{ilcp} \geq d_{lcp}$ $\forall_{l,c,p}$ (13)

$\sum_j H_{jp} \leq H_p$ $\forall_p$ (14)

$\sum_k G_{kp} \leq G_p$ $\forall_p$ (15)

$\sum_m M_{mp} \leq M_p$ $\forall_p$ (16)

$\sum_h N_{hp} \leq N_p$ $\forall_p$ (17)

$\sum_r \sum_w A_{riwp} - \sum_j \sum_c X_{ijcp} - \sum_l \sum_c S_{ilcp} = 0$ $\forall_{i,p}$ (18)

$\sum_i X_{ijcp} + \sum_q I_{qjc(p-1)} - r_{wc}.\sum_k Y_{jkp} = 0$ $\forall_{j,p,c}$ (19)

$\sum_j Y_{jkp} - \sum_l Z_{klp} = 0$ $\forall_{k,p}$ (20)

$\sum_k Z_{klp} - \sum_m W_{lm(p+1)} = 0$ $\forall_{l,p}$ (21)

$\sum_i S_{ilcp} + \sum_h R_{hlcp} - B_{lc(p+1)} = 0$ $\forall_{l,p}$ (22)

$\sum_l W_{lmp} - \sum_h L_{mhp} = 0$ $\forall_{m,p}$ (23)

$\sum_c rw_c \,.\sum_m L_{mhp}\,.\,\eta - \sum_l \sum_c R_{hlcp} = 0$ $\forall_{h,p}$ (24)

$\sum_c rw_c \,.\sum_m L_{mhp}\,.\,\kappa - \sum_q \sum_c U_{hqcp} = 0$ $\forall_{h,p}$ (25)

$\sum_m L_{mhp}\,.\,\lambda - \sum_r \sum_w F_{hrwp} = 0$ $\forall_{h,p}$ (26)

$\sum_m L_{mhp}\,.\,\mu - \sum_w D_{hwp} = 0$ $\forall_{h,p}$ (27)

$\sum_h U_{hqcp} - \sum_j I_{qjcp} = 0$ $\forall_{q,c,p}$ (28)

$A_{riwp} \geq 0$ $\forall_{r,i,,w,p}$ (29)

$X_{ijcp} \geq 0$ $\forall_{i,j,c,p}$ (30)

$Y_{jkp} \geq 0$	$\forall_{j,k,p}$	(31)
$Z_{klp} \geq 0$	$\forall_{k,l,p}$	(32)
$W_{lmp} \geq 0$	$\forall_{l,m,p}$	(33)
$L_{mhp} \geq 0$	$\forall_{m,h,p}$	(34)
$U_{hqcp} \geq 0$	$\forall_{h,q,c,p}$	(35)
$F_{hrwp} \geq 0$	$\forall_{h,r,w,p}$	(36)
$R_{hlcp} \geq 0$	$\forall_{h,l,c,p}$	(37)
$S_{ilcp} \geq 0$	$\forall_{i,l,c,p}$	(38)
$I_{qicp} \geq 0$	$\forall_{q,i,c,p}$	(39)
$D_{hwp} \geq 0$	$\forall_{h,w,p}$	(40)
$H_{jp}, G_{kp}, M_{mp}, N_{hp} \in \{0,1\}$	$\forall_{j,k,m,h,p}$	(41)

The objective function has four components. The first component represents the cost of transportation on some arcs of the network in the forward and reverse chains (1). The second component represents the cost of purchasing over all products parts (2). The third components represents the cost of refurbishing of product parts (3) and the last component represents the fixed costs associated with locating the plants and retailers, respectively (4). Constraints (5) - (11) stipulate that the production and transportation amount must not exceed the capacity of raw material suppliers, suppliers, plants, distribution centers, collection centers, dismantler centers, and refurbishing centers, respectively. Constraints (12) and (13) ensure that demands for each product and each part must fully be met. Constraints (14) - (17) limit the number of plants, retailers, collection centers and dismantler centers that can be opened. Constraints (18) - (28) are the balance equations for the forward and reverse part facilities: the quantities that enter to these facilities must be equal to the amount of products/parts that leave the facilities. Constraints (29) - (40) enforce the non-negativity restriction on the decision variables. Lastly, constraint (41) represents the binary variables.

METHOD

GENETIC ALGORITHM BASED HYBRID SOLUTION APPROACH

The multi-stage logistics problems where the decisions for opening / not to open the facilities are taken are in NP hard class [4]. Generally, the use of meta-heuristic algorithms for the solution of such kinds of problems increased in recent years. Generally, the information about the supply chain and the applications of it were mentioned in the literature search section about the studies done regarding meta-heuristic.

Besides that, the hybridization algorithm is the approach which finds the place in literature in recent years. The fundamental philosophy in this approach that is generally used also in algorithms is examined in two parts as hybridization of two heuristic or hybridization of an heuristic and an algorithm gives a certain solution [2]. While we look at the literature, we can see some studies which hybridize the forward multi-level, multi-stage supply chain network designs and heuristic solution methods [19], [7], [1], [3].

There has been proposed a hybrid model where Genetic Algorithm and GAMS-Cplex are used together for the solution of proposed model. There has been targeted to reach the result in the shorter time with the active call which would scan a specific part of solution space instead of scanning the whole as a result of using GA. GA could be used in different types for the solution of a problem [1].

There has been used the binary coding in the step of forming chromosome structures for the solution for the problem. The length of chromosome developed has been determined as much as the total of the numbers of plants, distribution centers, collection centers and the decomposition centers (j+k+m+h). As a result of the use of binary coding, the genes consist of the numbers of genes [0 or 1]. The chromosome structure discussed consists of 4 (four) parts. The first part specifies the plants, the second part specifies the distribution centers, the third part specifies the collection centers and the last part specifies the decomposition centers. The positions of the genes in the chromosome (locus) state decisions about the facilities which will be/will not be opened. These values will be used in the determination of plants, distribution centers, collection centers and decomposition centers which would be opened in this model. The value of conformity has been evaluated as the objective function and discussed as mostly minimizing the total cost. The initial population has been created by using C ++ software package randomly.

First of all, the information about the plant, distribution center, collection center and decomposition center are obtained in the process of producing the chromosomal solution. Thus, first of all, the total costs for each individual who is in the initial population, will be calculated separately. Then, the complexity of multi-period, multi-stage, mixed integer mathematical model will decrease which was developed as a result of obtaining the determination transactions with heuristic algorithm about which plants, distribution centers, collection centers and decomposition center will be opened. The solution of reified problem with GAMS-Cplex will be easier and the nearly best results will be obtained in short periods.

FINDINGS

As it is seen in Table 5.1, two different approaches were used together in the solution phase about the genetic-based hybrid approach. These transactions which were made only for one data set in the first phase have been repeated for all data sets in dimensional analysis and the Table 5.9 was obtained accordingly.

The difference column in Table 5.1 was calculated by using the upper limit value given by GAMS and the value of objective function obtained from heuristic solution method as follows:

$$\%\,Difference = \frac{\text{GAMS (Upper Bound)} - \text{Hybrid GA}}{\text{GAMS (Upper Bound)}} * 100$$

Table 5.1. The Comparison of Heuristic Solution Method Developed and GAMS-Cplex Results

No	Problem Set	GAMS-Cplex		Hybrid GA		
		Objective Function	CPU Time (sc)	Objective Function	CPU Time (sc)	Difference (%)
1	5-4-3-3-6-2-3-3	✓ **23.812.537**	0.086	**23.749.327**	35.8	**0,27**
2	6-5-4-4-7-2-3-3	✓ **32.765.670**	0.74	**32.665.495**	36.1	**0,31**
3	7-6-5-5-8-3-4-4	✓ **49.148.505**	15	**48.884.814**	37.2	**0,54**
4	9-8-7-7-10-4-5-5	✓ **61.259.354**	143	**60.784.507**	37.6	**0,78**
5	10-9-8-8-11-4-5-5	✓ **78.637.608**	373	**78.383.316**	40.2	**0,32**
6	12-10-8-8-12-5-6-6	✓ **102.228.938**	138	**101.704.257**	41.5	**0,51**

7	13-11-9-9-13-5-6-6	✓ **107.340.354**	1475	**106.489.082**	46.7	**0,79**
8	15-13-11-11-14-6-7-7	✓ **115.264.657**	10253	**113.672.394**	52.1	**1,38**
9	18-15-13-12-16-7-8-8	✓ **123.628.452**	8122	**120.439.163**	59.3	**2,58**
10	20-18-15-14-16-8-10-10	✓ **130.696.038**	13725	**126.731.272**	65.5	**3,03**
11	23-20-17-16-18-10-11-11	**145.265.869**	> 36000	**140.598.379**	95.7	**3,21**
12	30-24-18-18-19-12-14-14	**253.990.179**	> 36000	**244.783.492**	133.4	**3,62**
✓ Optimal Solution						

The difference between the best solutions for the set of first 10 problems taken place in the Table 5.1 where the best solution is obtained with GAMS-Cplex and the results obtained from the developed solution method varied between %0.27 and %3.03. Although the heuristic solution methods do not guarantee the best result, the close results found for a model where the size of the problem was enlarged 12 times and which has 2585 variables and 1019 restrictions in its initial testing problem shows that the hybrid GA approach has given quite well results.

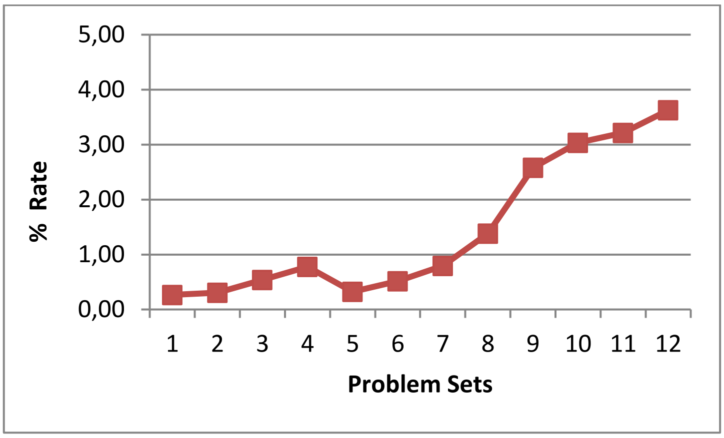

Figure 1. The % Differences Between the Results of GAMS and Hybrid GA

In Figure 5.1, the difference between results obtained from Hybrid GA Approach and GAMS-Cplex program was shown. According to this, the difference between the results continues under % 1 until 7th problem set. The difference has risen until % 3.53 in parallel with the growing of the size in later problem sets.

The variances of GAMS-Cplex approach and Hybrid GA approach in terms of solution times as long as the size of the problem grows are seen in Figure 5.2. According to this there was seen that the times of the solutions obtained with GAMS-Cplex package program increased exponentially. The difference between the solutions approaches which have the close solution times and which show the similarity until the sixth problem set spread dramatically after seventh problem set. This was also because of the NP hard nature of the problem and the exponential increase about the solution times is seen clearly from the graphic. The solution times stayed in certain limits within the proposed Hybrid GA Approach and they were solved in a very short time and the results seen in Figure 5.2 were obtained accordingly.

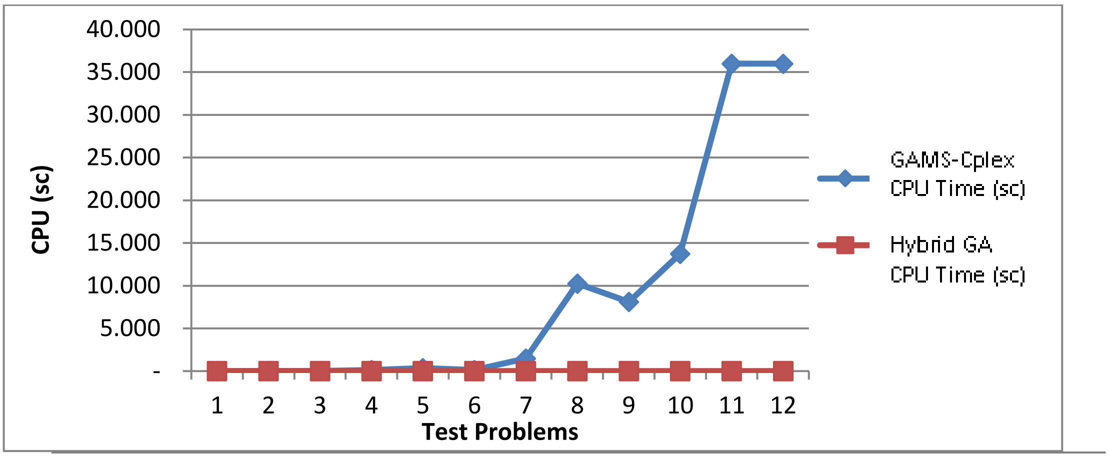

Figure 2. The Solution Times of GAMS and Hybrid GA Approaches for Different Data Sets

The impact of the increase in the size of the problem on the total cost was seen that the change in the dimensions of the problem also reflected on the costs evenly and the increase of costs showed similar changes. There is also seen the most significant change was lived on the transition between 11th problem set and 12th problem set. While the data sets are examined, it is clearly seen this situation originated because of the fast increase in the facilities which are in last problem set. There was also seen the Hybrid GA approach has given the results which were quite close to the definite solution value while the change in total costs was analyzed.

CONCLUSION

As a conclusion of the study, there has been seen that the solution time extends as long as the size of problem grows and there has been proposed a Genetic Algorithm-based hybrid solution approach because of the fact that the problem NP was difficult and the problem has been solved in a very shorter time with hybrid GA approach where the mathematical model was proposed and below results were obtained accordingly.

- Nearly the best results were taken while the Hybrid GA approach is evaluated over the solutions obtained with GAMS-Cplex. The difference was seen in the test problem done was determined as %3.53 mostly.
- The developed intuitive approach gave a solution in quite fast and the short time in comparison with GAMS-Cplex approach and there was not lived a significant change in the time of problem although the size of problem has grown.
- The data which were reached as a result of the solution of test problem showed that the proposed Hybrid GA approach performed quite well in reasonable period of time for KTDP models developed for CLCS network design.

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OPPOSITON-BASED WEIGHTED SUPERPOSITION ATTRACTION ALGORITHM FOR TRAVELLING SALESMAN PROBLEMS

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Abstract − *Weighted Superposition Attraction is a new metaheuristic algorithm which is recently proposed by the first author, has very effective results for continuous and combinatorial optimization problems. On the other hand, Opposition Based Learning is another effective technique that has high success rate for solving continuous and combinatorial optimization problems when it is combined with different algorithms. In this paper, two successful techniques for optimization problems, Weighted Superposition Attraction and Opposition Based Learning, are cooperated and Opposition-Based Weighted Superposition Attraction algorithm is proposed. The performance of the algorithm is tested on several travelling salesman problems. Preliminary results show that performance of the Opposition-Based Weighted Superposition Attraction algorithm has promising results in comparison to other approaches in the literature.*

Keywords − *Opposition Based Learning, Travelling Salesman Problem, Weighted Superposition Attraction*

1. INTRODUCTION

Many authors conducted research in swarm intelligence since it is very effective in solving combinatorial and functional optimization problems. Swarm intelligence algorithms mimic routine behavior of different swarms such as colonies of ants and termites, schools of fish, flocks of birds, herds of land animals etc. “Genetic algorithms(GA)” [1], “ant colony optimization(ACO)” [2] and “particle swarm optimization(PSO)” [3] are the most popular members of the swarm intelligence algorithms. Wahab et al. [4] presented a detailed review about metaheuristic algorithms which are based on swarm intelligence.

There are many other forms of livings that can be source of inspiration for developing effective optimization algorithms in the nature. Throughout this motivation, the first author recently introduced a new swarm intelligence based metaheuristic algorithm which was called as Weighted Superposition Attraction (WSA) algorithm to solve continuous and combinatorial optimization problems [5,6,7]. “Superposition” and “attracted movement of agents” are the two main mechanisms behind the WSA. Basically, we can define WSA as movements of different individuals towards an attractive superposition. As the life is dynamic, the structure of the WSA is also dynamic. The attraction point dynamically changes throughout individuals’ movements. Another important issue is that, it is easy to determine superposition in continuous domains by making use of vector arithmetic; on the other hand, it is complicated to represent superposition in combinatorial domains by making use vector arithmetic as permutation vectors do not lend themselves for such computations. Hence, in this paper a new method which was recently proposed by the authors is utilized for direct representation of superposition [16]. In addition, determining step length is very important issue for diversification, so that random walk (Lévy flight) mechanism is used as a way of determining step length. Opposition Based Learning (OBL) strategy is also collaborated with the proposed method for improving search performance further.

Traveling Salesman Problem (TSP) is one of the most famous operations research problems with many logistics implications. TSP is easy to understand. Despite its easiness in understanding, it is a problem of high computational complexity (NP-hard). There is not a polynomial time algorithm to solve this problem. As it is one of the most famous test beds for evaluating new algorithmic ideas, research on this

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problem is always active. In the current paper we applied the WSA algorithm to TSP first time in the literature. The preliminary results are very encouraging.

2. AN OVERVIEW OF WSA

WSA is a new metaheuristic algorithm which was introduced by the first author recently [5, 6, 7]. WSA is based on two basic principles “superposition” and “attracted movement of agents” that are observable in many natural and social systems. WSA, try to mimic dynamic changes in the superposition according to the lively nature of the system in combination with the attracted movement of agents [5, 6, 7].

2.1 Main phases of WSA

WSA has two main phases. The first phase is initialization phase and the other phase is the neighbor generation phase. Detailed information about phases of WSA can be found in following references [5, 6]. The main steps of the WSA algorithm are shown in Figure 1 along with notations and their definitions in Table1.

Table 1. Notations of WSA and their definitions

Maxiter iteration number (stopping condition)
Iteration current iteration number
AA number of artificial agents
D number of dimensions of the problem
τ user defined parameter
λ user defined parameter
ϕ user defined parameter
UL upper limit for the dimensions
LL lower limit for the dimensions
f(i) fitness of the current point of agent i
f(tar) fitness of the target point
weight weight of the current point of an agent
$\vec{x}$ current position vector of an agent
→ **tar** position vector of the target point
→ **gap** vector combines an agent to target point
→ **direct** move direction vector of an agent
sign() signum function
sl step length

```
1: Initialize algorithm parameters, best solution and best fitness.
2: Generate a pre-defined number of initial solutions.
3: Evaluate fitness values of initial solutions, and update best solution and best fitness.
4: Iteration = 1
      While Iteration<=Maxiter
            •  rank solutions according to their fitness values
            •  assign a weight to each solution by considering their ranks
            •  determine a target point to move solutions towards it.
            •  evaluate the fitness value of the target point
            •  determine search directions for each solution considering the target point
               and its fitness value
            •  move each solution towards its determined direction
            •  evaluate fitness values of each solution, and update best solution and
               best fitness
           Iteration = Iteration+1
        end while
```

Fig. 11. The main steps of WSA [5, 6]

3. ADOPTATION of WSA to TSP

In this paper, the first application of the combinatorial version of the WSA algorithm (which was recently presented by the authors as cWSA) to TSP is presented [7]. cWSA necessarily differs from the continuous WSA in some characteristics. Basically, calculation of "superposition (target) point" and "step length mechanism" is different from the continuous WSA [16]. Despite these differences, general flow of the algorithm is similar to continuous WSA. cWSA consists of three main phases that are named as "Creation of Solution Matrix", "Calculation of Superposition", and "Determining Agents' Next Moves" [7].

3.1 Creation of the Solution Matrix

Like the continuous WSA, cWSA begins with the generation of random initial solutions (It is also possible to start the algorithm with previously known solutions or solutions generated by some well known heuristics). Generated solutions are evaluated through their fitness values and solutions are ranked according to their fitness values. The solution which has the best fitness gets the lowest rank. After ranking the solutions, weights of each solution in the solution matrix are calculated with the help of equation $i^{(-1)^{\tau}}$, where *i* is the rank value of the solution and τ is a user defined parameter. Through these calculated weights, the special mechanism of calculation of Superposition is ready for use. This special mechanism is defined next [7].

3.2 Calculation of Superposition

The main difference between continuous WSA and cWSA is in determining the superposition. The continuous WSA use vector arithmetic for calculating superposition on the other hand, as cWSA works with permutation vectors, it is not possible to utilize the same procedure. Therefore, a special mechanism was developed for determining superposition for permutation vectors [7]. In this mechanism, superposition point is calculated after an iterative process. First of all, a blank vector is defined. Then a random number is generated and every member of the solution matrix weights is compared with this number. If the weight is greater than the random number, that element is a candidate for that position. After comparing all of the elements, candidate list is completed. Elements in the candidate list are reevaluated according to roulette wheel approach. At that point, the element is chosen for that position and that element is marked as selected for preventing to select the same element again. This iterative process lasts until all of the elements of the pre-defined blank target vector is filled. At some iteration, there may not be a candidate element for selection, then, a random element is selected among the unselected elements [7]. Finally, superposition vector is defined and all of the agents are ready for deciding their next moves.

3.3 Determining Agents' Next Moves

The final step is to decide agents' next moves. In order to determine these moves, every agent's fitness value and fitness value of the superposition is compared. If the fitness value of the superposition point is better than the agent's fitness value, the agent applies the linear order-crossover (LOX) mechanism with the superposition. Otherwise, one of the local search mechanisms is applied to the agent's solution vector. Moreover, the step length is also an important factor that affects the algorithm's performance. In order to further improve the algorithm's performance, the Levy-flight mechanism is utilized for adjusting step length.

3.3.1 Crossover Mechanisms

LOX crossover mechanism is selected as crossover mechanism because of its easy implementation and segment copying advantage. The detailed information about this mechanism is given in [8].

3.3.2 Local Search Mechanisms

Seven neighborhood structures which are widely used in combinatorial optimization literature are employed in cWSA. These are "single swap", "two-block swap", "three-block swap", "inversion", "ejection chain", "single insertion" and "block insertion" .The step length (i.e. number of single, two and three block swaps; length of inversion and ejection chain; and number and length of single and block insertions) is determined by making use of Lévy flight mechanism.

3.3.3 Lévy Flight

Lévy Flight is a random walk procedure that steps are delineated in terms of the step lengths, which have a certain probability distribution, with the directions of the steps being isotropic and random. Detailed information about this mechanism can be found in [9].

4. OPPOSITION BASED LEARNING

Opposition-Based Learning (OBL) was first introduced by Tizhoosh [10] as a machine intelligence scheme for reinforcement learning. Many studies [11-14] proved that combination of OBL and differential evolution has high success rate for solving continuous optimization problems. Ergezer and Simon [15] adapted OBL to Biogeography-Based Optimization (BBO) for combinatorial problems; the results show that OBL, which has improved continuous optimization, has also improved discrete optimization. Detailed information about OBL and its variations can be found in [15].

5. OBL BASED WSA

The cWSA algorithm is integrated with OBL in order to improve its effectiveness. The outline of the cWSA with OBL is demonstrated in Figure 2. In order to observe the effect of the proposed algorithm, the opposite path is calculated for every solution in the initial solution matrix. Moreover, in calculating superposition phase, all targets' opposites are determined and the best superposition is selected.

```
Procedure cWSA with OBL
Randomly generate initial population, P
Generate the opposite of the initial population, OP
Combine populations
Sort combined population according to fitness values
Maintain the best half of the population
while itr<maxiter
   Determine the superpositions
   Calculate the superposition' fitness and their opposites
   Maintain the best superposition point
   for each agent in the population
      if agent fitness<superposition's fitness
         Apply one of the neighborhood mechanisms
      else
      LOX- Crossover with superposition
      endif
     endfor
  Sort population according to fitness values
  end while
 return best_fitness
 end procedure
```

Fig. 2. cWSA with OBL

6. EXPERIMENTAL RESULTS

TSP is an example of one of the well-known closed path combinatorial problem. Despite it is a well-known problem, there is still no polynomial time method that guarantee the optimal solution. In TSP, there are list of cities to be visited only once and this list is sorted to minimize total travel distance. In this section six TSP benchmark problems that were previously experimented by Yousefikhoshbakht et al. [16] are used for experimental testing. For our runs, clockwise opposite path approach is implemented. A computational experiment is conducted to measure the performance of the proposed model for TSP against other techniques namely "ACO", "GA", "PSO", "bee colony optimization (BCO)", "self-organizing neural network (NN)", "genetic algorithm combined by simulated annealing and ant colony system and particle swarm optimization (GSAP)", "the genetic reactive bone route algorithm with ant colony system (REACSGA)". Six of the TSP problem instances namely "Eil51", "Berlin52", "Eil76", "Kroa100", "Eil101", "Lin105" are solved. A parameter, optimality gap (Op_Gap) (Eq.1) is used to determine the quality of the solutions. OBL based cWSA algorithm is able to solve the selected problems with the optimality Gap of %0, %0, %0, %1.21, % 2.23, and %6.23. The proposed algorithm is able to provide comparable and acceptable solutions.

$$\text{Op\_Gap} = \frac{Obtained - Optimal}{Optimal} * 100 \tag{1}$$

Table2. Experimental Results

			ACS	GA	NN	GSAP	PSO	BCO	ACO	REACSGA	OP-CWSA
Number	Instance	n	Op_Gap	Op_Gap	Op_Gap	Op_Gap	Op_Gap	Op_Gap	Op_Gap	Op_Gap	Op_Gap
1	Eil51	51	0.0023	0.0070	0.0023	0.0023	0.0023	0.0047	0	0	0
2	Berlin52	52	0	0.00079	0	0	0	---	0	0	0
3	Eil76	76	0.0074	0.0204	0.0056	0	0.0037	0.0019	0.0093	0	0
4	Kroa100	100	0.0013	0.0121	0.0024	0	0.00065	0.0213	0.0028	0	0.0121
5	Eil101	101	0.0111	0.0223	0.0143	0.0016	--	0.0095	--	0	0.0223
6	Lin105	105	0.0225	0	0	0.0632	--	0	--	0	0.0632

7. CONCLUSIONS

In this study, two successful approaches for optimization problem solving, namely WSA and opposition based learning, are integrated for solving TSP. Different move mechanisms, LOX crossover mechanism, and Lévy flight approach are employed to the proposed algorithm to improve greediness and diversification. The preliminary results obtained from the experimental study has shown that opposition based learning based WSA algorithm is capable of providing comparable results in comparison to existing algorithms for TSP. The research is still under progress and we aim to improve the proposed algorithm further by proper parameter optimization.

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SIMULATION MODELING OF THE SERVICE SYSTEM OF A DENTAL HOSPITAL

Behice Meltem Kayhan[1], Özgür Yalçınkaya [2] , Gökalp Yıldız [3]

Abstract *−Hospitals and clinics are facing increasing competition in the services and they are requested to provide a fast and efficient health services to patients. On behalf of both cost and efficiency, shortened waiting time in the system of the patient for adequate and effective patient flow processes, usage sufficient amount of staff, reduction in the number of patient renege are needed. For this purpose, first of all, the existing system should be analyzed and the characteristics of the system should be defined. The bottlenecks, problems in the system, departments which need to be improved should be specified. Simulation is an effective tool allows determining the efficiency of a system before the system is actually constructed and diminishes the overall cost of building the system significantly. Furthermore simulation permits decision makers to create different alternatives of the system easily. In this study, the service performance of a Faculty of Dentistry is analyzed via simulation modeling. Utilization of dentist, time spent by the patients in the system, number of patients in the queues, number of patient reneges, and waiting time of patient in the system are chosen as performance criteria. Additionally a new appointment system is proposed and results of the models are compared.*

Keywords −Dental hospital, Healthcare systems, Simulation, Appointment system

INTRODUCTION

Nowadays, competition among hospitals and clinics has become intense. It imposed hospitals to provide fast and efficient health services to patients and to improve their quality of service and operational effectiveness [1]. Since people are free to select their healthcare providers, patients have started to demand more efficient health care at a reasonable cost, and with better quality of service [2]. Therefore, in order to survive, hospitals are making efforts to improve their service quality and more emphasis on patient's expectations [3]. One of the most important issue in customer satisfaction is the reduction of waiting times for scheduled appointments [4]. Many studies showed that if patients encounter too lengthy waiting or throughput times, they are prone to select other clinics [5-7]. Hence, appointment systems has critical role in controlling the arrival of patients and reducing the waiting time of patients. Beside this, it is also important to distribute workload equally among healthcare personnel and to increase the utilization of resources [8]. For this purpose, first of all, the existing system should be analyzed and the characteristics of the system should be defined. The bottlenecks, problems of the system, departments which need to improve should be specified. Afterwards, the characteristics of the system are changed, for example numbers of staff, the differences are analyzed and the improvement which could be utilized is determined. Simulation allows much more accurate modeling of these systems and allows determining the efficiency of a system before the system is actually constructed. Furthermore simulation permits decision makers to create different alternatives including transient conditions based on random patient arrival and service time with realistic statistical distribution [9].

In this study, firstly, the service performance of a Faculty of Dentistry is analyzed via simulation modeling. Utilization of dentist, time spent by the patients in the system, number of patients in the queues, number of patient reneges, and waiting time of patient in the system are chosen as performance criteria. After that, a new appointment system is proposed and performance criteria of the two systems are compared.

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SYSTEM AND PROBLEM DEFINITION

Faculty of Dentistry serving with 8 departments in an eight-hour shift from 8:00 a.m. to 12:00 a.m. and from 1:00 p.m. to 5:00 p.m. during weekdays and shuts down between 12:00 a.m. and 1:00 p.m. The departments in the faculty are: Oral and Maxillofacial Surgery, Oral and Maxillofacial Radiology, Endodontics, Orthodontics, Pediatric Dentistry, Periodontology, Prosthodontics, and Restorative Dentistry. The number of these departments is given in the Table 1.

Table 13. Number of Departments

Number	Department
2	Department of Oral and Maxillofacial Surgery
3	Department of Periodontology
4	Department of Prosthodontics
5	Department of Endodontics
6	Department of Restorative Dentistry
7	Department of Pediatric Dentistry
8	Department of Oral and Maxillofacial Radiology
9	Department of Orthodontics

Pediatric Dentistry department deal with all dentistry issues of children who are equal and under age 12. The other departments serve to other patient.

The time between the arrivals of patients to the system is exponentially distributed and changes during the day. Between 8:00 a.m. and 10:00 a.m. it is exponentially distributed with a mean of 2.5 minutes, between 10:00 a.m and 03:00 p.m. with a mean of 3 minutes and between 03:00 p.m and 5:00 p.m. with a mean of 4 minutes.

Patients arrive at the hospital without an appointment for first clinical examination. First clinical examination is conducted in 8th department with 4 dentists, 1 secretary and 3 radiologists. Patients take an order paper from a thumbwheel switch and waits for registration. There are 3 people in the registration desk which serves patients. The registration process time is uniform distributed with minimum and maximum times of 1 and 2 minutes. Patients which are over the age of 65 have priority over the other patients within the queue. Because of long waits, patients leave the hospital before they are serviced. Dentist accepts the patients by order and conducts first examination and decides to which dental x-ray is needed and sends the patient to x-ray room in the same department. The time this process takes is normally distributed with a mean of 4 minutes and a standard deviation of 0.5 minute. There are 3 radiologist in the x- ray room and the process time is triangularly distributed with minimum, most likely and maximum times of 2, 3, and 4 minutes, respectively. After the x-ray process completed, dentist analyzes the results and defines the treatments. The process time is triangularly distributed with minimum, most likely and maximum times of 3, 4 and 5 minutes, respectively. The probability of the treatments according to departments is given in Table 2.

Table 14. The Distribution of the Treatments According to Departments

Departments Number	2	3	5	6
Probability	0.15	0.40	0.25	0.20

After the treatment definition, patient goes the secretary's department and completes the registration for appointment. The secretary computerizes the sequence of treatments of patient in order to take appointment from the system for the next day. The process time is triangularly distributed with minimum, most likely and maximum times of 1.5, 2 and 2.5 minutes, respectively. After these processes are completed, the patient leaves the hospital and takes an appointment for the next department.

On the appointment day, patient comes to the hospital and first goes the secretary's department and completes the registration and waits for examination. Each department has 1 secretary. Dentists accept the patients by order and conduct examination. After the examination process completed the patient leaves the department. If there is any treatment in the sequence patient takes another appointment otherwise patient leaves the hospital. The number of dentists, and process times for secretary and examination is given in Table 3.

Table 15. Information about the Departments

Departments Number	**2**	**3**	**5**	**6**
The Number of Dentist	6	7	7	8
Secretary Time	Unif(1,2)	Unif(1,2)	Tria(2,3,4)	Tria(1,1.5,2)
Examination Time	Norm(35,3)	Tria(20,35,30)	Norm(35,2)	Norm(45,2)

Department of Pediatric Dentistry has different operation procedures from the other departments. Only the patients at the age of 12 and below are accepted and all examinations are conducted in this department. Patients arrive at the hospital without appointment for the first clinical examination. There are 8 dentists, 1 secretary and 2 radiologists in the department. Patients take an order paper from a thumbwheel switch and waits in the waiting area of 7th department. Dentist accepts the patients by order and conducts first examination and decides to which dental x-ray is needed and sends the patient to x-ray room in the same department. The process time is triangularly distributed with minimum, most likely and maximum times of 2, 3 and 4 minutes, respectively. There are 2 radiologists in the x- ray room and the process time is normally distributed with a mean of 5 minutes and a standard deviation of 0.5 minute. After the x-ray process completed, dentist analyzes the results and decides the treatment. The process time is triangularly distributed with minimum, most likely and maximum times of 2, 3 and 4 minutes, respectively. After treatments definition patient goes the secretary's department and completes the registration for appointment. The secretary computerizes the sequence of treatments of patient in order to take appointment from the system for the next day. The process time is triangularly distributed with minimum, most likely and maximum times of 1, 2 and 3 minutes, respectively.

On the appointment day, dentist accepts the patients by order and conducts examination. Patients come to the hospital with appointment have priority over the other patients come for the first examination within the queue. The process time of treatment is triangularly distributed with minimum, most likely and maximum times of 35, 40 and 45 minutes, respectively. After the examination process completed the patient leaves the hospital.

The flow process diagram created for patients is shown Figure 1.

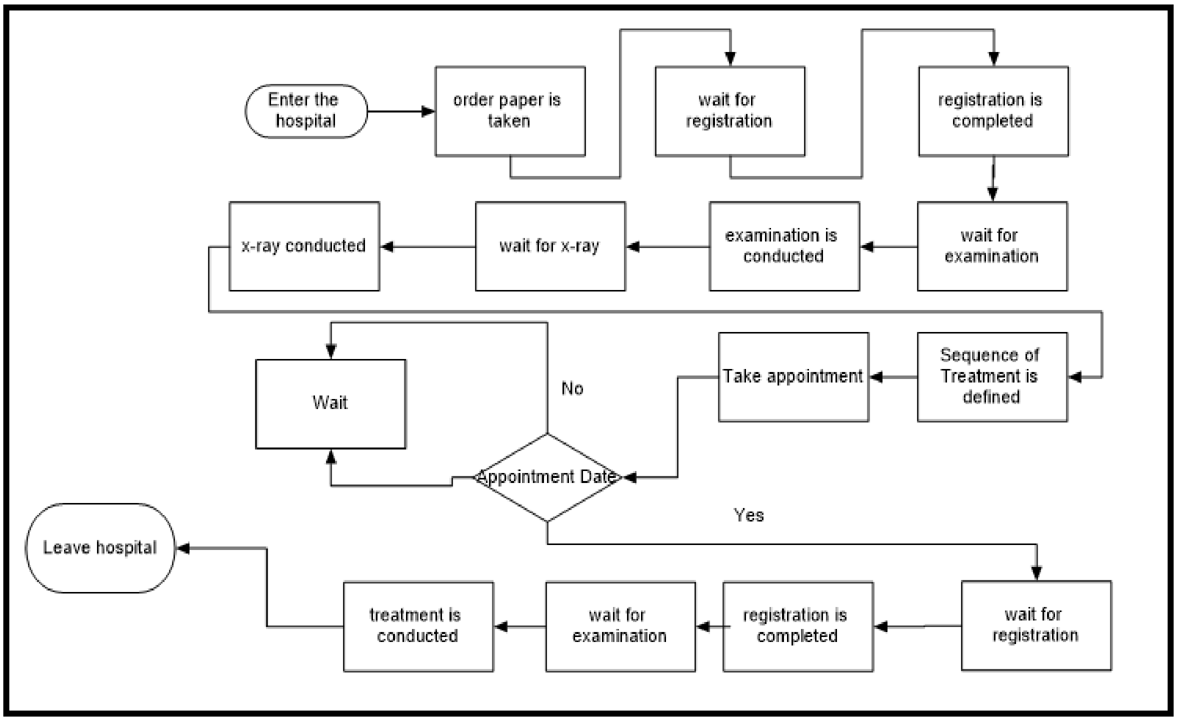


Figure 12. The Flow Process Diagram for Patients

RESULTS OF THE CURRENT SITUTATION

The current model is run for 10 replications and each replication takes 118800 minutes which corresponding to 200 days. In a non-terminating system, the steady-state behavior of system should be defined. Because any observation recorded during the transient phase biases the results. For example, the early arriving patients will be served quickly without waiting in the queue and the performance measure will be biased during the early part of the simulation. After the warm up period system begins to exhibit its long-term behavior. In this study, Output Analyzer is used to plot waiting times for appointment over time and the point at which the steady state behavior becomes significant is determined visually. Roughly 10000 minutes later behavior of the system changes and system becomes in a steady form. For model point of 10800 minutes, which corresponding to 20 days is chosen as truncation point. The results of the system are shown in Figure 2.

```
                         ARENA Simulation Results
                                 Asus Pc

                       Summary for Replication 1 of 10

Project: Unnamed Project                            Run execution date : 2/ 3/2016
Analyst: Rockwell Automation                        Model revision date: 2/ 3/2016

Replication ended at time      : 118800.0 Minutes
Statistics were cleared at time: 10800.0 Minutes (Wednesday, February 10, 2016, 12:00:00)
Statistics accumulated for time: 108000.0 Minutes
Base Time Units: Minutes

                              TALLY VARIABLES

Identifier                          Average   Half Width  Minimum   Maximum   Observations
_______________________________________________________________________________________

PatientsTimeInSystem                 691.53     17.113     24.776    2023.0      22070
```

Figure 13.Waiting Times for Patients

Waiting time for the appointment is recorded and named PatientsTimeInSystem and this time is chosen as one of the performance measures. The result shows that patients wait minimum, average and maximum times of 24.776, 691.53 and 2023 minutes, respectively and this times is recorded for 22070 entities.

Patients waiting in the queues, utilization of dentist and workers are also chosen as performance measure and given in Figure 3.

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Pediatric Queue	3.2111	.57414	.00000	49.000	.00000
Radiology Queue in Pediatric	.14535	.02720	.00000	6.0000	.00000
Pediatric Sec.Queue	.12677	.01642	.00000	4.0000	.00000
Registration Queue	.00208	2.5230E-04	.00000	4.0000	.00000
Oral Radiology Queue	.39804	.03563	.00000	10.000	.00000
Radiology Queue in Oral Radiology	.10870	.01688	.00000	4.0000	.00000
Oral Radiology Sec.Queue	.27999	.01697	.00000	4.0000	.00000
Oral Surgery Sec.Queue	.15388	.02370	.00000	15.000	5.0000
Oral Surgery Dentist Queue	.15675	.02777	.00000	11.000	.00000
Periodontology Sec.Queue	1.6646	.16036	.00000	46.000	.00000
Periodontology Dentist Queue	1.6146	.15170	.00000	29.000	.00000
Endodontics Sec Queue	1.4170	.14774	.00000	29.000	.00000
Endodontics Dentist Queue	.45395	.04897	.00000	13.000	.00000
Restorative Sec Queue	.27530	.01708	.00000	19.000	.00000
Restorative Dentist Queue	.37912	.03242	.00000	13.000	.00000
Pediatric Dentist Utilization	.50212	.00848	.00000	1.0000	.12500
Pediatric Secretary Utilization	.17602	(Corr)	.00000	1.0000	.00000
Radiology2 Worker Utilization	.22094	(Corr)	.00000	1.0000	.00000
Registration Worker Utilization	.14645	.00165	.00000	1.0000	.33333
Oral Radiology Dentist Utilization	.58983	.00775	.00000	1.0000	1.0000
Radiology 1 Worker Utilization	.20481	.00232	.00000	1.0000	.33333
Oral Radiology Secretary Utilization	.40897	.00455	.00000	1.0000	.00000
Oral Surgery Secretary Utilization	.04555	.00171	.00000	1.0000	1.0000
Oral Surgery Dentist Utilization	.17735	.00670	.00000	1.0000	.00000
Periodontology Secretary Utilization	.12204	.00253	.00000	1.0000	.00000
Periodontology Dentist Utilization	.34781	.00456	.00000	1.0000	.00000
Endodontics Secretary Utilization	.15406	.00552	.00000	1.0000	.00000
Endodontics Dentist Utilization	.25664	(Corr)	.00000	1.0000	.00000
Restorative Secretary Utilization	.06156	.00166	.00000	1.0000	.00000
Restorative Dentist Utilization	.23154	.00618	.00000	1.0000	.00000

Figure 14. Queue Lengths and Utilizations

The number of patients waiting for the Pediatric department has the minimum, average and maximum values of 0, 3.21 and 49, respectively. When we analyzed the results, it is seen that there are long queues in Pediatric, Endodontics and Periodontology departments.

The utilization of the dentist of Pediatric is 50.21 percent. The utilization of the dentist of Oral Radiology is 58.98 percent and has the most workload among the other dentists.

The number of patients served in each department are given in Figure 4.

COUNTERS

Identifier	Count	Limit
#ofTreatedPediatricP	7829	Infinite
#ofTreatedOralRadiologyP	22079	Infinite
#ofTreatedOralSurgeryP	3285	Infinite
#ofTreatedPeriodontologyP	8794	Infinite
#ofTreatedEndodonticsP	5545	Infinite
#ofTreatedRestorativeDentistryP	4440	Infinite
#ofRenegedP	25	Infinite

Figure 15. The Number of Patients

The number of patients treated in pediatric department, and the number of reneged patients because of the long queue is found 7829 and 25 respectively.

The current model is run for 10 replications and statistics are recorded. The average results of the 10 replication and given in Figure 5.

ARENA Simulation Results
Asus Pc

Output Summary for 10 Replications

Project: Unnamed Project — Run execution date : 2/ 3/2016
Analyst: Rockwell Automation — Model revision date: 2/ 3/2016

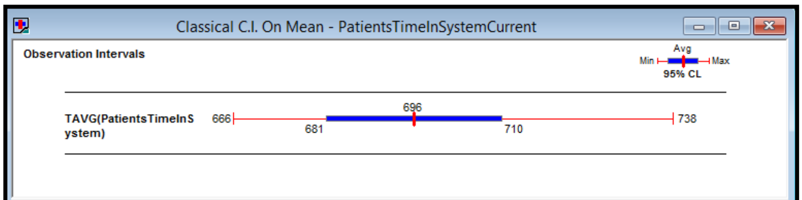
OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
TAVG(PatientsTimeInSystem)	695.90	14.448	666.22	738.22	10
DAVG(Pediatric Queue)	3.0615	.10539	2.9028	3.3493	10
DAVG(Oral Radiology Queue)	.41417	.01143	.39251	.43439	10
DAVG(Oral Surgery Dentist Queue)	.17138	.01095	.15239	.20487	10
DAVG(Periodontology Dentist Queue)	1.4981	.05706	1.3830	1.6309	10
DAVG(Endodontics Dentist Queue)	.48869	.01646	.45395	.51816	10
DAVG(Restorative Dentist Queue)	.36736	.01822	.31335	.41057	10
DAVG(Pediatric Dentist Utilization)	.50091	.00173	.49703	.50465	10
DAVG(Oral Radiology Dentist Utilization)	.58913	.00229	.58329	.59469	10
DAVG(Oral Surgery Dentist Utilization)	.18014	.00219	.17594	.18676	10
DAVG(Periodontology Dentist Utilization)	.34836	.00248	.34309	.35513	10
DAVG(Endodontics Dentist Utilization)	.25765	.00166	.25415	.26178	10
DAVG(Restorative Dentist Utilization)	.22991	.00233	.22475	.23601	10
System.NumberOut	.00000	.00000	.00000	.00000	10

Simulation run time: 8.22 minutes.
Simulation run complete.

Figure 16. Average Results for Ten Replications

The average waiting times for 10 replications is recorded and confidence interval of the performance measure is developed and given in Figure 6.



Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
TAVG(PatientsTimeInSystem)	696	20.2	14.4	666	738	10

Figure 17. Confidence interval for the performance measure

The average waiting time has the minimum value of 666 minutes and maximum value of 738 minutes. Confidence interval with confidence level of 0.95 has the minimum value of 981 and the maximum values of 710 minutes and the average value of 696 minutes.

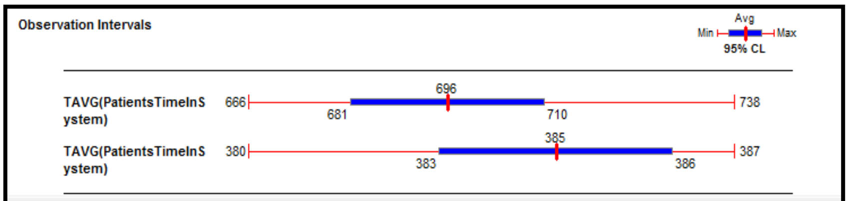
THE SIMULATION OF PROPOSED MODEL

The objective of the study is to minimize waiting times for appointments. For this purpose the current system is simulated and the results of the current model are analyzed.

In current system, the appointments of departments are given for the 1 hour zone and utilization of the dentist of the departments has maximum 34.8 percentage. The processes in some departments generally takes 30 minutes. Thus the time slot of appointments for Oral Surgery, Endodontics and Periodontology decreased to the 30 minutes and system simulated in this condition.

COMPARISON OF THE CURRENT AND THE PROPOSED MODEL

The average waiting times for 10 replications are recorded in two systems and confidence intervals on means are shown Figure 7.



Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
TAVG(PatientsTimeInSystem)	696	20.2	14.4	666	738	10
TAVG(PatientsTimeInSystem)	385	2.29	1.64	380	387	10

Figure 7. Comparison of Performance Measures

The average waiting time for proposed model has the minimum value of 380 minutes and maximum value of 387 minutes. Confidence interval with confidence level of 0.95 has the minimum value of 383 and the maximum values of 386 minutes and the average value of 385 minutes.

The results are also analyzed in Output Analyzer by using Compare Means option. The Compare Means option generates confidence intervals of the difference of means for models.

The hypotheses are:

H_0: The means are equal to each other.
H_a: The means are not equal to each other.

If the confidence interval of the difference of means includes the 0 value the null hypothesis cannot be rejected. The results of the compare means shown in Figure 8.

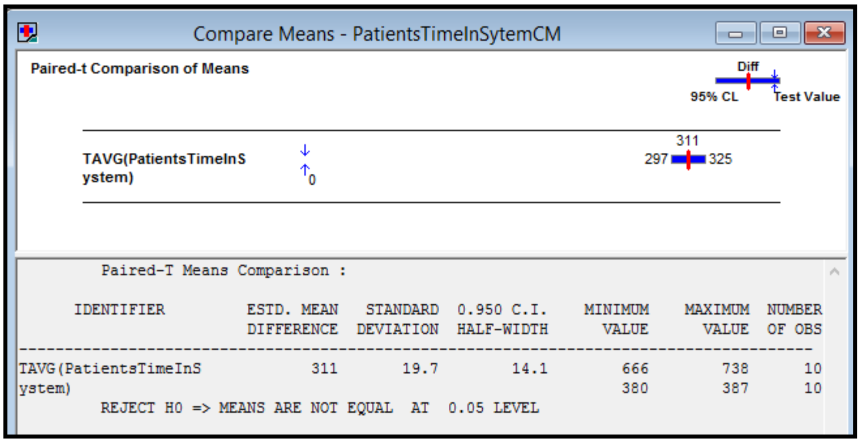


Figure 8. Comparison of means of performance measure

To compare means, the file includes result of the current model is chosen first and compared with proposed model. It is easily seen that means are not equal at 0.05 level and current model has longer waiting times. The average mean difference is 311 minutes which means patients in proposed model wait less.

CONCLUSION

In this study a University Faculty of Dentistry is analyzed and to improve the functioning of the dental service using simulation approach is intended. In the first stages of the study Faculty of Dentistry visited several times to observe the system. Characteristics of the system are defined and related data is gathered. Afterwards, the current model is simulated in Arena and results of the system analyzed. Based on the results, it is indicated that patients wait long times for the appointment. Also utilization of the dentist, secretary and other workers the number of patients waiting in the queues are recorded. Beside these the number of patient reneges and the number of patients served in each department are counted for separately. The waiting time for the appointment is selected as performance criteria. The average waiting time for current model has the minimum value of 666 minutes and maximum value of 738 minutes. In proposed model, the time of appointment for Oral Surgery, Endodontics and Periodontology decreased to the 30 minutes and system simulated again. As a result, the average waiting time for proposed model has the minimum value of 380 minutes and maximum value of 387 minutes. The waiting time is shortened 311 minutes averagely.

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A SIMULATION MODELLING APPROACH FOR BERTH ALLOCATION AND QUAY CRANE SCHEDULING PROBLEMS

Gökçeçiçek TAŞOĞLU[1], Gökalp YILDIZ[2]

Abstract− *In order to gain competitive advantage, container terminals need advanced planning for berths and quay cranes which are critical resources of container terminals. The management of a container terminal usually focuses on reducing the turnaround time of vessels. The turnaround time of a vessel is the time between arrival and departure of a vessel and it is directly affected by berth allocation and crane scheduling decisions. In this study, a simulation modelling approach is adopted for solving berth allocation and quay crane scheduling problems together. The study is comprised of three parts. In the first part, a simulation model which represents the seaside operations in a container terminal is developed assuming that the quay cranes can move freely. However, in practice, the identical quay cranes are located on a rail along the quay and they cannot pass each other. Thus, in the second part, an algorithm is developed for crane allocation so as to handle the non-crossing constraint. In the final part, the simulation model is improved by integrating the algorithm. Moreover, numerical experiments via simulation models are conducted to show the effect of non-crossing constraint on the total turnaround time.*

Keywords −Berth Allocation, Container Terminals, Crane Scheduling, Simulation

1. INTRODUCTION

Nowadays, both containerization and increasing globalization has raised the importance of the maritime transportation. Maritime transportation has become an important ring of the global supply chain and this leads a tough competition between the container terminals. To succeed in this competitive environment, they should reduce operational costs (port handling cost) by efficiently utilizing resources such as human, berths, quay cranes, yards and various equipment. Considering these resources, operations in container terminal can be broken down into three functional systems: seaside operations, yard operations and land-side operations (Theofanis, Boile, &Golias, [1].Among these three functional systems, to attract new customers and improve customer satisfaction, container terminals should primarily focus on efficient management of seaside operations in order to both attract new customers and satisfy the existing customers. Moreover they should provide high level of service and increase port throughput by accelerating seaside operations.

Seaside operations in container terminals include several problems such as berth allocation, quay crane scheduling, and quay crane assignment.

Berth allocation problem determines the berthing time and berthing position of the incoming vessels. According to the berth layout, berth allocation problem is classified into two different cases: discrete and continuous. In discrete case, the quay is divided into discrete berth segments and each berth segment can be occupied by only one vessel at a time. Otherwise, in continuous case, the quay is not partitioned and the vessels can moor anywhere along the quay.

Quay crane scheduling problem determines the sequence of loading/unloading tasks that each quay crane will perform on each incoming vessel. Crane scheduling decisions directly affect the total turnaround time of all vessels because of the physical movement limitations of the cranes and they are strongly interrelated with berth allocation decisions. In this context, solving berth allocation and crane scheduling problems simultaneously is more realistic.

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While managing all these seaside operations and solving aforementioned problems, uncertainties in arrival time and loading/unloading time may be encountered due to the factors such as weather conditions, lack of information, maintenance and reliability of equipment.

In this study, the handling time which refers to loading/ unloading time of a vessel is assumed to be uncertain. Thus, simulation modelling approach is adopted for solving berth allocation and quay crane scheduling processes simultaneously. The study consists of three parts. In the first part, berth allocation and quay crane scheduling operations are modeled using simulation software ARENA. The simulation model doesn't take into account the non-crossing constraint and cranes can move regardless of the other cranes' movements. In the following part, a decision algorithm which considers the non-crossing constraint is constructed. In the final part, the algorithm is combined with the simulation model. Additionally, effect of non–crossing constraint on the total turnaround time of all vessels is analyzed.

The remainder of this paper is organized as follows: In Chapter 2, related literature is summarized. In Chapter 3, simulated sample container terminal as system is described in detail. Chapter 4 presents the simulation modelling approach with its subdivisions. In Chapter 5, numerical analyses are carried out. The study is concluded in Chapter 6.

2. RELATED LITERATURE

Since the Berth Allocation, Quay Crane Scheduling and Quay Crane Assignment Problems are generally optimization problems that have many conflicting constraints, various operations research methods and techniques have been applied.

Steenken ,Voß, and Stahlbock [2], Stahlbock and Voß [3], Bierwirth and Meisel [4], Bierwirth and Meisel [5] comprehensively reviewed these problems and related solution methods.

Studies deal with the Berth Allocation and Quay Crane Scheduling Problems using simulation modelling methods have been described as follows:

Canonaco et al. [6], solved a real problem of logistics at a maritime container terminal by developing a complex queuing network model. It was described by an event graph-based discrete-event simulation and validated against real data.

In order to obtain a proactive berth and quay crane schedule, Han et al. [7] addressed a mixed integer programming model. Afterwards a simulation model based genetic algorithm search procedure applied and handling and arrival times are stochastic. Monte Carlo Sampling is used to evaluate objective function value.

Vis and Anholt [8] conduct a simulation study in order to compare the performance of QCs at a classical berth, where the vessel is served from one side, with an indented berth. The experiments show that the indented berth can reduce the handling time of vessels by up to 30 percent.

Arango et al., [9] studied the problems associated with allocating berths for containerships in the port of Seville. This paper addressed the berth allocation planning problems using simulation and optimization with Arena software. A mathematical model was proposed and heuristic procedure based on genetic algorithm was developed to solve non-linear problems. The objective of the study was to minimize the total service time for each ship and considers a first-come-first-served allocation strategy.

Esmer et al., [10] developed a simulation modelling approach to continuous berth allocation problem. Continuous quayside along Port of Alsancak , İzmir with two main wharfs aimed to be modeled. According to the results proposed modelling approach gives more accurate and realistic estimates of performance measures.

Karafa et al., [11] formulated the berth allocation problem with stochastic vessel handling times as a biobjective problem that minimizes the total service time for all vessels & minimize the service start and finish time risk for all vessels. To solve the resulting problem, an evolutionary algorithm-based heuristic and a simulation-based Pareto front pruning algorithm has been proposed.

Legato et al., [12] integrated two separate models into a simulation-optimization framework for Berth Allocation. They used an event-based Monte Carlo Simulator in order to consider randomness in loading/unloading operations Also, a non-standard ranking and selection procedure is applied to compare the different Berth Allocation Solutions.

To the best of our knowledge, there is not any study which considers the berth allocation and quay crane scheduling problems together and deals with the non-crossing constraint according to the real-life application, using simulation software ARENA.

3. SYSTEM DESCRIPTION

Sample container terminal is a multi-user container terminal which consists of only one long quay. The quay is partitioned into discrete berths. Each berth can serve only one vessel at a time considering the relevance between length of the berth and length of the vessel. Moreover, there is also a relationship between vessel draft and water depth. These constraints should be avoided before the berth allocation decision is made. Vessels arrive dynamically and their arrival times are assumed to be known with certainty while the handling time (loading/unloading time) of vessel is uncertain. The identical quay cranes are located on a rail along the quay and because of the physical restrictions, they cannot pass each other. Loading/unloading tasks are represented by sequential ship bays as shown in Figure1. In Figure 1, a quayside with two discrete berths and six mounted quay cranes is depicted.

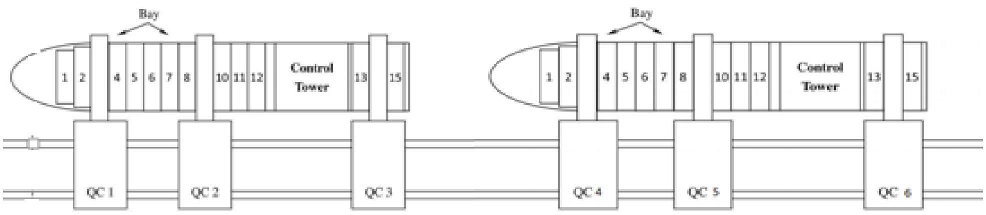

Figure 1. Representation of a Quayside

According to the information given above, loading/unloading operations in the container terminal occurs as follows: Once, a feasible berth schedule which considers length and water depth constraints is constructed and all of the incoming vessels are assigned to a berth. When a vessel arrives at the port, it waits for the service order of the berth where the vessel is assigned to. After the vessel is moored at the berth, a quay crane is requested for each loading/unloading bay. When loading/unloading operations of the vessel are completed, quay cranes are released and the vessel leaves the berth. Then the berth becomes available again. These processes continue until loading/unloading operations of all the incoming vessels in the planning period are completed.

4. APPLYING THE SIMULATION MODELLING APPROACH

4.1. Simulation Model of the Container Terminal

The sample container terminal is modeled by means of simulation software ARENA 14.0. Simulation model uses a pre-determined feasible berth plan as an input. According to this berth allocation scheme, the model assigns vessels to the berths and determines a quay crane schedule. In addition, it estimates the total turnaround time of all vessels as a performance measure. Unlike the real-life implementation, in the simulation model, quay cranes are assumed to move regardless of the other cranes' movements.

In order to facilitate simulation modelling, following assumptions are made:

- Quayside is divided into equal sized nodes (intersections) and numbered longitudinally.
- These nodes represent the loading/unloading points for the cranes.
- Cranes are numbered in ascending order from left to the right.
- Each crane can occupy only one node and serve only one ship bay at a time.
- Ship bays on a vessel are also numbered ascending order from left to the right.
- Each ship bay should be positioned on the opposite side of a single node.

In Figure 2, representation of the simulated system with two discrete berths and six quay cranes operating on two vessels is given. Ship bays colored in yellow represents the bays which demand a crane for loading/unloading and demanding ship bays are determined randomly.

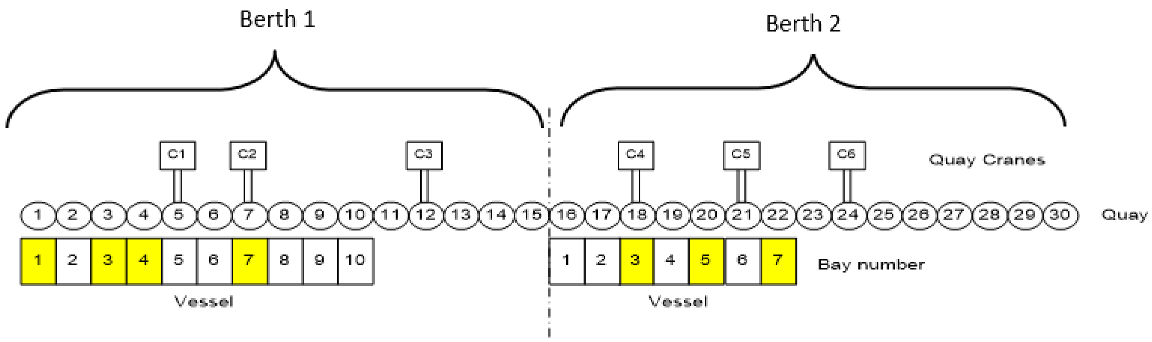

Figure 2. Representation of the System

When a vessel is moored at the berth where it is assigned to, a quay crane is requested for each random bay. Under the assumption that the quay cranes can move freely ignoring the existence of the mounted rail along the quay, simulation model always requests the available quay crane with the smallest distance.

4.2. Development of the Non-crossing Algorithm

In this part, an algorithm is aimed to be developed to obtain a conflict-free quay crane schedule. Representation of the system in Figure 2, simplifies the design of the algorithm. With the aid of this figure, the algorithm which allocates a quay crane for only one bay is given as follows:

STEP 0: Transform the bay number into the corresponding node number.

STEP 1: COUNT the occupied bays by quay cranes from first node to the corresponding node.

STEP 2: ASSIGN number of occupied nodes to the variable 'Occupied_nodes'

STEP 3: IF corresponding node is occupied by a crane ASSIGN 'Occupied_nodes+1' to the variable 'Crane_to_request' GO TO STEP 5 ELSE GO TO STEP 4

STEP 4: DECIDE to selection of two cranes

STEP 5: IF one of the cranes with number ‘Occupied_nodes’ and with number ‘Occupied_nodes+1’ is busy SELECT the busy one to REQUEST GO TO STEP 7 ELSE IF both of the cranes are idle REQUEST the nearest one GO TO STEP 7 ELSE IF both of the cranes are busy REQUEST one of them randomly GO TO STEP 7

STEP 6: REQUEST the crane with number ‘Crane_to_request’.

STEP 7: START handling of the bay.

STEP 8: DELAY for handling time.

STEP 9: FREE the quay crane with number ‘Crane_to_request’.

4.3. Integration of the Algorithm into the Simulation Model

With the aim of representing real-life mechanism in the container terminals, the non-crossing algorithm should be integrated into the simulation model. With this integration, an extended simulation model which considers the assumptions given in section 3.1 is obtained. Since the new model handles the non-crossing constraint, it calculates the performance measure in a more realistic way.

5. NUMERICAL EXPERIMENTS

Numerical experiments are carried out using the hypothetical data given in Table 1. Vessel numbers, their presumed arrival times and related berth numbers can be found in the table.

Table 1. Information for Numerical Experiments

Vessel No	Assigned Berth Number	Arrival time
1	1	10
2	2	2
3	3	3
4	2	14
5	3	20
6	1	19
7	2	45
8	2	33
9	3	23
10	3	10

Two simulation models were developed in the previous studies: The first one which ignores the non-crossing constraint and the second one which considers the non-crossing constraint. Effect of this movement restriction on the total turnaround time of all vessels has been compared via these two models. Also, the total turnaround time is evaluated for varying number of quay cranes.

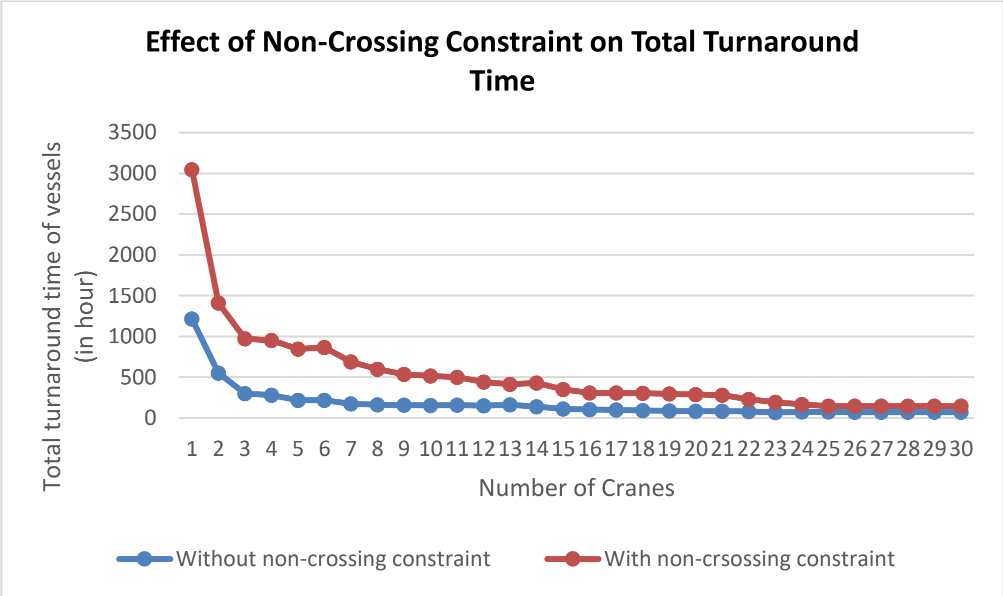

Figure 3. Results of the Simulation Models

The results obtained from the simulation models are illustrated in Figure 3. It is observed that when the number of operating quay cranes is smaller, the non-crossing constraint significantly influences and almost doubles the total turnaround time of all vessels. On the other hand, as the number of operating cranes increases up to the maximum number allowed by the physical structure of the quay, the total turnaround times of the two models become closer to each other.

Berth allocation and quay crane scheduling decisions directly effect the efficient use of the resources in a container terminal. Thus, container terminals should focus on these decisions so as to compete with other terminals and attract new customers.

6. CONCLUSION

In this study, berth allocation and quay crane scheduling decisions are evaluated by means of simulation modelling approach. The study is mainly divided into three sections. A simulation model of the system is constructed, an algorithm is proposed to solve the conflict between the quay cranes and then, an extended simulation model is obtained by integrating the proposed algorithm with the first model. Finally, effect of non-crossing constraint on the total turnaround time of all vessels is analyzed.

In the future research, we may consider the continuous case of berth layout in the simulation model. Furthermore, a simulation optimization procedure which minimizes the total turnaround time can be developed in order to determine optimal berth plan and dynamic quay crane schedule simultaneously.

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FUZZY TOPSIS METHODOLOGY FOR WASHING LIQUIDE MATERIAL SELECTION

Mehtap Dursun[1], Nazli Goker[2]

Abstract − New product development process (NPD) is considered as the key factor of competition among different markets. Material selection is a challenging procedure in NPD. It is seen as a multi-criteria decision making (MCDM) problem in engineering because of requiring to consider multiple criteria from different dimensions. The aim of this study is to present a fuzzy multi criteria decision making (MCDM) approach for material selection procedure. The proposed methodology illustrated through a case study of washing liquid material selection procedure.

Keywords −Material selection, multi-criteria decision making, new product development, fuzzy TOPSIS

INTRODUCTION

New product development is a series of process that involves the conceptualization, design, development and marketing of newly created goods or services. The aim of new product development is to augment company's market share by satisfying consumer demands. A poor management in developing process could result in sales reduction and minimize companies' profit.

Innovation in product development starts with appropriate material selection. Developing successful commercial products demands a sound understanding of the materials that go into those products. Material selection is seen as a multi-criteria decision making (MCDM) problem in engineering because of requiring to consider multiple conflicting criteria. Improper material selection may affect the performance of products negatively, thus productivity, success and prestige of the firm are also effected poorly [1].

In the literature, there are some articles related to material selection. Chatterjee and Chakraborty [2] applied four preference ranking based MCDM methods to solve a material selection problem. Girubba and Vinodh [3] utilized VIKOR method as MCDM tool to determine the most appropriate material for instrument panel used in electric panel. Rahman et al. [4] proposed a knowledge based decision support system to make ideal materials selections for roof design. The procedure utilized TOPSIS method to facilitate selection process. Liu et al. [1] proposed an approach that employs MCDM method with interval 2-tuple linguistic information to solve the material selection problem in two different cases, for an automative company and for a flywheel respectively. Anojkumar et al. [5] introduced 4 different MCDM methods, fuzzy analytic hierarchy process (FAHP)-technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), FAHP-VIKOR, FAHP-ELECTRE and FAHP-PROMTHEE to select material for the pipes in sugar industry by taking into account different alternatives and evaluation criteria. Liu et al. [6] integrated decision-making trial and evaluation laboratory (DEMATEL) based analytic network process (ANP) and VIKOR to resolve the bush material selection problem that consists of many interdependent criteria. Liao [7] presented interval type 2 fuzzy multi-attribute decision making for material selection. The method is illustrated in an engineering application of material selection in a jet fuel system. Govindan et al. [8] constructed a model to select the most appropriate construction material by utilizing DEMATEL, ANP and TOPSIS.

The aim of this paper is to propose a fuzzy MCDM approach for washing liquid material selection procedure. The rest of this paper is organized as follows. Section 2 presents fuzzy TOPSIS method. A case study is illustrated in section 3. Finally, concluding statements are given in the last section.

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FUZZY TOPSIS METHOD

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a common method introduced by Hwang and Yoon [9]. This technique is typically used for solving MCDM problems. In TOPSIS method, two solutions are identified, ideal solution and anti-ideal solution. While ideal solution maximizes the benefit criteria and minimizes the cost criteria, anti-ideal solution maximizes the cost criteria and minimizes the benefit criteria. Because of this reason, the principal idea behind TOPSIS is, locating shortest distance to ideal solution and longest distance to anti-ideal solution.

It is a well-known fact that, to express the necessities, preferences and thoughts is not sufficient by using crisp numbers only. Fuzzy set theory was evolved to eliminate this limitation by allowing to model uncertainty of human judgments [10]. While in classical TOPSIS, the ratings for criteria are known literally, in fuzzy TOPSIS, the ratings for criteria are described in linguistic terms.

The steps of fuzzy TOPSIS method are given below:

Step 1: Determine the alternatives and the required evaluation criteria

The criteria are determined by carrying out a literature survey and utilizing expert knowledge. There are *m* alternatives denoted as $A_i = \{A_1, A_2, ..., A_m\}$, which are evaluated under *n* criteria, $C_j = \{C_1, C_2, ..., C_n\}$.

Step 2: Construct the fuzzy decision matrix $(\tilde{D})$ that denote the evaluation of alternatives with respect to criteria and the weight matrix of criteria $(\tilde{w})$ as

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \quad i = 1,2, \ldots, m; j = 1,2, \ldots, n. \tag{1}$$

$$\tilde{w}_j = (\tilde{w}_1, \tilde{w}_2 ..., \tilde{w}_n) \qquad j = 1,2, \ldots, n. \tag{2}$$

where $\tilde{x}_{ij}$ and $\tilde{w}_j$ can be represented as $\tilde{x}_{ij} = \left(x_{ij}^1, x_{ij}^2, x_{ij}^3\right)$ and $\tilde{w}_j = \left(w_j^1, w_j^2, w_j^3\right)$, respectively, in triangular fuzzy number format.

Step 3: Normalize the fuzzy decision matrix

The normalized fuzzy decision matrix $\tilde{R}$ is constructed as $\tilde{R} = [\tilde{r}_{ij}]_{mxn}$, i=1,2,…,m; j=1,2,…,n,

$$\tilde{r}_{ij} = \begin{cases} \left(\dfrac{x_{ij}^1}{x_j^*}, \dfrac{x_{ij}^2}{x_j^*}, \dfrac{x_{ij}^3}{x_j^*}\right), & x_j^* = \max\limits_i x_{ij}^3, \quad j \in B_j \\ \left(\dfrac{x_j^-}{x_{ij}^3}, \dfrac{x_j^-}{x_{ij}^2}, \dfrac{x_j^-}{x_{ij}^1}\right), & x_j^- = \min\limits_i x_{ij}^1, \quad j \in C_j \end{cases} \tag{3}$$

where B_j represents the set of benefit-related criteria for which the greater the performance value the more its preference, C_j represents the set of cost-related criteria for which the greater the performance value the less its preference.

Step 4: Compute the weighted normalized decision matrix, $\tilde{V} = [\tilde{v}_{ij}]_{mxn}$, as

$$\tilde{v}_{ij} = \tilde{r}_{ij}\tilde{w}_j \tag{4}$$

Step 5: Define the ideal solution $\left(A^*\right) = \left(\tilde{v}_1^*, \tilde{v}_2^*, ..., \tilde{v}_n^*\right)$, and the anti-ideal solution $\left(A^-\right) = \left(\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_n^-\right)$, where $\tilde{v}_j^* = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$ for $j = 1,2, \dots, n$.

Step 6: Compute the distances from ideal and anti-ideal solutions (d_i^* and d_i^-, respectively) for each alternative A_i as

$$d_i^* = d\left(A_i, A^*\right) = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right) \tag{5}$$

where

$$d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right) = \sqrt{\frac{1}{3}\left[\left(v_{ij}^1 - v_j^{*1}\right)^2 + \left(v_{ij}^2 - v_j^{*2}\right)^2 + \left(v_{ij}^3 - v_j^{*3}\right)^2\right]} \tag{6}$$

and

$$d_i^- = d\left(A_i, A^-\right) = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right) \tag{7}$$

where

$$d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right) = \sqrt{\frac{1}{3}\left[\left(v_{ij}^1 - v_j^{-1}\right)^2 + \left(v_{ij}^2 - v_j^{-2}\right)^2 + \left(v_{ij}^3 - v_j^{-3}\right)^2\right]} \tag{8}$$

Step 7: Calculate the closeness coefficient (CC_i) of each alternative as follows:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*}, \quad i = 1,2,...,m \tag{9}$$

Step 8: Rank the alternatives according to CC_i values in descending order. Identify the alternative with the highest CC_i as the best alternative.

CASE STUDY

The application of the developed methodology is illustrated by a case study conducted in a detergent manufacturer factory located in south part of Turkey. First, an analysis is conducted with quality control department and then the features of washing liquids, expectations of customers, factors that effects on production process are stated. Finally, a survey is constructed with the contribution of quality control department.

Five criteria that are considered as evaluation criteria can be listed as

"pH (C_1)",

"viscosity (C_2)",

"anionic active material (C_3)",

"nonionic active material (C_4)",

"total active material (C_5)".

Three decision-makers (DM_1, DM_2, DM_3) used the linguistic term set given in Table 1 for determining the ratings of alternatives with respect to criteria and the importance of evaluation criteria. The results are given in Table 2.

Table 1. Linguistic Variables

Linguistic terms	Fuzzy numerical values
Very Low (VL)	(0, 0, 0.25)
Low (L)	(0, 0.25, 0.50)
Average(A)	(0.25, 0.50, 0.75)
High(H)	(0.50, 0.75, 1)
Very High(VH)	(0.75, 1, 1)

Table 2. Ratings of Decision-makers

	C_1	C_2	C_3	C_4	C_5
Formulation1	(H,M,H)	(H,H,M)	(VH,H,M)	(VH,H,M)	(VH,H,M)
Formulation2	(H,M,M)	(M,M,L)	(M,M,M)	(H,M,L)	(M,M,L)
Formulation3	(M,L,M)	(M,M,H)	(H,H,M)	(H,M,M)	(M,H,M)
Formulation4	(H,M,H)	(H,VH,H)	(H,M,H)	(M,H,H)	(H,M,M)
Formulation5	(M,M,M)	(VH,H,M)	(H,L,M)	(H,H,M)	(M,L,L)
Formulation6	(H,M,H)	(M,H,H)	(M,M,H)	(L,M,M)	(M,H,M)
Weights	(L,M,H)	(H,H,H)	(VH,H,H)	(M,H,H)	(H,VH,VH)

The weighted normalized fuzzy decision matrix is constructed employing Eq. (4). Then the distances from the ideal ant the anti-ideal solutions and the closeness coefficients for each alternative are computed as in Table 3.

Table 3. Ranking results of the alternatives

	d_i^*	d_i^-	CC_i	Rank
Formulation1	2.3063	2.3734	0.5071	2
Formulation2	2.8984	1.7038	0.3702	6
Formulation3	2.6602	1.9936	0.4283	5
Formulation4	2.3199	2.4149	0.5100	1
Formulation5	2.6072	2.0360	0.4384	3
Formulation6	2.6591	2.0002	0.4293	4

CONCLUSIONS

Material selection problem, which requires the consideration of multiple conflicting criteria, can be grouped as an important multi-criteria decision making problem. In this paper, fuzzy TOPSIS method is used for material selection procedure. The application of the methodology is illustrated by a case study conducted in a detergent manufacturer factory. Future research might focus on the improvement of different MCDM approaches for material selection problem.

ACKNOWLEDGMENT

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ROBOT SELECTION FOR WAREHOUSES

Burcu Bahadır[1], Gülçin Büyüközkan[2]

Abstract – *The industrial revolution starts with the introduction of mechanical systems in manufacturing processes. As a result of developing and advancing technologies, industrial revolution has reached a new stage called industry 4.0. In industry 4.0 all value chain activities are connected with the help of various technologies, including cyber-physical systems, internet of things, cloud services, big data, sensors, 3D printers, robotics and augmented reality. Technological developments, which trigger industry 4.0, also affect logistics, supply chain processes as well as production processes. Many technologies have become prominent with the transformation that can be called logistics 4.0 and autonomous mobile robots are not an exception. Selecting the most suitable technology among different alternatives is a vital process for companies because incorrect and unnecessary investments in technology can cause damage to businesses. Therefore, companies must determine appropriate technologies for their specific needs. This paper aims to solve the autonomous mobile robot selection problem in warehouses. For this reason, Fuzzy VIKOR method is used to select the best robot alternative from seven robot alternatives by evaluating five criteria through a case study.*

Keywords –Autonomous Mobile Robot Selection, Logistics 4.0, MCDM, Fuzzy VIKOR

INTRODUCTION

Throughout history, there have been three major industrial revolutions. The first industrial revolution began with the invention of the steam engine in the late 18th century. The second industrial revolution sparked by the using of electricity and mass production. In 1970's the third industrial revolution began with the integrated usage of electronics and information technologies. Today, we all witness the new industrial revolution. Fourth industrial revolution, mostly known as Industry 4.0 emerged with the involvement of internet of things in manufacturing systems. In Industry 4.0, all value chain activities are connected with the help of various technologies, including cyber-physical systems, internet of things, cloud services, big data, sensors, 3D printers, robotics and augmented reality [1]. The technologies that compose Industry 4.0 also effect supply chain processes. Supply chain processes must operate in an integrated manner with all the processes within the factory to be able to deal with the increasing demand that comes along with Industry 4.0 [2]. Technologies like the internet of things, big data, augmented reality and robotics must be applied to the supply chain process to make sure that it can work together with all the other processes.

Order picking is an important part of the logistics and supply chain processes because it is labor intensive and costly. It has been observed to generate almost 55% of the operation cost compared to other processes occurring in the warehouse. Companies began to look for solutions for this issue because of the costly nature of order picking and the effect that it has on customer satisfaction [3]. Autonomous mobile robots became involved in the warehouses with the emergence of Industry 4.0 to reduce cost and increase customer satisfaction. Robots interacting with one another can take the orders to the desired location quickly and without becoming caught up by obstacles. Additionally labor costs are reduced with the usage of these robots by utilizing a minimum of manpower. A human can make from 100 to 150 picks while an autonomous robot can make 500-600 picks on average.

The aim of this study is to identify the best autonomous mobile robot alternative for ABC Company's warehouse. The paper is organized as follows. Next section provides a brief literature survey for robot selection. The following section presents the proposed methodology. In latter section, a case study is presented and last section concludes the study.

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LITERATURE SURVEY

In the literature, a number of authors have used the multi criteria decision-making (MCDM) and other techniques for robot selection problems. Kumar and Garg [4] developed a deterministic quantitative model based on the Distance Based Approach method to evaluate, select and rank the robot alternatives. Karsak [5] introduced a decision model for robot selection based on quality function deployment and fuzzy regression that can integrate user demands and technical characteristics of robots. In the study repeatability, velocity, load capacity, horizontal reach and warranty period used as robot characteristics and improved product quality, reduced cycle time, increased manufacturing flexibility, low cost, and vendor support used for the customer requirements. Chakraborty and Mondal [6] applied 4 different data envelopment analysis (Charnes, Cooper and Rhodes (CCR); Banker, Charnes and Cooper (BCC); additive; and cone-ratio) to identify the feasible robot alternatives having the optimal performance measures. Athawale and Chakraborty [7] used ten different MCDM methods including VIKOR, analytic hierarchy process (AHP), technique for order preference by similarity to ideal solution (TOPSIS), elimination and et choice translating reality method (ELECTRE), grey relational analysis (GRA), preference ranking organization method for enrichment evaluation (PROMETHEE), simple additive weighting (SAW), weighted product method (WPM), graph theory and matrix approach (GTMA), range of value method to determine the applicability of these MCDM methods for industrial robot selection problems. Chatterjee et al. [8] used two different MCDM methods (VIKOR, ELECTRE) to solve the robot selection problem. Also these methods applied in two real examples for prove the applicability of these methods. Adakane & Narkhade [9] presented a robot selection procedure based on the three different MCDM methods (AHP, TOPSIS and PROMETHEE) to solve the robot selection problem for powder coating operations. The most convenient robot alternative from 15 different alternatives was determined by evaluating seven criteria such as vertical reach, horizontal reach, load capacity, repeatability, cost of robot, mass of robot and speed of robot. Shahrabi [10] used hybrid MCDM approach which includes fuzzy AHP and fuzzy TOPSIS to select the most convenient robot for material handling tasks in metal cutting workshop in a truck factory.

METHODOLOGY

Proposed methodology for the study can be summarized in four steps. These steps are as follows:

Step 1: Defining the appropriate autonomous mobile robot selection alternatives.

Step 2: Defining the relevant autonomous mobile robot evaluation criteria.

Step 3: Calculating the importance weight of each criterion by fuzzy assessments.

Step 4: Ranking the alternatives by fuzzy VIKOR method.

Detailed version of these steps are shown in Figure 1.

Fuzzy Set Theory

Fuzzy set theory, form the basis of fuzzy logic, was introduced by Lotfi Zadeh in 1965 to deal with problems involving uncertainty and vagueness [11]. Fuzzy set theory is.an extension of classical set theory. In fuzzy set theory, the membership function of elements that are not belong to set are assigned to 0 and those that are completely within the set are assigned to 1. Also elements that are unclear whether they are within the set are assigned a value between 0 and 1 depending on their uncertainty of situation. However, there is no such thing as an uncertain element in classical set theory. An element is belongs to a set or is completely out of a set. Therefore an element’s membership value can be assigned to 0 or 1 in classical set theory. A membership function for a fuzzy set A of a set X can be defined as [11]:

$$\mu_A = X \rightarrow [0,1] \quad (1)$$

Trapezoidal fuzzy numbers and triangular fuzzy numbers are the most widely used type of fuzzy numbers. In this study, due to ease of operation, triangular fuzzy numbers were used. Triangular fuzzy numbers are shown as A= (a_1, a_2, a_3).

Terms cannot be precisely determined therefore people mostly use uncertain expressions. Fuzzy logic is a multi-valued logic that has been developed against binary logic and which determines the rate of events that occur by assigning membership values to the variables that we use in real life. Fuzzy logic which uses colloquial speech can ensure being closest to human logic by using linguistic variables such as "slightly", "quite", "very" etc. [16] Fuzzy logic can be used in almost any field. The main application areas are decision-making, economy, control systems, medical tests, operations research etc.

Fuzzy VIKOR

The VIKOR (VlseKriterijumsa Optimizacija Kompromisno Resenje) method was developed by Opricovic in 1988. VIKOR is a multi-criteria decision making method which was developed for optimization of complex systems [12]. This method is used to determine compromise solutions for problems containing conflicting criteria and rank among alternatives with the help of decision makers to reach a final decision. Compromise solution which is a solution that is formed with mutual concessions is closest to ideal.There are many studies in the literature about VIKOR method. Application areas of the VIKOR can be categorized as follows; design, mechanical engineering and manufacturing, business management, logistics and supply chain management, environmental management, information technology, policy social and education, energy management, financial management, transportation engineering [13].

The Fuzzy VIKOR procedure consists of the following steps [14].

- Calculate the importance weight of criteria: In this step, to obtain the importance weights for each criterion linguistic values used to evaluate criteria by experts. Then, the aggregated importance weight is calculated with Equation (2).

$$\widetilde{w_J} = \frac{1}{N}\left(\widetilde{w}_j^1 + \widetilde{w}_j^2 + \cdots \widetilde{w}_j^N\right) \quad j = 1, 2,...,k \tag{2}$$

where $\widetilde{w}_j^n$ is the importance weight of the N th expert. Linguistic variables for criteria evaluation are given in Table 1 [15].

Table 1. Linguistic variables for criteria evaluation

Linguistic Variables	Fuzzy Numbers		
Very Low	0	0	0,1
Low	0	0,1	0,3
Medium Low	0,1	0,3	0,5
Medium	0,3	0,5	0,7
Medium High	0,5	0,7	0,9
High	0,7	0,9	1
Very High	0,9	1	1

Evaluate the alternatives with respect to each criterion by using linguistic variables [15] given in Table 2.

Table 2. Linguistic variables for the ratings

Linguistic Variables	Fuzzy Numbers		
Very Poor	0	0	1
Poor	0	1	3
Medium Poor	1	3	5
Fair	3	5	7

Medium Good	5	7	9
Good	7	9	10
Very Good	9	10	10

The ratings of alternatives are obtained with using Equation (3). In this equation, it assumed decision making groups have N decision makers.

$$\tilde{x}_{ij} = \frac{1}{N}\left(\tilde{x}_{ij}^{1} + \tilde{x}_{ij}^{2} + \cdots \tilde{x}_{ij}^{N}\right)$$
(3)

and $\tilde{x}_{ij}^{N}$ is the evaluation of the Nth expert for ith alternative with respect to jth criterion.

- Create the fuzzy decision matrix

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$
(4)

$$W = [w_1, w_2, w_3 \ldots w_n] \quad j=1,2,\ldots\ldots n$$
(5)

x_{ij} represents the rating of alternative i with respect to criterion j and w_j is importance weight of criterion j.

- Determine the fuzzy best rating f_i^* and fuzzy worst rating f_i^- values for all criterion as seen in Equation (6)-(7).

$$f_i^* = \max_j f_{ij}\,, f_i^- = \min_j f_{ij},$$
(6)

where, $i = 1, 2, 3, \ldots, n;\ \ i - \text{th criterion represents a benefit}$

$$f_i^* = \min_j f_{ij}\, f_i^- = \max_j f_{ij}, \tag{7}$$

where, $i = 1, 2, 3, \ldots, n;\ i - \text{th criterion represents a cost}$

- Calculation of the S_j and R_j values: Compute the mean of group utility S_j and maximal regret R_j j= 1,2..J, using Equation (8) and (9) respectively

$$S_j = \sum_{i=1}^{n} \frac{w_i(f_i^* - f_{ij})}{(f_i^* - f_i^-)} \tag{8}$$

$$R_j = \max_j \left[\frac{w_i(f_i^* - f_{ij})}{(f_i^* - f_i^-)}\right] \tag{9}$$

Where w_i are the weights of criteria, expressing their relative importance.

- Calculation of the Q values: Compute the values Q_j by using Equation (10).

$$Q_j = \frac{v(S_j - S^*)}{(S^- - S^*)} + \frac{(1-v)(R_j - R^*)}{(R^- - R^*)} \tag{10}$$

where $S^* = \min_j S_j$, $S^- = \max_j S_j$, $R^* = \min_j R_j$, $R^- = \max_j R_j$ (11)

v is weight of the strategy of 'the majority of attributes'. (1-v) is the weight of the individual regret. Generally the value of v is taken 0.5.

- Defuzzify triangular fuzzy numbers (S_j ,R_j and Q_j). In the literature there are many defuzzification method to convert fuzzy numbers into a crisp number. According to the graded mean integration approach, the triangular fuzzy numbers can be converted to crisp values with Equation (12) [16] .

$$A = (a_1, a_2, a_3) \;\; P(A) = \frac{a_1 + 4a_2 + a_3}{6} \tag{12}$$

- Rank the alternatives: Rank the alternatives increasingly according to S_j, R_j, and Q_j values. The results are set of three ranking lists.

- Condition Check: Propose a compromise solution the alternative (A^1) which is ranked the best by the measure Q (minimum) if the following two conditions are satisfied:

Condition 1 (C1) : "Acceptable advantage"

$$Q(A^2) - Q(A^1) < DQ \tag{13}$$

where A^2 is the second alternative in the ranking list by Q.

$$DQ = \frac{1}{J-1} \tag{14}$$

J is the number of alternatives. If J<4 than the DQ value is taken as 0,25.

Condition 2 (C2) : "Acceptable stability in decision - making"

Alternative$^{(1)}$ must also be ranked as the best by S and R .

When one of this conditions are not satisfied then a set of compromise solution is selected. These compromise solutions are consisting of :

1)If only condition 2 (C2) is not satisfied then alternatives A^1 and A^2 are the best compromise solution.

2) If condition 1 (C1) is not satisfied, then A^M is determined by using Equation (15) for maximum M (the positions of these alternatives are "in closeness")

$$Q(A^M) - Q(A^1) < \frac{1}{J-1} \tag{15}$$

CASE STUDY

In this section, the proposed methodology is applied in autonomous mobile robot selection problem for the ABC Company's warehouse. The proposed methodology are detailed in Figure 1.

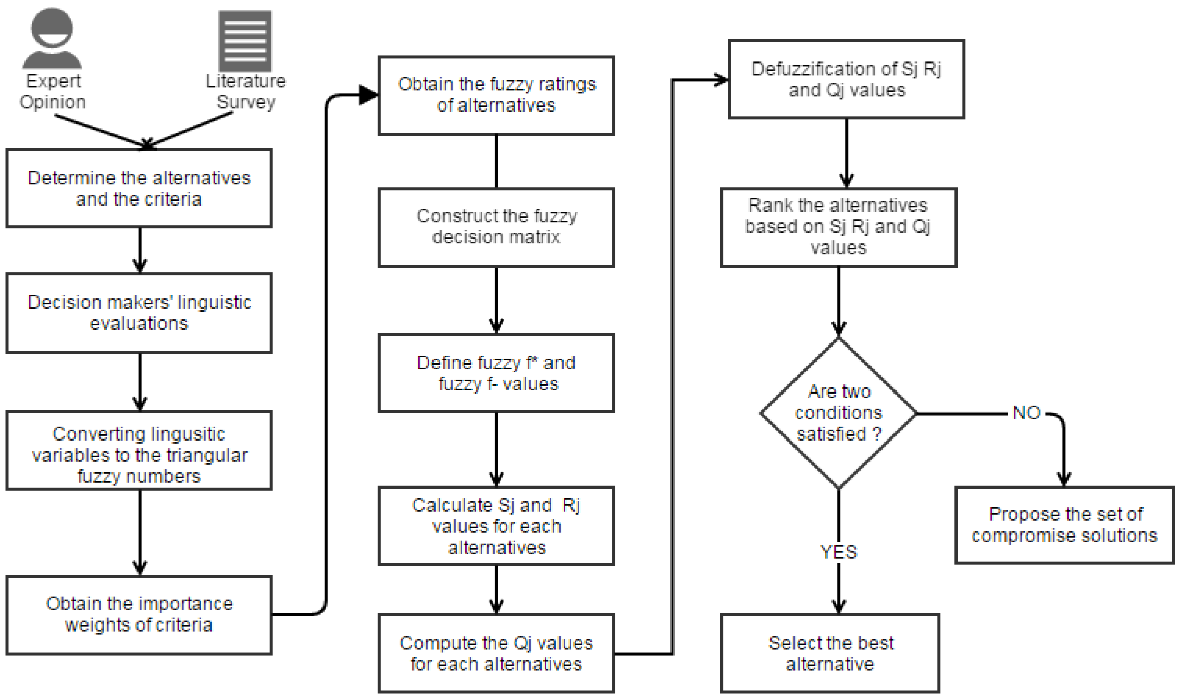

Figure 1. Proposed methodology

Based on the literature review and discussion with industrial experts, seven alternatives and five evaluation criteria are determined for decision-making process. The autonomous mobile robot alternatives are: Invia (A1), Locus (A2), Freight (A3), Milvus (A4), Iamrobotics (A5), MagazinoToru (A6), Adept Lynx (A7). Evaluation criteria and their definitions are:

- Total Cost (C1): Investment and operation cost.
- Velocity (C2): Maximum travel speed.
- Load Capacity (C3): Maximum weight to be carried by robots.
- Operating Time (C4): How long the robots can work continuously without needing to charge.
- Functionality (C5): Robot's ability to pick up orders with or without human interference.

Decision makers evaluate five criteria with linguistic variables given in Table 1 to calculate the importance weight of each criterion. Consensus of decision-makers' evaluations reached by Delphi methodology is presented in Table 3.

Table 3. Decision makers' evaluations

Criteria	DM
C1	VH
C2	MH
C3	VH
C4	M
C5	H

Linguistic values shown in the Table 4 are converted to fuzzy numbers using Table 1 and importance weight of each criterion obtained as fuzzy triangular numbers. C1 (Total Cost) and C3 (Load Capacity) are obtained as the most important criteria. Decision makers' consensus alternative ratings are given in

Table 4. Linguistic values shown in the Table 4 were converted to fuzzy numbers using Table 2 to create the fuzzy decision matrix for the study.

Table 4. Decision makers' ratings

Criteria	A1	A2	A3	A4	A5	A6	A7
C1	G	MP	F	MP	G	P	VP
C2	VG	G	G	VP	VP	MP	MG
C3	F	F	MG	VG	VP	P	MP
C4	MG	MG	F	MP	MG	MP	VG
C5	VG	F	F	F	G	G	F

After the decision matrix is created, next step is determine the fuzzy best values (f^*) and the fuzzy worst (f^-) values for each criterion. After determining these values, S_j and R_j values are calculated using Equation (8) and (9) respectively. In the next step, using with Equation (11), S^*, S^-, R^* and R^- values are calculated. Then Q_j values for each alternative are computed using Equation (10). In the calculation, the weight of the strategy of the maximum group utility (v) is assumed to be 0.5. After all values are computed, S_j, R_j and Q_j values are defuzzified using Equation (12). The results are presented in Table 6.

Table 5. Crisp values

	S	R	Q
A1	0.61	0.45	0.69
A2	2.83	1.22	8.37
A3	2.56	1.22	8.10
A4	1.88	1.10	8.72
A5	2.40	1.04	5.82
A6	3.33	0.97	7.70
A7	3.22	1.34	8.46

Next step is rank the alternatives according to S_j, R_j and Q_j values in ascending order. The ranking lists are given in Table 6.

Table 6. Ranking list

	S	R	Q
1	A1	A1	A1
2	A4	A6	A5
3	A5	A5	A6
4	A3	A4	A3
5	A2	A3	A2
6	A7	A2	A7
7	A6	A7	A4

After ranking the alternatives, the two conditions that explained in VIKOR stage should be checked. According the first condition in other word acceptable advantage condition to satisfy this condition $Q(A2)-Q(A1) \geq DQ$ should be satisfied. In the study Q(A2)-Q(A1) equals 5.14 and DQ equals 0.167. According to these values the first condition is satisfied. In second condition, acceptable stability, the first alternative in ranking list for each S, R and Q values should be the same. In the study A1 is the first one on the list for each three list so condition 2 is satisfied either. As a result the best alternative is determined. A1 is selected as the best autonomous mobile robot alternative for ABC firm's warehouse.

CONCLUSION

Companies should reduce their costs as much as possible to stay afloat in an increasingly competitive environment and to increase their competitiveness. Therefore the decisions that create cost for companies must be made carefully. The selection of autonomous mobile robots can be costly and for this reason the selection of the appropriate robot should be made after thorough analysis. In this study a decision making group consisting of three decision makers has been formed for the autonomous mobile robot selection and said group reached consensus to evaluate criteria and alternatives using the Delphi group decision making method. Five evaluation criteria and seven alternatives have been evaluated and the linguistic assessments from the decision makers have been analyzed with the fuzzy VIKOR method. In the light of the obtained results the most suitable alternative for the company has been determined to be the Invia Robot alternative (www.inviarobotics.com).

The standard criteria used for decades for robot selection is present in the literature. However autonomous mobile robots treated in this study are emerging technologies in recent years and are treated for the first time in literature. Therefore there are no standard criteria like other robot selection studies. The subject of autonomous mobile robot selection can be advanced in future studies by increasing the number of criteria and the decision makers or using different decision making methods. In this study, the interactions between evaluation criteria are not considered. One of the other perspectives for future work can be to consider the dependence of the criteria, the interaction between the criteria, and to extend our analysis by applying the analytic network process approach [17] to identify the criteria weights.

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IMPLEMENTATION OF THE BALANCED SCORECARD CONCEPT UNDER INTERVAL TYPE-2 FUZZY ENVIRONMENT

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Abstract −Balanced Scorecard (BSC) is a strategic performance evaluation tool which utilizes lagging and leading indicators on the basis of vision and strategies. In the BSC, business performance is evaluated not only by financial indicators but also non-financial aspects such as customer, business processes, and innovation and learning are taken into consideration simultaneously. Despite many successful applications of the BSC approaches reported in the literature, there is still a room for improvement in quantitative BSC evaluations. In this study, an interval type-2 fuzzy Analytical Hierarchy Process (AHP) and interval type-2 fuzzy DEMATEL (Decision Making Trial and Evaluation Laboratory) methods are integrated with the BSC for strategic performance evaluation. The proposed model is realized in a logistics company operating in Turkey.

Keywords −AHP, Balanced scorecards, DEMATEL, Interval type-2 fuzzy sets

1. INTRODUCTION

Balanced Scorecard (BSC) is a periodical and systematic performance control method developed by Kaplan and Norton [1]. A few decades ago the amount of tangible assets and financial conditions of the companies were used to determine power. Companies are now shifting from industrial age competition to information age competition [2]. No longer can companies gain sustainable competitive advantage just by rapidly deploying new technology into physical assets or by excellent management of financial assets and liabilities [3].

Logistics companies are operating under highly dynamic and volatile environments. Logistic organizations should use new management techniques in order to have an effective strategic management. Because of the complexity of logistics processes, applying new management tool and techniques is of critical importance. BSCs can be considered as an appropriate management tool in that respect.

As performance measurement systems entail human judgements, uncertainty in the linguistic expressions of the decision makers should be modeled appropriately. Because words mean different things to different people, interval type-2 fuzzy sets (IT2FSs) are recommended for modeling experts' linguistic judgements [4, 5]. In this study, interval type-2 fuzzy analytical hierarchy process (IT2F-AHP) [6] and interval type-2 fuzzy Decision Making and Trial and Evaluation Laboratory (IT2F-DEMATEL) [7, 8] methods are integrated into the BSC performance measurement hierarchy.

This study contributes to the literature in the following ways:

- First time in the literature IT2FSs are integrated into quantitative performance measurement within BSC framework.
- IT2FS-DEMATEL method is used to analyze causal relationships among BSC performance indicators.
- A novel weighting scheme is proposed by integrating IT2F-AHP and IT2F-DEMATEL methods.
- A real world case study is conducted in order to demonstrate the applicability of the method.

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In section 2, background information about IT2FSs are given. In section 3, methods used in the paper are explained. In section 4, application of the proposed method is presented. Concluding remarks are given in section 5.

2. BACKGROUND INFORMATION

2.1. Interval Type-2 Fuzzy Sets

Definition 1 [4, 5]: A type-2 fuzzy set (T2FS) $\tilde{\tilde{A}}$ in the universe of discourse X can be represented by a type-2 membership function $\mu_{\tilde{\tilde{A}}}$, shown as in Eq. 1.

$$\tilde{\tilde{A}} = \left\{((x,u), \mu_{\tilde{\tilde{A}}}(x,u)) \mid \forall x \in X, \forall u \in J_x \subseteq [0,1], 0 \le \mu_{\tilde{\tilde{A}}}(x,u) \le 1\right\}$$

(1)

where J_x denotes an interval in [0,1]. Moreover, the type-2 fuzzy set $\tilde{\tilde{A}}$ also can be represented as in Eq. 2.

$$\tilde{\tilde{A}} = \int_{x \in X} \int_{u \in J_x} \mu_{\tilde{\tilde{A}}}(x,u) / (x,u)$$

(2)

where $J_x \subseteq [0,1]$ and $\int\int$ denotes union over all admissible x and u.

Definition 2 [4, 5]: Let $\tilde{\tilde{A}}$ be a T2FS in the universe of discourse X represented by the type-2 membership function $\mu_{\tilde{\tilde{A}}}$. If all $\mu_{\tilde{\tilde{A}}}(x,u) = 1$, then $\tilde{\tilde{A}}$ is called an IT2FS. An IT2FS $\tilde{\tilde{A}}$ can be regarded as a special case of a type-2 fuzzy set, represented as follows:

$$\tilde{\tilde{A}} = \int_{x \in X} \int_{u \in J_x} 1 / (x,u)$$

(3)

where $J_x \subseteq [0,1]$.

Definition 3 [4, 5]: The upper membership function and the lower membership function of an IT2FS are type-1 membership functions, respectively. Figure 1 shows a trapezoidal IT2FS $\tilde{\tilde{A}}$ as given in Eq. 4.

$$\tilde{\tilde{A}} = \left(\tilde{A}_i^U, \tilde{A}_i^L\right) = \left(\left(a_{i1}^U, a_{i1}^U, a_{i1}^U, a_{i1}^U; H_1(\tilde{A}_i^U), H_2(\tilde{A}_i^U)\right), \left(a_{i1}^L, a_{i1}^L, a_{i1}^L, a_{i1}^L; H_1(\tilde{A}_i^L), H_2(\tilde{A}_i^L)\right)\right)$$

(4)

where $\tilde{A}_i^U$ and $\tilde{A}_i^L$ are type-1 fuzzy sets, $a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U, a_{i1}^L, a_{i2}^L, a_{i3}^L$ and a_{i4}^L are the reference points of the IT2FS $\tilde{\tilde{A}}_i$, $H_j(\tilde{A}_i^U)$ denotes the membership value of the element $a_{i(j+1)}^U$ in the upper trapezoidal membership function $\tilde{A}_i^U$, $1 \le j \le 2$, $H_j(\tilde{A}_i^L)$ denotes the membership value of the element $a_{i(j+1)}^L$ in the lower trapezoidal membership function.

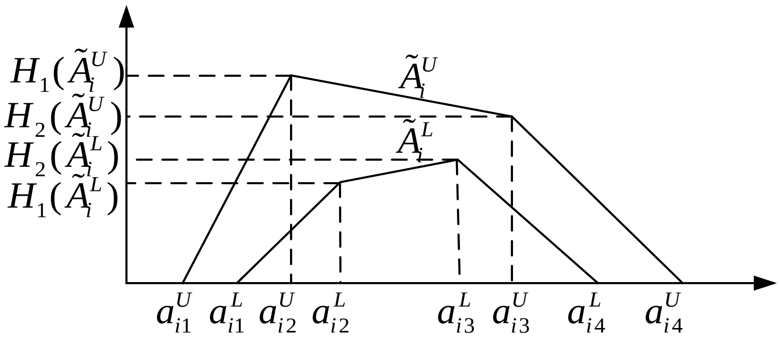

Fig. 1. A trapezoidal type-2 fuzzy set [9]

2.2. Arithmetic Operations of Interval Type-2 Fuzzy Sets

Definition 4 [9, 10]: The addition operation between the trapezoidal IT2FSs is defined as in Eq. 5:

$$\tilde{\tilde{A}}_1 \oplus \tilde{\tilde{A}}_2 = \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \oplus \left(\tilde{A}_2^U, \tilde{A}_2^L\right)$$
$$= \begin{pmatrix} \left(a_{11}^U + a_{21}^U, a_{12}^U + a_{22}^U, a_{13}^U + a_{23}^U, a_{14}^U + a_{24}^U; \min\left(H_1(\tilde{A}_1^U), H_1(\tilde{A}_2^U)\right), \min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)\right), \\ \left(a_{11}^L + a_{21}^L, a_{12}^L + a_{22}^L, a_{13}^L + a_{23}^L, a_{14}^L + a_{24}^L; \min\left(H_1(\tilde{A}_1^L), H_1(\tilde{A}_2^L)\right), \min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)\right) \end{pmatrix} \quad (5)$$

Definition 5 [9, 10]: The subtraction operation between the trapezoidal IT2FSs is defined as in Eq. 6:

$$\tilde{\tilde{A}}_1 \ominus \tilde{\tilde{A}}_2 = \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \ominus \left(\tilde{A}_2^U, \tilde{A}_2^L\right)$$
$$= \begin{pmatrix} \left(a_{11}^U - a_{24}^U, a_{12}^U - a_{23}^U, a_{13}^U - a_{22}^U, a_{14}^U - a_{21}^U; \min\left(H_1(\tilde{A}_1^U), H_1(\tilde{A}_2^U)\right), \min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)\right), \\ \left(a_{11}^L - a_{24}^L, a_{12}^L - a_{23}^L, a_{13}^L - a_{22}^L, a_{14}^L - a_{21}^L; \min\left(H_1(\tilde{A}_1^L), H_1(\tilde{A}_2^L)\right), \min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)\right) \end{pmatrix} \quad (6)$$

Definition 6 [9, 10]: The multiplication operation between the trapezoidal IT2FSs is defined as in Eq. 7:

$$\tilde{\tilde{A}}_1 \otimes \tilde{\tilde{A}}_2 = \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \otimes \left(\tilde{A}_2^U, \tilde{A}_2^L\right)$$
$$= \begin{pmatrix} \left(a_{11}^U \times a_{21}^U, a_{12}^U \times a_{22}^U, a_{13}^U \times a_{23}^U, a_{14}^U \times a_{24}^U; \min\left(H_1(\tilde{A}_1^U), H_1(\tilde{A}_2^U)\right), \min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)\right), \\ \left(a_{11}^L \times a_{21}^L, a_{12}^L \times a_{22}^L, a_{13}^L \times a_{23}^L, a_{14}^L \times a_{24}^L; \min\left(H_1(\tilde{A}_1^L), H_1(\tilde{A}_2^L)\right), \min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)\right) \end{pmatrix} \quad (7)$$

Definition 7 [9, 10]: The multiplication and division operations between IT2FS and a crisp value k is defined as in Eq. 8-9, respectively:

$$\tilde{\tilde{A}}\otimes k=\begin{pmatrix}\left(a_{11}^U\times k,a_{12}^U\times k,a_{13}^U\times k,a_{14}^U\times k;H_1(\tilde{A}_1^U),H_2(\tilde{A}_1^U)\right),\\ \left(a_{11}^L\times k,a_{12}^L\times k,a_{13}^L\times k,a_{14}^L\times k;\ H_1(\tilde{A}_1^L),H_2(\tilde{A}_1^L)\right)\end{pmatrix} \tag{8}$$

$$\frac{\tilde{\tilde{A}}_1}{k}=\left(\begin{array}{c}\left(a_{11}^U\times\frac{1}{k},a_{12}^U\times\frac{1}{k},a_{13}^U\times\frac{1}{k},a_{14}^U\times\frac{1}{k};H_1(\tilde{A}_1^U),H_2(\tilde{A}_1^U)\right),\\ \left(a_{11}^L\times\frac{1}{k},a_{12}^L\times\frac{1}{k},a_{13}^L\times\frac{1}{k},a_{14}^L\times\frac{1}{k};\ H_1(\tilde{A}_1^L),H_2(\tilde{A}_1^L)\right)\end{array}\right) \tag{9}$$

Definition 8 [11]: Expected value of a trapezoidal IT2FS $\tilde{\tilde{A}}$ is calculated by using Eq. 10.

$$E(A)=\frac{1}{2}\left(\frac{1}{4}\sum_{i=1}^{4}(a_i^L+a_i^U)\right)\times\frac{1}{4}\left(\sum_{i=1}^{2}(H_i(A^L)+H_i(A^U))\right) \tag{10}$$

where $\tilde{\tilde{A}}=\left((a_1^U,a_2^U,a_3^U,a_4^U;H_1(\tilde{A}^U),H_2(\tilde{A}^U)),(a_1^L,a_2^L,a_3^L,a_4^L;H_1(\tilde{A}^L),H_2(\tilde{A}^L))\right)$.

3. METHODOLOGY

3.1. Interval Type-2 Fuzzy AHP

This section introduces the extension of Buckley’s type-1 fuzzy AHP to the interval type-2 fuzzy sets. The linguistic scale of the IT2F-AHP is given below [6].

Step 1: Fuzzy pairwise comparison matrices are constructed as given in Eq. 11.

$$\tilde{\tilde{A}}=\begin{bmatrix}1 & \tilde{\tilde{a}}_{12} & \cdots & \tilde{\tilde{a}}_{1n}\\ \tilde{\tilde{a}}_{21} & 1 & \cdots & \tilde{\tilde{a}}_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ \tilde{\tilde{a}}_{n1} & \tilde{\tilde{a}}_{n2} & \cdots & 1\end{bmatrix}=\begin{bmatrix}1 & \tilde{\tilde{a}}_{12} & \cdots & \tilde{\tilde{a}}_{1n}\\ 1/\tilde{\tilde{a}}_{12} & 1 & \cdots & \tilde{\tilde{a}}_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ 1/\tilde{\tilde{a}}_{1n} & 1/\tilde{\tilde{a}}_{2n} & \cdots & 1\end{bmatrix} \tag{11}$$

where reciprocal comparisons are given by:

$$1/\tilde{\tilde{a}}=\left(\left(\frac{1}{a_{14}^U},\frac{1}{a_{13}^U},\frac{1}{a_{12}^U},\frac{1}{a_{11}^U};H_1(a_{12}^U),H_2(a_{13}^U)\right),\left(\frac{1}{a_{24}^L},\frac{1}{a_{23}^L},\frac{1}{a_{22}^L},\frac{1}{a_{21}^L};H_1(a_{22}^L),H_2(a_{23}^L)\right)\right) \tag{12}$$

Step 2: Fuzzy pairwise comparison matrices are checked for consistency. The defuzzification method is implemented in order to check the consistency of pairwise comparison matrix. If the comparison matrix $A=\left[a_{ij}\right]$ is consistent, then it implies that IT2F pairwise comparison matrix $\tilde{\tilde{A}}=\left[\tilde{\tilde{a}}_{ij}\right]$ is also consistent.

Step 3: The fuzzy geometric mean for each criterion is computed. The geometric mean of each row $\tilde{\tilde{r}}_i$ is calculated as in the Eq. 13.

$$\tilde{\tilde{r}}_i = \left[\tilde{\tilde{a}}_{i1} \otimes \cdots \otimes \tilde{\tilde{a}}_{in} \right]^{1/n}$$

(13)

where

$$\sqrt[n]{\tilde{\tilde{a}}_{ij}} = \begin{pmatrix} \left(\sqrt[n]{a_{ij1}^U}, \sqrt[n]{a_{ij2}^U}, \sqrt[n]{a_{ij3}^U}, \sqrt[n]{a_{ij4}^U}; H_1^U(a_{ij}), H_2^U(a_{ij}) \right), \\ \left(\sqrt[n]{a_{ij1}^L}, \sqrt[n]{a_{ij2}^L}, \sqrt[n]{a_{ij3}^L}, \sqrt[n]{a_{ij4}^L}; H_1^L(a_{ij}), H_2^L(a_{ij}) \right) \end{pmatrix}$$

(14)

Step 4: Normalized fuzzy weighs are computed. The fuzzy weight $\tilde{\tilde{w}}_i$ of the ith criterion is calculated as given in Eq. 15.

$$\tilde{\tilde{w}}_i = \tilde{\tilde{r}}_i \otimes \left[\tilde{\tilde{r}}_1 \oplus \cdots \oplus \tilde{\tilde{r}}_i \oplus \cdots \oplus \tilde{\tilde{r}}_n \right]^{-1}$$

(15)

where

$$\frac{\tilde{\tilde{a}}}{\tilde{\tilde{b}}} = \begin{pmatrix} \left(\frac{a_1^U}{b_4^U}, \frac{a_2^U}{b_3^U}, \frac{a_3^U}{b_2^U}, \frac{a_4^U}{b_1^U}; \min\left(H_1^U(\tilde{a}), H_1^U(\tilde{b}) \right), \min\left(H_2^U(\tilde{a}), H_2^U(\tilde{b}) \right) \right), \\ \left(\frac{a_1^L}{b_4^L}, \frac{a_2^L}{b_3^L}, \frac{a_3^L}{b_2^L}, \frac{a_4^L}{b_1^L}; \min\left(H_1^L(\tilde{a}), H_1^L(\tilde{b}) \right), \min\left(H_2^L(\tilde{a}), H_2^L(\tilde{b}) \right) \right) \end{pmatrix}$$

(16)

3.2. Interval Type-2 Fuzzy DEMATEL

In this step, the IT2F-DEMATEL method is used to capture the relationships among criteria. Then the relationships are transformed into local priorities. The main steps of the IT2F-DEMATEL method are briefly described as follows [7-8]:

Step 1: Acquiring the assessments of decision makers. The group of experts are asked to fill out the IT2F influence matrices. For that aim, total of k influence matrices, $\tilde{\tilde{\boldsymbol{Z}}}^{\langle 1 \rangle}, \tilde{\tilde{\boldsymbol{Z}}}^{\langle 2 \rangle}, \ldots, \tilde{\tilde{\boldsymbol{Z}}}^{\langle k \rangle}$ are collected.

Step 2: Calculating the average of the IT2F influence matrices. In this step, the average of the IT2F influence matrices is calculated as in the Eq. 17.

$$\tilde{\tilde{\boldsymbol{Z}}} = \frac{\tilde{\tilde{\boldsymbol{Z}}}^{\langle 1 \rangle} \oplus \tilde{\tilde{\boldsymbol{Z}}}^{\langle 2 \rangle} \oplus \ldots \oplus \tilde{\tilde{\boldsymbol{Z}}}^{\langle k \rangle}}{k}$$

(17)

where $\tilde{\tilde{\boldsymbol{Z}}}$ denotes the initial direct relation matrix. The initial direct relation matrix takes the form as seen in Eq. 18.

$$\tilde{\tilde{\boldsymbol{Z}}} = \begin{bmatrix} 0 & \tilde{\tilde{z}}_{12} & \cdots & \tilde{\tilde{z}}_{1n} \\ \tilde{\tilde{z}}_{21} & 0 & \cdots & \tilde{\tilde{z}}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\tilde{z}}_{n1} & \tilde{\tilde{z}}_{n2} & \cdots & 0 \end{bmatrix} \tag{18}$$

where $\tilde{\tilde{z}}_{ij} = \left(\left(a_{ij}, b_{ij}, c_{ij}, d_{ij}; H_1(\tilde{z}_{ij}^U), H_2(\tilde{z}_{ij}^U)\right), \left(e_{ij}, f_{ij}, g_{ij}, h_{ij}; H_1(\tilde{z}_{ij}^L), H_2(\tilde{z}_{ij}^L)\right)\right)$.

Step 3: Acquiring the normalized direct relation matrix. In order to calculate the normalized direct relation matrix, the trapezoidal IT2F initial direct relation matrix is rearranged according to membership functions. For the sake of simplicity, the heights of the IT2FNs are omitted from the subsequent representations as they do not affect the calculations. Therefore, total of eight $m \times m$ matrices are constructed as in the Eq. 19:

$$\boldsymbol{Z}_{a'} = \begin{bmatrix} 0 & a'_{12} & \cdots & a'_{1n} \\ a'_{21} & 0 & \cdots & a'_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a'_{n1} & a'_{n2} & \cdots & 0 \end{bmatrix}, \boldsymbol{Z}_{b'} = \begin{bmatrix} 0 & b'_{12} & \cdots & b'_{1n} \\ b'_{21} & 0 & \cdots & b'_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b'_{n1} & b'_{n2} & \cdots & 0 \end{bmatrix}, \ldots, \boldsymbol{Z}_{h'} = \begin{bmatrix} 0 & h'_{12} & \cdots & h'_{1n} \\ h'_{21} & 0 & \cdots & h'_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ h'_{n1} & h'_{n2} & \cdots & 0 \end{bmatrix} \tag{19}$$

Therefore, $\boldsymbol{Z}_{d'}$ contains the greatest element which is used to calculate the normalization coefficient. The normalized direct relation matrix is defined as in Eq. 20.

$$\tilde{\tilde{\boldsymbol{X}}} = \begin{bmatrix} \tilde{\tilde{x}}_{11} & \tilde{\tilde{x}}_{12} & \cdots & \tilde{\tilde{x}}_{1n} \\ \tilde{\tilde{x}}_{21} & \tilde{\tilde{x}}_{22} & \cdots & \tilde{\tilde{x}}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\tilde{x}}_{n1} & \tilde{\tilde{x}}_{n2} & \cdots & \tilde{\tilde{x}}_{nn} \end{bmatrix} \tag{20}$$

The elements of the normalized direct relation matrix are calculated as in the Eq. 21.

$$\tilde{\tilde{x}}_{ij} = \frac{\tilde{\tilde{z}}_{ij}}{s} = \left(\left(\frac{\boldsymbol{Z}_{a'_{ij}}}{s}, \frac{\boldsymbol{Z}_{b'_{ij}}}{s}, \frac{\boldsymbol{Z}_{c'_{ij}}}{s}, \frac{\boldsymbol{Z}_{d'_{ij}}}{s}; H_1(\tilde{z}_{ij}^U), H_2(\tilde{z}_{ij}^U)\right), \left(\frac{\boldsymbol{Z}_{e'_{ij}}}{s}, \frac{\boldsymbol{Z}_{f'_{ij}}}{s}, \frac{\boldsymbol{Z}_{g'_{ij}}}{s}, \frac{\boldsymbol{Z}_{h'_{ij}}}{s}; H_1(\tilde{z}_{ij}^L), H_2(\tilde{z}_{ij}^L)\right)\right) \tag{21}$$

where the normalization coefficient s is calculated as in the Eq. 22.

$$s = \max\left(\max_{1 \le i \le n} \sum_{j=1}^{n} \boldsymbol{Z}_{d'_{ij}}, \max_{1 \le j \le n} \sum_{i=1}^{n} \boldsymbol{Z}_{d'_{ij}}\right) \tag{22}$$

Step 4: Calculating the total relation matrix. In a very similar fashion to the Step 3, the normalized direct relation matrix can be represented by eight crisp matrices as in the Eq. 23:

$$\boldsymbol{X}_{a''}=\begin{bmatrix} 0 & a''_{12} & \cdots & a''_{1n} \\ a''_{21} & 0 & \cdots & a''_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a''_{n1} & a''_{n2} & \cdots & 0 \end{bmatrix}, \boldsymbol{X}_{b''}=\begin{bmatrix} 0 & b''_{12} & \cdots & b''_{1n} \\ b''_{21} & 0 & \cdots & b''_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b''_{n1} & b''_{n2} & \cdots & 0 \end{bmatrix}, \ldots, \boldsymbol{X}_{h''}=\begin{bmatrix} 0 & h''_{12} & \cdots & h''_{1n} \\ h''_{21} & 0 & \cdots & h''_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ h''_{n1} & h''_{n2} & \cdots & 0 \end{bmatrix}$$

(23)

The total relation matrix is represented by $\tilde{\tilde{\boldsymbol{T}}}$ as:

$$\tilde{\tilde{\boldsymbol{T}}}=\begin{bmatrix} \tilde{\tilde{t}}_{11} & \tilde{\tilde{t}}_{12} & \cdots & \tilde{\tilde{t}}_{1n} \\ \tilde{\tilde{t}}_{21} & \tilde{\tilde{t}}_{22} & \cdots & \tilde{\tilde{t}}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\tilde{t}}_{n1} & \tilde{\tilde{t}}_{n2} & \cdots & \tilde{\tilde{t}}_{nn} \end{bmatrix}$$

(24)

where $\tilde{\tilde{t}}_{ij}=\left(\left(a'''_{ij},b'''_{ij},c'''_{ij},d'''_{ij};H_1(\tilde{t}^U_{ij}),H_2(\tilde{t}^U_{ij})\right),\left(e'''_{ij},f'''_{ij},g'''_{ij},h'''_{ij};H_1(\tilde{t}^L_{ij}),H_2(\tilde{t}^L_{ij})\right)\right)$. The elements of the total relation matrix are calculated as in the Eq. 25:

$$\begin{aligned} \left[a'''_{ij}\right] &= \boldsymbol{X}_{a''}\times\left(\boldsymbol{I}-\boldsymbol{X}_{a''}\right)^{-1} \\ \left[b'''_{ij}\right] &= \boldsymbol{X}_{b''}\times\left(\boldsymbol{I}-\boldsymbol{X}_{b''}\right)^{-1},\ldots, \\ \left[h'''_{ij}\right] &= \boldsymbol{X}_{h''}\times\left(\boldsymbol{I}-\boldsymbol{X}_{h''}\right)^{-1} \end{aligned}$$

(25)

Note that the heights of the IT2FNs are the same for each entry of the total relation matrix; i.e. $H_1(\tilde{t}^U_{ij})=H_1(\tilde{x}^U_{ij})$.

Step 5: Conducting structural correlation analysis. The elements of the total relation matrix $\tilde{\tilde{t}}_{ij}$ are used to conduct structural correlation analysis. The sum of the rows and the sum of the columns of the $\tilde{\tilde{\boldsymbol{T}}}$ matrix, denoted as $\tilde{\tilde{D}}_i$ and $\tilde{\tilde{R}}_j$, respectively, can be obtained by using Eq. 26-27.

$$\tilde{\tilde{D}}_i=\sum_{j=1}^{n}\tilde{\tilde{t}}_{ij} \quad (i=1,2,\ldots,n)$$

(26)

$$\tilde{\tilde{R}}_j=\sum_{i=1}^{n}\tilde{\tilde{t}}_{ij} \quad (j=1,2,\ldots,n)$$

(27)

Then, the ordered pairs $\left(\tilde{\tilde{D}}_i\oplus\tilde{\tilde{R}}_i,\tilde{\tilde{D}}_i \,\$\, \tilde{\tilde{R}}_i\right)$ are calculated. In order to draw a causal diagram, expected values of the ordered pairs $\left(\tilde{\tilde{D}}_i\oplus\tilde{\tilde{R}}_i,\tilde{\tilde{D}}_i \,\$\, \tilde{\tilde{R}}_i\right)$ are calculated. The expected value of the $\tilde{\tilde{D}}_i\oplus\tilde{\tilde{R}}_i$ is denoted by $E\left(\tilde{\tilde{D}}_i \oplus \tilde{\tilde{R}}_i\right)$ and called expected prominence. Similarly, $E\left(\tilde{\tilde{D}}_i \$ \ \tilde{\tilde{R}}_i\right)$ is called expected relation.

Step 6: Calculating the weights of criteria. When the expected prominence and relation values are calculated, the importance of each criterion is calculated by Eq. 28:

$$W_i = \sqrt{\left(E\left(\tilde{\tilde{w}}_i\right) \times E\left(\tilde{\tilde{D}}_i \oplus \tilde{\tilde{R}}_i\right)\right)^2 + \left(E\left(\tilde{\tilde{w}}_i\right) \times E\left(\tilde{\tilde{D}}_i \$ \ \tilde{\tilde{R}}_i\right)\right)^2} \tag{28}$$

Where $\tilde{\tilde{w}}_i$ represents the *i*th criterion weight obtained by using IT2F-AHP method. Finally, the normalized importance degree of each criterion nw_i is calculated as in Eq. 29:

$$nw_i = \frac{W_i}{\sum_{i=1}^{n} W_i} \tag{29}$$

3.3. The Proposed Method

This section presents the main framework of the proposed method used in this paper. The proposed methodology is introduced and the algorithmic steps are provided. The proposed methodology consists of following procedures:

- The problem structuring
- IT2F-AHP to determine attribute weights
- IT2F-DEMATEL to resolve interrelationships among attributes

In the next section, the solution procedure is given in order to illustrate the proposed model.

4. APPLICATON

In this section, implementation of the proposed algorithm is provided. The case study is conducted in the logistics company located in Gaziantep, Turkey. First, three experts from the company are identified based on their professional backgrounds. Number of participants are reduced by assuring the heterogeneity of panel members. The experts consist of a team manager, an analyst, and a consultant who have more than five years of experience. Then, the linguistic scales are determined as given in Tables 1-2. Then, a comprehensive literature review has been conducted in order to identify the BSC criteria. The problem structure is formed as seen in the Figure 1.

Table 16 Scale of the Interval Type-2 Fuzzy AHP

Linguistic variables	Trapezoidal interval type-2 fuzzy scale
Absolutely strong (AS)	((7,8,9,9;1,1)(7.2,8.2, 8.8,9,0.9,0.9))
Very strong (VS)	((5,6,8,9;1,1)(5.2,6.2, 7.8,8.8,0.9,0.9))
Fairly strong (FS)	((3,4,6,7;1,1)(3.2,4.2,5.8,6.8,0.9,0.9))
Slightly strong (SS)	((1,2,4,5;1,1)(1.2,2.2,3.8,4.8;0.9,0.9))
Exactly equal (E)	((1,1,1,1;1,1)(1,1,1,1;1,1))

Table 2. Scale of the Interval Type-2 Fuzzy DEMATEL

Linguistic variable	ITFN
Very very low (VVL)	((0,0.1,0.1,0.2;1,1),(0.05,0.1,0.1,0.15;0.9,0.9))
Very low (VL)	((0.1,0.2,0.2,0.35;1,1),(0.15,0.2,0.2,0.3;0.9,0.9))

Low (L)	((0.2,0.35,0.35,0.5;1,1),(0.25,0.35,0.35,0.45;0.9,0.9))
Medium (M)	((0.35,0.5,0.5,0.65;1,1),(0.4,0.5,0.5,0.6;0.9,0.9))
High (H)	((0.5,0.65,0.65,0.8;1,1),(0.55,0.65,0.65,0.75;0.9,0.9))
Very high (VH)	((0.65,0.8,0.8,0.9;1,1),(0.7,0.8,0.8,0.85;0.9,0.9))
Very very high (VVH)	((0.8,0.9,0.9,1;1,1),(0.85,0.9,0.9,0.95;0.9,0.9))

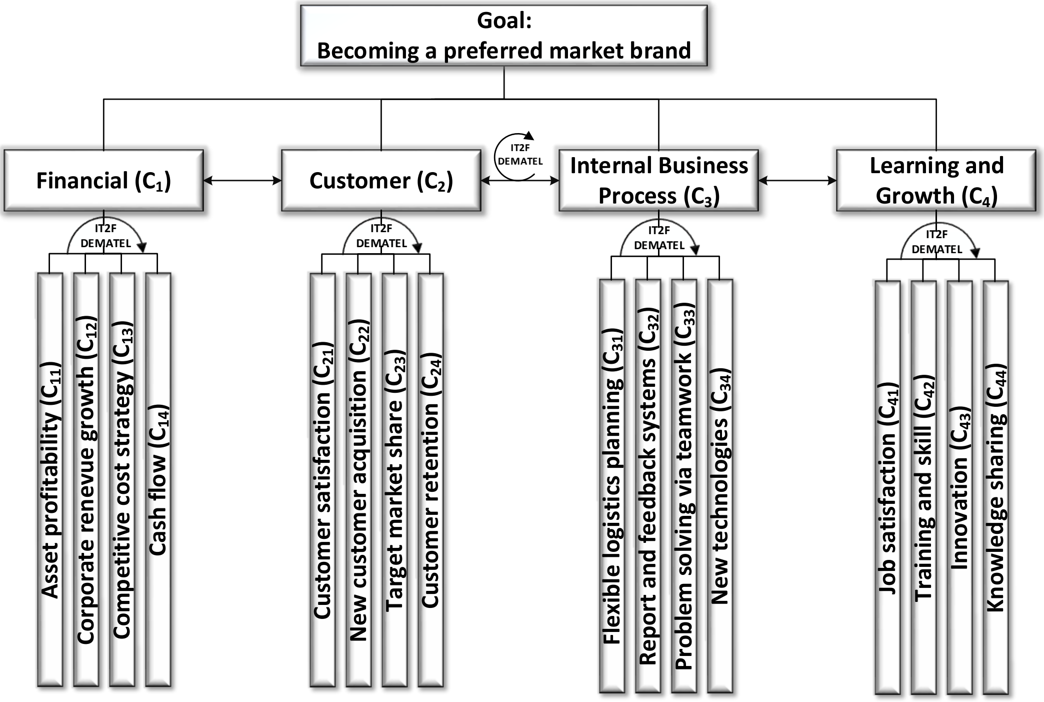

Figure 18. Problem structure

When the proposed method is implemented, the overall criteria weights are found as given in Table 3.

Table 3. Scale the performance ratings

BSC criteria	BSC weights	BSC Sub-criteria	Sub-criteria weights	Overall weights
Financial (C_1)	0.26	Asset profitability (C_{11})	0.26	0.068
		Corporate revenue growth (C_{12})	0.29	0.075
		Competitive cost strategy (C_{13})	0.28	0.073
		Cash flow (C_{14})	0.17	0.044
Customer (C_2)	0.30	Customer satisfaction (C_{21})	0.25	0.075
		New customer acquisition (C_{22})	0.14	0.042
		Target market share (C_{23})	0.36	0.108
		Customer retention (C_{24})	0.25	0.075
Internal Business Process (C_3)	0.14	Flexible logistics planning (C_{31})	0.44	0.062
		Report and feedback systems (C_{32})	0.34	0.048
		Problem solving via teamwork (C_{33})	0.12	0.017
		New technologies (C_{34})	0.10	0.014
Learning and	0.31	Job satisfaction (C_{41})	0.13	0.130

growth (C_4)				
		Training and skill (C_{42})	0.21	0.210
		Innovation (C_{43})	0.32	0.320
		Knowledge sharing (C_{44})	0.35	0.350

When the overall weights of the BSC attributes are found, they are multiplied by the scaled performance values. Ultimately, the performance of each BSC indicator are calculated as shown in Table 4.

Table 4. Performance Measure by Proposed Method

Performance Attributes	Overall Weights (OW)	Scaled performance (SP)	Performance (OW x SP)
C_{11}	0.068	0.25	0.017
C_{12}	0.075	1	0.075
C_{13}	0.073	0.75	0.055
C_{14}	0.044	0.25	0.011
C_{21}	0.075	1	0.075
C_{22}	0.042	0.5	0.021
C_{23}	0.108	0.75	0.081
C_{24}	0.075	0.25	0.019
C_{31}	0.062	1	0.062
C_{32}	0.048	0.75	0.036
C_{33}	0.017	0.25	0.004
C_{34}	0.014	0.5	0.007
C_{41}	0.130	0.75	0.098
C_{42}	0.210	0.25	0.053
C_{43}	0.320	0.25	0.080
C_{44}	0.350	0.25	0.088

5. CONCLUSIONS

In this paper an application of balanced scorecard in a logistics company is presented. It is figured out balanced scorecard can help to company in formulating its business strategy systematically. As there are interdependencies among BSC factors and the experts' linguistic judgements are inherently uncertain, classical performance measurement approaches fail to satisfy those requirements. For that reason, IT2F-AHP and IT2F-DEMATEL methods are integrated in order to assess the performance of the company in terms of BSC indicators. Although IT2F-AHP is able to derive criteria weights under fuzzy environment, possible interactions among criteria are ignored. The proposed method incorporates IT2F-DEMATEL method that the interactions are taken into consideration within the derived weights. Furthermore, IT2F-DEMATEL method is used to gain insights into the cause-effect relationships among BSC factors. Result of the study indicated that the company has relatively high performance in job satisfaction, innovation, and knowledge sharing. On the other hand, the company needs to improve team working and adopting new technologies. In the future studies, other IT2F MADM methods can be integrated into the model. Also, the presented method can be used for modeling wide variety of performance measurement problems in logistics companies.

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SOLAR PANEL SITE SELECTION USING HESITANT FUZZY DECISION MAKING

Ahmet Aktas [1], Mehmet Kabak [2]

Abstract − Due to the scarce fossil fuels and increasing energy demand, new energy generation technologies have been searched around the world. After these searches, renewable energy types are proposed as the new source for energy demand. Types of renewable energy can be listed as wind energy, solar energy, geothermal energy, etc. Solar energy has a great potential in Turkey, but usage of this potential is very limited. Solar energy is commonly used for hot water in Turkey and only 0,1% of energy demand in industry is satisfied from solar energy. Two solar energy plants are started operation in 2016 in Turkey and there is still a big solar energy potential. So, new solar plant plans should be developed and one of the important decisions in these plans is determination of plant locations. The main aim of this study is developing a decision making tool to determine solar energy plant site locations in Turkey. Solar panel site selection problem contains different alternatives, conflicting decision criteria and uncertainty. So, it can be modeled as a multiple criteria decision making problem and hesitant fuzzy linguistic term sets can be proposed to deal with uncertainty. Possible hesitance of decision makers in criteria evaluation is taken into consideration and AHP based on hesitant fuzzy linguistic term sets is proposed for solution of the problem. Applicability of the proposed approach is tested on a case study in Turkey.

Keywords −Decision making, facilities location, hesitant fuzzy sets, site selection, solar energy

INTRODUCTION

Energy is probably the most important part of daily life activities in the world since it is needed for transportation, lighting, production etc. Governments should be able to satisfy energy demand of their country. In case of unsatisfied demand, life quality of citizens will be decreased. Hence, energy policies take importance places in government plans.

Because of the increasing population and rapid growth in industrialization, energy demand of world is increasing every moment. Increasing demand requires countries to generate greater amounts of energy. At this point, people are facing with scarcity of conventional energy generation resources. Most of conventional energy generation techniques need fossil fuels and scarce nature of fossil fuels lead countries to search for new energy generation technologies.

Many countries in the world accepted nuclear power as a good way to satisfy increasing energy demand. Although nuclear energy is one of the most economic ways in energy generation technologies, possible damages of nuclear plants are seen after some nuclear disasters, such as the disaster at Chernobyl in 1986 and at Fukushima in 2011. These disasters show people that energy generation should not damage the environment.

Generating energy in a clean way is the new trend in energy generation technologies and renewable energy sources become very popular in the last decade. Renewable energy is defined as the energy that obtained from the energy flow of natural processes. Wind energy, solar energy, geothermal energy are some kinds of renewable energy and many countries are supporting investments on renewable energy technologies.

Because of the large amount of money to be invested in renewable energy systems, some issues related to these investments should be considered carefully. There are a number of important decisions to be made in renewable energy investments. Some of these decisions are prioritization of renewable resources, selection of equipment and technology and determination of plant locations. These decisions

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consist a number of conflicting criteria and non-dominant alternatives. Thus, it is possible to model these problems as a multiple criteria decision making problem. Multiple criteria decision making approaches are very good at finding compromise solutions to this kind of decision making problems.

In this study, site selection problem for a solar energy plant is considered. Since solar plant site selection problem consists of conflicting criteria and alternatives, multiple criteria decision making is proposed as the solution technique of this problem. Hesitancy of decision makers is also considered at the solution stage and hesitant fuzzy linguistic terms set theory is used in order to take uncertainty into account. Rest of the paper organized as follows: a literature review based on the decision making approaches and decision making criteria for solar panel site selection problem is given in the second part. In third part, proposed decision making methodology is explained. Next, an application of solar panel site selection in Turkey is given in the fourth part. This study concluded in the fifth part by giving discussions and further research directions.

LITERATURE REVIEW

It is possible to observe solar energy plant site selection in recent literature. In this section, studies with multiple criteria decision making are taken into account. 12 articles of SCI-indexed journals are selected and literature review is done based on decision making approaches and site selection criteria. Findings of this review are given as follows:

Different decision making approaches are utilized for solar panel site selection problem. Analytic Hierarchy Process (AHP) is the most common utilized approach in these studies [1-8]. AHP is an approach that commonly used in decision making problems, because of its ease of applicability for both qualitative and quantitative criteria evaluation. Furthermore, integration of AHP with other decision making methods, fuzzy logic, geographical information systems (GIS), etc. makes AHP a good choice for decision making problems. It is observed in this review that AHP is integrated with Fuzzy Information Axiom (FIA) [2], GIS [3-7] and fuzzy logic [8].

Other observed approaches utilized for site selection are a hybrid approach integrating Decision Making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process (ANP) and GIS [9], a hybrid approach based on Artificial Neural Networks (ANN) and GIS [10], a hybrid approach combining Elemination and Choice Translating Reality - TRI (ELECTRE-TRI) and GIS [11] and Linguistic Choquet Integral [12].

Next, same papers are analyzed based on site selection criteria. There are different site selection criteria related to technical, economic, social and environmental aspects of solar energy plants.

Technical criteria can be listed as sunshine hours [1 – 3, 12], sunshine radiation [1 – 4, 6 – 7, 9, 11 – 12], mean temperature [2 – 4, 7, 9, 11], distance to roads [4 – 7, 9, 11], grid connection [1, 12], topography [2, 8, 12], land use [3 – 5, 7 – 9, 11], visual impact [3], slope [3 – 5, 7, 9, 11], orientation [3 – 4, 7, 9, 11], highway access [3], distance to substations [3, 9, 11], distance to transmission lines [5 – 7, 9, 11], dustfall [7], sandstorms [7], land availability [8] and water supply [12].

Economic aspects of solar plants are considered as return of investment [1], net profit on capital [1], service life [8], land cost [8, 12], construction cost [8], equipment cost [8], operation and maintenance cost [8], electric power transmission cost [8], energy – saving benefit [12] and impact on local economy [12].

Social aspects are listed as public security [1], local residential acceptance [1, 8], impact on local residential life [1], policy support [1, 8], distance to urban areas [3 – 7, 9, 11], distance to historically important areas [6, 8], local government support [12] and public support [12].

Finally, pollution [1, 12], distance from wildlife designations [6, 11], agrologic effects [9, 11], impact on environment [12] are environmental aspects.

The review shows that solar panel site selection decisions are commonly being made based on technical and social aspects and AHP is the most frequently used methodology for site selection.

METHODOLOGY

One of the activities frequently done in daily lives is decision making. Decision making is defined as selecting one from a number of alternatives. If there is only one alternative, the decision is certain. If there are more than one alternative, the decision maker should select one of the alternatives. It is easier to decide, if there is only one criterion to consider. In case of existence of many criteria, it becomes more complex to decide. This kind of decision problems which contains a number of alternatives and many criteria are called as multiple criteria decision making problems. In the literature, there are different types of approaches for modeling and solving multiple criteria decision making problems.

Decision making problems are classified into three groups according to the structure of problem data. These three groups are decision making under certainty, decision making under risk and decision making under uncertainty. If decision makers have certain data of the problem, it is called as decision making under certainty. When problem data are known and can be expressed by some probability distributions, it is defined as decision making under risk. The last class of decision making problems is decision making under uncertainty and problem data are uncertain in this class of decision making problems. Fuzzy logic is commonly used for decision making under uncertainty, because fuzzy logic is appropriate for dealing with uncertain or linguistic terms.

In this study, a decision making approach based on AHP and Hesitant Fuzzy Linguistic Terms Set (HFLTS) proposed by Yavuz et al. [13] is used for site selection of solar panels. Hesitant fuzzy linguistic terms set is used in this study, because it is aimed to model hesitancy of decision makers in evaluating criteria of site selection. The steps of the algorithm are given as follows:

Step 1: Definition of goal, criteria and alternatives related to the decision making problem.

Step 2: Definition of linguistic terms and context – free grammar.

Step 3: Collecting preferences of experts for criteria and alternatives.

Step 4: Transformation of experts' preferences into HFLTS.

Step 5: Obtaining optimistic and pessimistic collective preferences by using a selected linguistic aggregation operator.

Step 6: Building the vector of intervals for collective preferences.

Step 7: Obtaining priority values by normalization of interval values.

Step 8: Selection of appropriate solar panel location by multiplying alternative values for each criteria and criteria weights.

These steps of the algorithm are given in detail in the next section of the study.

AN APPLICATION OF SOLAR PANEL SITE SELECTION IN TURKEY

Detailed expressions for algorithm steps and steps of site selection application in Turkey are given in this section. Opinions of 3 experts for evaluation of criteria and alternatives are collected. One of the experts is an academician who works in the field of energy, one of them is a manager in an energy sector company and the other one is a manager from Turkish Ministry of Energy and Natural Sciences. Steps of the algorithm goes on as follows:

Step 1: Definition of goal, criteria and alternatives related to the decision making problem.

Hierarchical structure of solar panel site selection problem is given in Fig. 1.

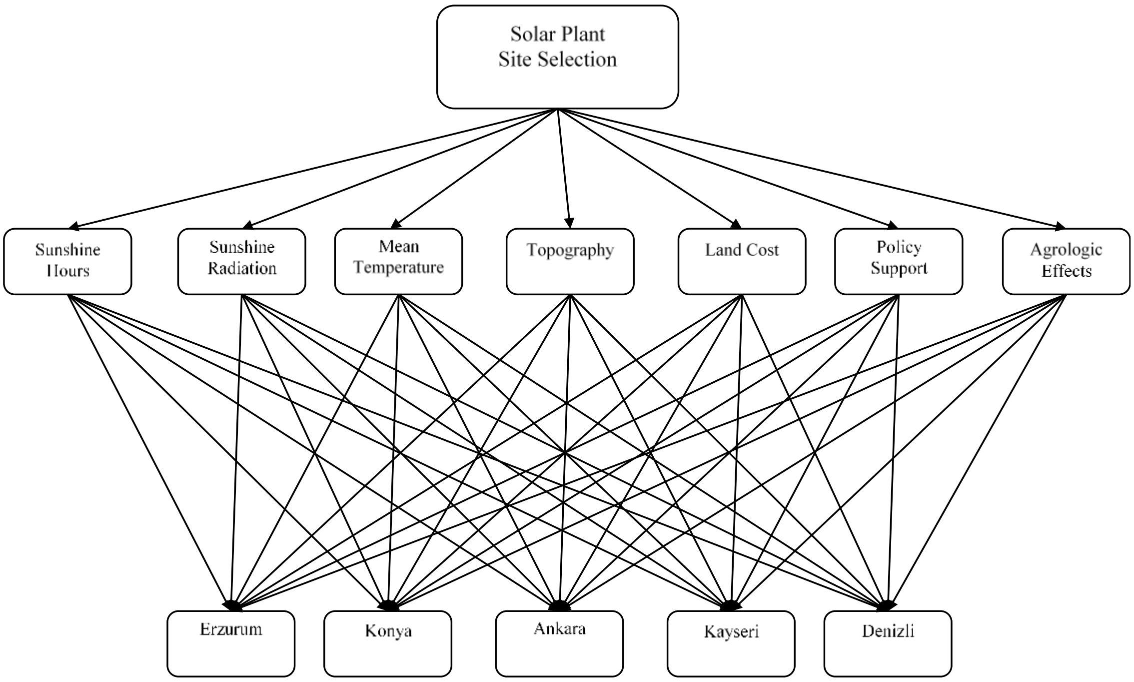

Figure 19. Different Modes of Transportation

Step 2: Definition of linguistic terms and context – free grammar.

Linguistic terms for importance degrees used in the study are presented in Table 1. Linguistic terms are connected to the others by using an appropriate relation term from the set of "at most", "at least", "greater than", "lower than", "is" and "between".

Table 17. Importance Degrees and Related Linguistic Terms

Importance degree	Linguistic Term
0	No importance (n)
1	Very low importance (vl)
2	Low importance (l)
3	Medium importance (m)
4	High importance (h)
5	Very high importance (vh)
6	Absolute importance (a)

Step 3: Collecting preferences of experts for criteria and alternatives.

Experts' preferences are given in Table 2, Table 3 and Table 4, respectively. Due to the paper limitations, only preferences and calculations for criteria evaluation are given.

Table 2. Preferences of Expert 1 for Criteria

	C1	C2	C3	C4	C5	C6	C7
C1	-	between l and m	between l and h	at least m	at least h	at least h	between m and vh
C2	between m and h	-	at least m	at least h	greater than m	at least vh	at least h
C3	between l and h	at most m	-	between l and h	at least m	between m and vh	between m and h

C4	at most m	at most h	between l and h	-	at least m	between l and h	at least h
C5	at most l	lower than m	at most m	at most m	-	at most m	between l and h
C6	at most l	at most vl	between vl and m	between l and h	at least m	-	at least h
C7	between vl and m	at most l	between l and m	at most l	between l and h	at most l	-

Table 3. Preferences of Expert 2 for Criteria

	C1	C2	C3	C4	C5	C6	C7
C1	-	between l and h	between l and h	greater than m	at least m	between m and vh	at least h
C2	between l and h	-	is h	at least m	greater than h	is h	at least h
C3	between l and h	is l	-	between m and vh	between m and vh	between l and h	at least m
C4	lower than m	at most m	between vl and m	-	is h	at most h	at least m
C5	at most m	lower than l	between vl and m	is l	-	at most l	at most h
C6	between vl and m	is l	between l and h	at least l	at least h	-	at least h
C7	at most l	at most l	at most m	at most m	at least l	at most l	-

Table 4. Preferences of Expert 3 for Criteria

	C1	C2	C3	C4	C5	C6	C7
C1	-	between l and m	between m and vh	between l and h	greater than m	between m and h	at least m
C2	between m and h	-	is h	at least h	at least vh	between m and vh	is vh
C3	between vl and m	is l	-	between l and h	at least m	between l and h	between m and h
C4	between l and h	at most l	between l and h	-	at least h	between l and h	between l and h
C5	lower than m	at most vl	at most m	at most l	-	at most l	at most m
C6	between l and m	between vl and m	between l and h	between l and h	at least h	-	at least h
C7	at most m	is vl	between l and m	between l and h	at least m	at most l	-

Step 4: Transformation of experts' preferences into HFLTS.

By using grammar rules, experts' preferences are transformed into HFLTS. Grammar rules and HFLTS equivalents are presented in Table 5 as follows, where x and y represents the linguistic term in the preference of mentioned expert. x – 1, x+1 represents the importance degree of the linguistic term for the lower and higher importance degree, respectively.

Table 5. Importance Degrees and Related Linguistic Terms

Experts' Preference	HFLTS Equivalent
At most x	[n, x]
At least x	[x, a]
Lower than x	[n, x–1]
Greater than x	[x+1, a]
Is x	[x, x]
Between x and y	[x, y]

Step 5: Obtaining optimistic and pessimistic collective preferences by using a selected linguistic aggregation operator.

Optimistic and pessimistic collective preferences are obtained by calculating arithmetic mean. Optimistic and pessimistic collective preferences for criteria are given in Table 6 and Table 7 as follows, respectively.

Table 6. Optimistic Collective Preferences for Criteria

	C1	C2	C3	C4	C5	C6	C7
C1	-	3.333	4.333	5.333	6.000	5.000	5.667
C2	4.000	-	4.667	6.000	6.000	5.000	5.667
C3	3.667	2.333	-	4.333	5.667	4.333	4.667
C4	3.000	2.333	3.667	-	5.333	4.000	5.333
C5	2.333	1.333	3.000	2.333	-	2.333	3.667
C6	2.667	2.000	3.667	4.667	6.000	-	6.000

C7	2.667	1.667	3.000	3.000	5.333	2.000	-

Table 7. Pessimistic Collective Preferences for Criteria

	C1	C2	C3	C4	C5	C6	C7
C1	-	2.000	2.333	3.000	3.667	3.333	3.333
C2	2.667	-	3.667	3.667	4.667	4.000	4.333
C3	1.667	1.333	-	2.333	3.000	2.333	3.000
C4	0.667	0.000	1.667	-	3.667	1.333	3.000
C5	0.000	0.000	0.333	0.667	-	0.000	0.667
C6	1.000	1.000	1.667	2.000	3.667	-	4.000
C7	0.333	0.333	1.333	0.667	2.333	0.000	-

Step 6: Building the vector of intervals for collective preferences.

Vector of intervals are built by arithmetic mean of rows in pessimistic and optimistic aggregate preferences matrices.

Step 7: Obtaining priority values by normalization of interval values.

Interval midpoints are calculated and normalized interval midpoints show priority values. Calculations in Step 6 and Step 7 for priority values of criteria in Table 8 as follows:

Table 8. Calculations for Criteria Weights

	Interval Utilities		Midpoints	Weights
C1	2.944	4.944	3.944	0.188
C2	3.833	5.222	4.528	0.216
C3	2.278	4.167	3.222	0.153
C4	1.722	3.944	2.833	0.135
C5	0.278	2.500	1.389	0.066
C6	2.222	4.167	3.194	0.152
C7	0.833	2.944	1.889	0.090

Step 8: Selection of appropriate solar panel location.

Appropriate solar panel location is determined by multiplying alternative comparisons for criteria and criteria weights. Due to paper limitations, alternative comparisons and calculations are not given in this paper. Results of comparisons are given here and appropriate location is determined and given as follows:

$$\begin{bmatrix} 0.15 & 0.19 & 0.12 & 0.15 & 0.13 & 0.15 & 0.10 \\ 0.15 & 0.19 & 0.11 & 0.16 & 0.13 & 0.16 & 0.10 \\ 0.14 & 0.17 & 0.12 & 0.16 & 0.14 & 0.15 & 0.12 \\ 0.16 & 0.18 & 0.12 & 0.15 & 0.15 & 0.14 & 0.10 \\ 0.19 & 0.20 & 0.18 & 0.11 & 0.09 & 0.14 & 0.10 \end{bmatrix} \times \begin{bmatrix} 0.188 \\ 0.216 \\ 0.153 \\ 0.135 \\ 0.066 \\ 0.152 \\ 0.090 \end{bmatrix} = \begin{bmatrix} 0.1500 \\ 0.1496 \\ 0.1460 \\ 0.1475 \\ 0.1562 \end{bmatrix}$$

The maximum value obtained in this calculation is the best alternative's score. Score of Denizli city is the maximum, so the most appropriate location for the solar panel is Denizli.

CONCLUSIONS

Location selection problem is one of the most important problems in solar energy investments. In this paper, solar panel site selection problem is handled as a multiple criteria decision making problem due to the existence of conflicting criteria and different alternatives. A new decision making approach based on Analytic Hierarchy Process and Hesitant Fuzzy Linguistic Terms Set is utilized for solving this problem.

The proposed algorithm is tested on an example case study in Turkey. Three experts are asked to evaluate site selection criteria and alternative plant sites. The most important site selection criteria are determined as sunshine radiation, sunshine hours and mean temperature. After the evaluation of alternative sites, best location for plant site is evaluated as Denizli.

Criteria weights obtained in this study can be used for locating new solar panels. Furthermore, it is possible to extend this study by using different fuzzy numbers such as triangular, trapezoidal or intuitionistic fuzzy numbers. In the site selection phase, using different multiple criteria decision making approaches such as TOPSIS, PROMETHEE or ELECTRE may be meaningful. Absolute measures for site evaluation can be thought for obtaining different results.

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AN EMPIRICAL STUDY ON TURKISH LOGISTICS COMPANIES' ATTITUDES TOWARD ENVIRONMENTAL MANAGEMENT PRACTICES

Reha MEMİŞOĞLU [1], Nergis ÖZİSPA [2], Erhan DEMİRBAŞ [3]

Abstract – *This paper aims to analyze the factors influencing Turkish logistics companies' attitudes toward environmental management practices. The determinant factors include technological, organizational and environmental dimensions. Data to test research hypotheses came from a questionnaire survey on logistics companies in Turkey. Research findings reveal that companies that apply environmental management practices found these practices consistent with their company's values and according to them, it's easy to integrate environmental practices with company's existing system. Based on the research results, the paper discusses implications and opportunities for future research.*

Keywords – environmental management practices, innovation, logistics, stakeholder theory, sustainability

INTRODUCTION

Sustainability is important for businesses and supply chains, as stakeholders are increasingly concerned about society, the environment and economic development [1]. Companies' actions affect stakeholders.

Stakeholder theory argues that there are many parties involved, such as employees, customers, suppliers, financiers, communities, governmental bodies, political groups, trade associations, and trade unions. Even competitors are sometimes counted as stakeholders – their status being derived from their capacity to affect the firm and its stakeholders [2]. An increasing number of companies are under pressure to develop environmentally responsible and friendly operations [3]. Governmental regulations, corporate social responsibilities, and stakeholders' demands make environmental management practices (EMP) an integral part of organizations' strategic planning process [4]. In recent years, the number of studies that analyze the relationship between companies and the natural environment has grown. This is because global environmental problems, such as climate change, have raised the awareness of society in general concerning the impact of business activities on planets sustainability [5]-[6]-[7]. Most studies on environmental issues focus on the manufacturing sectors that may consume considerable natural resources and little research pays attention to the environmental issues in service sectors because most services sectors may consume less natural resources so that they have smaller impact on the environment when compared to manufacturing sectors [8]. Logistics companies carry out logistics activities for their customers, including warehousing, transportation, inventory management, order processing, and packaging [9]. Logistics is a link in providing green products from the manufacturers to the consumers. Green products will be truly green if the value adding logistics activities also become green [10]. Thus, environmental issues in the logistics industry are significant for studying. However, there is only a limited number of articles which analyze environmental issues in the logistics industry [11] and also there is a lack of studies in the field of environmental sustainability and performance focusing on developing countries [1]. Considering that situation, Turkey has been selected for this study. This paper analyzes the influences of technological, organizational, and environmental factors on Turkish logistics companies' attitudes toward environmental management practices and this paper will contribute to the literature by examining factors on Turkish logistics companies' attitudes toward environmental management practices.

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RESEARCH HYPOTHESES

According to Damanpour [12], adaptation of environment management practices is a part of the technical innovation process. When looked at the literature it can be seen that there are a number of factors influencing the technical innovation. Mainly these factors are categorized as technological, organizational, and external environmental factors [13]. Lin & Ho [14] also have found that these factors played a significant role on analyzing the Taiwanese logistics companies attitudes towards green practices. Using the research framework created by Lin & Ho [14], this study will analyze the influences of technological, organizational, and environmental factors on Turkish logistics companies' attitudes toward environmental management practices.

Technological Factors

H1-1: The perceived environmental practices' complexity has a negative influence on Turkish logistics companies' attitudes toward environmental management practices.

H1-2: The perceived environmental practices' compatibility has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

H1-3: The perceived environmental practices' relative advantage has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

Organizational Factors

H2-1: The quality of human resources has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

H2-2: Organizational support has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

Environmental Factors

H1-1: The perceived environmental practices' complexity has a negative influence on Turkish logistics companies' attitudes toward environmental management practices.

H1-2: The perceived environmental practices' compatibility has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

H1-3: The perceived environmental practices' relative advantage has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

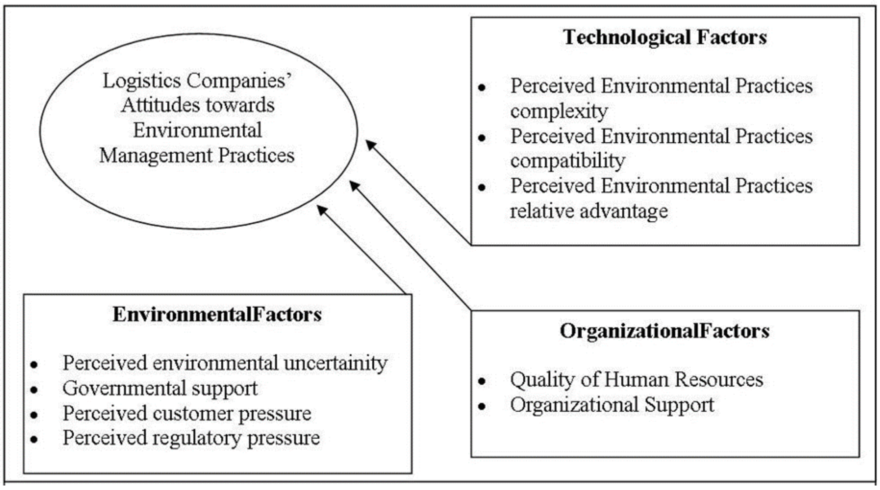

Figure 1. Research Conceptual Model

METHODOLOGY

Sample and Data Collection

To examine the influences of proposed factors on environmental practice adoption, data were collected by means of mailing questionnaires to logistics companies in Turkey. Seven thousand nine hundred thirteen samples were drawn from a list of logistics companies provided by Turkey IMEAK Marine Chamber of Commerce. Five hundred seventeen of them were located in İzmir and they composed this study's sampling unit. Extent of this study is in Turkey in Izmir. This study was conducted with 95% confidence level and with 5% margin of error. Judgmental technique of nonprobability techniques was used as a sampling technique in this study. According to this judgment; Logistics companies have 50% of shares due to nature of the study, logistics companies must be core part of this study's sample, and Scholars have 25% shares because also scholars are the main conductor and significant contributors of this subject. So they form second major group of this study. Ports have a reasonable share with 20% in the sample because they are an important part of logistics chain and environmentality is essential for them. Regulatory Bodies are one of the drivers for developing environmental management practices so they are included in sample for some extent with 5%.

FINDINGS

Reliability Analysis

Determinant Factors	Cronbach's Alpha	Number of Items
Technological Factors	,783	10
Organizational Factors	,918	8
Environmental Factors	,807	11
TOTAL	**,925**	**29**

According to SPSS reliability test results; ten variables of technological factors have 0,783 Cronbach's Alpha value, eight variables of organizational factors have 0,918 Cronbach's Alpha value and eleven variables of environmental factors have 0,807 Cronbach's Alpha value. At the end, total Cronbach's Alpha value of this study is 0,925 and because it is bigger than 0,70 it is assumed that, this study is reliable.

Descriptive Statistics

	Frequency	Percent
Company or Work Type		
Logistics Company	18	60
Scholar	6	20
Port	2	6,7
Regulatory Body	4	13,3
The amount of Time Served by the Company		
0 to 5 years	5	16,7
6 to 14 years	6	20
15 to 20 years	23	10
More than 21 years	16	53,3
Have the Company Branch or Representative Office		
Yes	20	66,7
No	10	33,3
Environmental Management Practices, Implementation Status		

Yes	21	70
No	9	30

[continued]

Gender of the Person Surveyed		
Male	16	46,7
Female	14	53,3
TOTAL	30	100

According to descriptive statistics results; company and work types in the study consist of, 60% logistics company, 20% scholar, 13% regulatory body and 7% port. 53% of these companies are older than 21 years old, 20% of them are in the sector between 6 to 14 years, 16% of them are in the sector between 0 to 5 years and lastly 7% of them are in the sector between 15 to 20 years. 67% of the companies have branch or representative office in different city or abroad and 33% of that companies have not. Also 70% of the companies in the study is implementing environmental management practices in their companies.

Hypotheses Results

Hypotheses results of technological factors are as follows:

H1-1: The perceived environmental practices' complexity has a negative influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
Understanding the environmental practice is difficult.	,509	,120
Learning the environmental practice is difficult	,331	,331
Sharing the knowledge of the environmental practice is difficult.	,204	,109
Using the environmental practice needs many experiences.	,449	,366

According to SPSS test results, main hypothesis is rejected. No significant result between these two variables could be found. Four factors of perceived environmental practices' complexity and test results are given above table.

H1-2: The perceived environmental practices' compatibility has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**	**t**
The environmental practice is compatible with our existing logistics operations.	,002	,496	
The environmental practice is consistent with our company's values.	*,597*	*,031*	*2,483*
Integrating the environmental practice with company's existing systems easy.	*,246*	*,000*	*4,857*

According to SPSS test results, main hypothesis cannot be rejected for two variables. According to group statistics results companies that apply environmental management practices found these practices consistent with their companies' values and according to them it is convenient to integrate environmental practices with companies' existing system. Factors related to perceived environmental practices' compatibility and results of them are given above table.

H1-3: The perceived environmental practices' relative advantage has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
The environmental practice can provide better environmental performance.	,584	,462
The environmental practice can provide higher economic benefits.	,601	1,000
The environmental practice can enhance our company's reputation.	,903	,973

According to SPSS test results, main hypothesis is completely rejected for all three factors. These factors are; the environmental practice can provide better environmental performance, the environmental practice can provide higher economic benefits and the environmental practice can enhance our company's reputation. The results of these factors are given above table.

Hypotheses results of organizational factors are as follows:

H2-1: The quality of human resources has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
Employees can learn new technologies easily.	,658	,379
Employees can share knowledge with each others.	,401	,499
Employees can easily use new technologies to solve problems.	,510	,797
Employees can provide new ideas for our company.	,421	,838

According to SPSS test results, main hypothesis main hypothesis is completely rejected. No significant result between these two variables could be found. Four factors of the quality of human resources and test results are given above table.

H2-2: Organizational support has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
Top management encourages employees to learn environmental practices.	,589	,069
Our Company provides rewards for employees' environmental behavior.	,457	,605
Our company provides resources for employees to learn environmental practices.	,593	,091
Top management can help employees when they face environmental problems.	,492	,183

According to Spss test results, main hypothesis is rejected. No significant result between these two variables could be found. Four factors of the organizational support and test results are given the table above.

Hypotheses results of environmental factors are as follows:

H3-1: Perceived environmental uncertainty has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
Predicting customers' preferences is difficult.	,238	,486
Predicting competitors' behavior is difficult.	,480	,581
The advance in new logistics service modes is quickly.	,034	,548
Customers' preferences vary frequently.	,012	,421

According to SPSS test results, main hypothesis is rejected. No significant result between these two variables could be found. Four factors of perceived environmental uncertainty and test results are given above table.

H3-2: The governmental support has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
Government provides financial support for adopting environmental practices.	,544	,400
Government provides technical assistance for adopting environmental practices.	,143	,672
Government helps training manpower with environmental logistics skills.	,549	,289

According to SPSS test results, main hypothesis is rejected. No significant result between these two variables could be found. Three factors of the governmental support and test results are given above table.

H3-3: The perceived customer pressure has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
Our customers require us to improve environmental performance.	,523	,348
Caring for the environment is an important consideration for our customers.	,891	,517

According to SPSS test results, main hypothesis is rejected. No significant result between these two variables could be found. Two factors of the perceived customer pressure and test results are given above table.

H3-4: The perceived regulatory pressure has a positive influence on Turkish logistics companies' attitudes toward environmental management practices.

	Levene sig.	**Sig.**
Government sets environmental regulations for logistics operations.	,609	,419
Industrial associations require us to conform to environmental regulations.	,495	,587

According to SPSS test results, main hypothesis is rejected. No significant result between these two variables could be found. Two factors of the perceived regulatory pressure and test results are given above table.

CONCLUSION AND FURTHER RESEARCH

When analyzed findings part of the study eight out of nine hypotheses constructed for the study are rejected. It is concluded that only the compatibility of environmental management practices has influence on Turkish logistics companies. According to survey results, companies that apply environmental management practices found these practices consistent with their company's values and according to them, it's easy to integrate environmental practices with company's existing system. Other eight hypotheses of the study rejected for this study's sample. As a conclusion, there could not be found any significant relation organizational and environmental factors between environmental management practices.

Because of the usage of questionnaire survey, the results of this study may suffer from the respondent bias. In addition to that, a study with the inclusion of different countries or industries may lead to conclusions different from this study. When analyzed similar studies findings, this part of our results found different from general literature. Because of the time limitation of this study, sample size couldn't be extended for the desired amount. Perhaps the further studies can be conducted on a wider size of sample that can bear varying results.

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SELECTION OF WEARABLE GLASSES IN THE LOGISTICS SECTOR

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Abstract - Nowadays, wearable technologies are becoming of the most developing subjects through technologic innovations. The short definition of wearable technology is clothing and accessories that incorporate computer and advanced electronic technologies. Predictions indicate that in the future, utilization of this technology is going to be also widespread in the logistics sector. Companies realize that wearable technologies, especially wearable glasses, can empower workers to achieve new levels of efficiency, productivity, and accuracy in package handling and warehouse applications. However, choosing the right wearable solution can be a challenge. The selection of a suitable technology is not an easy decision and is associated with complexity. Multiple influencing factors should be considered in the evaluation process. For this reason, this study proposes an integrated multi criteria decision making (MCDM) approach for an effective wearable glasses evaluation problem. The first part of the paper presents wearable technology evaluation criteria which are determined by literature review and industry experts. After constructing the evaluation criteria hierarchy, the criteria weights are calculated by applying the AHP (Analytic Hierarchy Process) method. A compromise ranking method, TOPSIS (Technic for Order Preference by Similarity to Ideal Solution) method is used to obtain the final wearable glasses ranking results. A case study is given to demonstrate the potential of the approach.

Keywords - Logistic sector, Multi criteria decision making, Wearable glasses, Wearable technology.

INTRODUCTION

Our age is age of technology. Technologic devices are being used by their different functions in personal life and in business life. Furthermore, it is possible to access some of these devices every time and everywhere. Computing devices are no longer items that we use in our homes and work places .Also no longer we only carry them in our bags and pockets. We can now wear those devices [1]. It is possible to describe wearable technology in other words with more detail. Wearable technology devices or simply wearables refer to electronic technologies or computing devices which are designed to be comfortably worn on the body [2].

Actually, studies show the growth of wearable devices in recent years. Generator Research reports that smart watches, smart glasses and body sensors have the most potential in the medium term. Their studies show that the markets for smart watches, smart glasses and personal health and fitness products will be worth USD 101.2 billion in 2018 [3]. In addition, according to “Connected Wearables - 2nd Edition" report, shipments of connected wearables reached 72.5 million in 2015, up from 25.3 million devices in the previous year [4]. Since then, IDC predicted shipments of more than 111 million wearable devices in 2016 and nearly 215 million units in 2019. That’s a compound annual growth rate of about 28 percent [5].

Wearable technology has so many types of application in daily life. It is adaptable and utilizable for all segments of the people. The potential of this technology is important in different areas like health, military, education, business and industry etc. This paper is focused on industrial approach. The need of innovation in industrial processes is obvious, these innovations make a difference for companies. In logistics sector, which is the management of the flow of things between the point of origin and the point of consumption in order to meet requirements of customers or corporations, there is a huge demand of technology. Examples from different countries and continents, from different parts of a logistics chain,

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with different actors, and for different logistics concepts give some ideas for future developments of the technology [6]. Smart glasses are promising to fulfill industrial operation, logistics service and homeland security [7]. Smart glasses are computerized eyewear that can present visual information within a user's field of view, typically through a monocular or binocular heads-worn display [8]. It is possible to access diverse forms of information or to perform tasks hands-free. In this context, smart glasses meet the demand of technology in logistics. Hence, the study proposes an integrated multi criteria decision making (MCDM) approach for an effective wearable glasses evaluation problem where the main objective is to decide on the most suitable smart glass alternative in the logistics sector.

Decision making is the act of choosing between two or more of action. However, it is clear that it cannot be a correct decision from the available choices. There may be a better choice which was not considered or the real information that was not available at that time. The MCDM problems consist of a finite number of alternatives explicitly known at the beginning of the solution process [9]. The AHP (Analytic Hierarchy Process) method [10] is one of the well-known MCDM approaches. In this research, AHP is used for determine criteria weights and TOPSIS (Technic for Order Preference by Similarity to Ideal Solution) is used for obtain the final wearable glasses ranking results. TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution (PIS) and the longest geometric distance from the negative ideal solution (NIS) [11].

The structure of this paper is as follows: in Section 2, the precedent researches are presented. In Section 3, the methods are explained in detail. In Section 4, an application is given to demonstrate the potential of the approach. In the latter, the results are presented in Section 5. Finally, in Section 6, the consequences of this research and the future work that is possible to be done in this subject is given.

BACKGROUND OF THE RESEARCH

The previous studies related literature may be grouped in four different areas with respect to their main subjects. First group is about technology in logistics sector, second is Information and Communication Technology (ICT) and its influence in logistics sector, third is determination of the place of wearables in logistics sector, and the fourth is smart glass in logistics sector. Some of the exemplar studies are summarized as follows.

Abushaikha and Schuman-Bölsche [6] and Crumbly and Carter [12] searched the appropriateness of mobile phone technology to support humanitarian operations and to create new humanitarian logistics concepts, and explored how to improve supply chain management in humanitarian organizations, such as food charities, by utilizing new service development and task technology fit as the theoretical foundation.

Shokoofeh [13] and Evangelista and Sweeney [14] described how ICT has affected the logistics system in organizations, and analyzed the role of ICT in customizing services and of the factors influencing ICT adoption.

Chih-Hsuan [7] utilized the method AHP to elicit customers' choices among smart alternatives. Result is: (1) smart phones are good at providing a platform for satisfying home entertainment, (2) smart watches are perceived as auxiliary carriers to accomplish health care and safety monitoring and (3) smart glasses are promising to fulfill industrial operation, logistics service and homeland security. Hobert and Schumann [15] made a qualitative empirical analysis on the use of smart glasses in the industrial sector to find potential application scenarios.

Sunwook et al. [8] and Diete et al. [16] presented a system that augments picking processes with smart glasses and examined the application of AR HWDs in various industry applications, including order picking (OP) operations and in assembly/maintenance/repair activities. Svensson and Thomasson [17] examined if the efficiency can be improved further by using smart glasses and if commercial use of smart glasses could have a future in warehousing.

RESEARCH METHODOLOGY

The MCDM techniques generally enable to structure the problem clearly and systematically. With this characteristic, decision makers have the possibility to easily examine the problem and scale it in accordance with their requirements [18].

The main steps of the evaluation of wearable glasses in logistics sector is as follows:

Step 1. Find the wearable glass evaluation criteria which effects mostly the decisions of consumers.

Step 2. Apply AHP method for calculate the weights of each criterion.

Step 3. Apply TOPSIS method for find the final result.

Evaluation Criteria

Evaluation criteria are identified with the consideration of the literature and the consultation of industrial experts. There are nine sub-criteria and three criteria which are technology (C1), ergonomics (C2) and privacy (C3). The sub-criteria are summarized as follows:

High performance on ubiquitous computing (C11): The rapid growth and development of virtual reality applications and their associated hardware, the personal computer and ubiquitous computing will become a tool of daily-use nowadays [19].

Information provision (C12) and Communication network (C13): From the above research, we concluded that smart 3C products should be equipped with the following: information provision, intuitive interaction, communication network, and automation [19].

Mobility and lightness (C21): Smart clothing, miniaturization of electronic devices created more opportunities to achieve higher mobility and comfort, while technical functions kept increasing [19].

Esthetic appearance (C22): The growth of the wearable market depends on its ability to match the aesthetics of existing consumer tastes and preferences through proper styling and by overcoming design hurdles [20].

Facility of using (user-friendly) (C23): Unless the device interface and app are intuitive and easy to use, only avid exercisers are likely to use them, while those who could benefit most may remain disengaged [21].

Protection and Security of Information (C31): Compared with other type of information such as demographic features and general transaction information, personal health information is more sensitive for individuals. Thus, considering the influences of privacy factors on consumer's acceptance of healthcare wearable device is necessary [22].

Defense against malware (C32): "Unlike desktop and network security, mobile security is often the weakest link in the security chain." [23].

Seamless life integration (to fit into user's life) (C33): "… users don't want to feel like they're making a lifestyle change; they want access to more concrete and accurate information and the ability to customize outputs." [24].

Alternatives of Wearable Glasses

Google Glass: Augmented Reality, 640×360 Himax LCoS Display, Interface: Phone, Touch, Voice [25].

Figure 1. Google Glass

KiSoft Vision: According to Logistics Viewpoints,Knapp AG, “a material handling and logistics software solution provider headquartered in Austria,” has actually developed augmented reality glasses designed specifically to address warehouse and logistics needs [26].

Figure 2. KiSoft Vision

Vuzix M100 Smart Glasses: Augmented Reality, 16:9 WQVGA full color display, Interface: Phone, Touch, Voice [25].

Figure 3. Vuzix M100 Smart Glass

Epson Moverio BT200: The MOVERIO BT-200 and BT-300 smart glasses are designed to change how you experience the world around you. With the smallest, most comfortable and most affordable smart eyewear on the market, and a growing ecosystem of partners and hardware, Epson continues to set the standard in Augmented Reality [27].

Figure 4. Epson Moverio BT200

The Method AHP

AHP is developed by Saaty [9], probably the best-known and most widely used model in decision making. AHP is a powerful decision making methodology in order to determine the priorities among different criteria. To make a decision in an organized way to generate priorities we need to decompose the decision into the following steps:

Step 1. Define the problem and determine the kind of knowledge sought.

Step 2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level which usually is a set of the alternatives).

Step 3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

The matrix *A* is a $m \times m$ real matrix, where m is the number of evaluation criteria considered. Each entry a_{jk} of the matrix *A* represents the importance of the j^{th} criterion relative to the k^{th} criterion. If $a_{jk} > 1$, then the j^{th} criterion is more important than the k^{th} criterion, while if $a_{jk} < 1$, then the j^{th} criterion is less important than the k^{th} criterion. If two criteria have the same importance, then the entry a_{jk} is 1. The entries a_{jk} and a_{kj} satisfy the following constraint:

$$a_{jk} \cdot a_{kj} = 1 . \tag{1}$$

Obviously, $a_{jj} = 1$ for all j.

Table 1. Table of relative scores

Value of a_{jk}	Interpretation
1	*j* and *k* are equally important
3	*j* is slightly more important than *k*
5	*j* is more important than *k*
7	*j* is strongly more important than *k*
9	*j* is absolutely more important than *k*

To make comparisons, we need a scale of numbers that indicates how many times one element is more important or dominant over another one with respect to the criterion or property with respect to which they are compared. Table 1 exhibits the scale. [9]

Once the matrix *A* is built, it is possible to derive from *A* the normalized pairwise comparison matrix A_{norm} by making equal to 1 the sum of the entries on each column, i.e. each entry a *jk* of the matrix A_{norm} is computed as:

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{jk}} . \tag{2}$$

Finally, the criteria weight vector w (that is an m-dimensional column vector) is built by averaging the entries on each row of A_{norm}, i.e.

$$w_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m} . \tag{3}$$

Step 4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level is obtained [28].

Step 5. AHP also calculates an inconsistency index (or consistency ratio) to reflect the consistency of decision maker's judgments during the evaluation phase. The inconsistency index in both the decision matrix and in pairwise comparison matrices could be calculated with the equation:

$$CI = \frac{\lambda_{max} - N}{N-1}. \quad (4)$$

The Method TOPSIS

The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method is presented in Chen and Hwang (1992), with reference to Hwang and Yoon (1981) [11]. The basic principle is that the chosen alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution. The ideal solution is the solution that maximizes the benefit and also minimizes the total cost. On the contrary, the negative-ideal solution is the solution that minimizes the benefit and also maximizes the total cost [11].

The TOPSIS procedure consists of the following steps:

Step 1. Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as:

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{J} f_{ij}^2}}, \ j = 1, \ldots, J; \ i = 1, \ldots, n. \quad (5)$$

Step 2. Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as

$$v_{ij} = w_i r_{ij}, \ j = 1, \ldots, J; \ i = 1, \ldots, n, \quad (6)$$

where w_i is the weight of the i^{th} criterion and $\sum_{i=1}^{n} w_i = 1$. (7)

Step 3. In this step, the ideal and negative-ideal solutions are determined.

$$A^* = \{v_1^*, \ldots, v_n^*\} = \{(\max_j v_{ij} | i \in I'), (\min_j v_{ij} | i \in I'')\}, \quad (8)$$

$$A^- = \{v_1^-, \ldots, v_n^-\} = \{(\min_j v_{ij} | i \in I'), (\max_j v_{ij} | i \in I'')\}, \quad (9)$$

where I' is associated with benefit criteria, and I'' is associated with cost criteria.

Step 4. Calculate the separation measures using the n-dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as

$$D_j^* = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^*)^2}, \ j = 1, \ldots, J. \quad (10)$$

Similarly, the separation from the negative-ideal solution is given as

$D_j^- = \sqrt{\sum_{i=1}^{n}(v_{ij} - v_i^-)^2}$, j = 1, …,J.
(11)

Step 5. The next step consists of the calculation of the relative closeness to the ideal solution. The relative closeness of the alternative a_j with respect to A* is defined as

$C_J^* = \frac{D_j^-}{(D_j^* + D_j^-)}$, j = 1, …,J.
(12)

Step 6. At the final step, the preference order is ranked.

CASE STUDY

There is a logistics company ABC which wants to find the best technologic wearable product. The Research & Development department analyses different types of wearable glasses in the market and decides to evaluate them by using scientific methods. There are four possible alternatives: A1 is Google Glass, A2 is KiSoft Vision, A3 is Vuzix M100 Smart Glasses and A4 is Epson Moverio BT200. The criteria and sub-criteria are explained in the research methodology section. These criteria are: C1 is technology (with high performance on ubiquitous computing (C11), information provision (C12) and communication network (C13)); C2 is ergonomics (with mobility and lightness (C21), esthetic appearance (C22), facility of using (user-friendly) (C23)) and C3 is privacy (with protection & security of information (C31), defense against malware (C32), seamless life integration (to fit into user's life) (C33)). Integrated AHP and TOPSIS are applied as given in the following parts.

Evaluating weights of criteria by AHP

In the first stage, every criterion is compared to each other. The pairwise comparison matrix is constructed and

the associated criteria weights are calculated by utilizing equations (2) and (3). The consistency ratios are also calculated in respect to equation (4). The obtained criteria weights and the consistency ratios are given in Table 2.

Table 2. Evaluation criteria weights

Criteria	C11	C12	C13	C21	C22	C23	C31	C32	C33
Weight	0,16	0,04	0,12	0,15	0,07	0,28	0,06	0,02	0,11
Rank	2	8	4	3	6	1	7	9	5
C.I.		0,037			0,002			0,019	

The results about weights shows that the most important criterion in the logistics sector is facility of using (user-friendly) (C23). The second criterion is high performance on ubiquitous computing (C11) and the third is mobility and lightness (C21).

Evaluating alternatives by TOPSIS

The method TOPSIS is applied to rank the alternatives. Thus, the experts evaluated four alternatives in respect to nine criteria. Using these evaluating values which is between 1 and 10 and using the weights which come from the method AHP, the weighted normalized decision matrix is constructed by equations (5), (6) and (7). In the next step the positive ideal solutions (A^*) and negative ideal solutions (A^-) are calculated. By utilizing equations (10) and (11), the Euclidian distances are calculated (D_j^*, D_j^-). At the end of the method, the relative closeness to the ideal solution (C_J^*) is calculated by equation (12) as given in Table 3. The alternatives are ranked as $A_1 \succ A_4 \succ A_2 \succ A_3$.

Table 3. Distance from positive-ideal solution and negative ideal solution and rankings

Alternatives	D_j^*	D_j^-	C_J^*	Rank
A1: Google Glass	0,03	0,10	0,77	1
A2: KiSoft Vision	0,05	0,09	0,62	3
A3: Vuzix M100 Smart Glasses	0,06	0,06	0,51	4
A4: Epson Moverio BT200	0,03	0,09	0,76	2

The results about alternatives give an idea to find the best technologic wearable product. As a result, Google Glass (A1) is the most desirable product through these alternatives and its closeness to the ideal solution is 0,77 with a little difference from his nearest competitor which is Epson Moverio BT200 (A4). KiSoft Vision (A2) has become the third, and the last one is Vuzix M100 Smart Glasses (A3).

CONCLUSION

The changing technology orients the companies to discover innovative ways. In logistics sector, this innovation may be attempt by wearable technology. Furthermore, the utilization of wearable technology could create a lot of value for logistics sector. Companies aim to select the right product among a variety of alternatives. Complexity of this type of problems makes decision making even more difficult. In this study, the main objective was to decide on the most suitable smart glass alternative in the logistics sector. This problem is solved by using the integrated methods AHP and TOPSIS. The criteria and the alternatives have been specified from a generic view. This problem is illustrated by a case study and the results of this study are given. The logistics companies can benefit from this study for the decision problems about wearables. Additionally, the number of criteria or alternatives may have been different. In the future research it can be interesting to use different MCDM methods on solving this problem and comparing the results.

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COST-EFFICIENCY OF VEHICLE TRACKING SYSTEMS (VTS): A CASE STUDY FOR 30 VEHICLES

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Abstract - Vehicle Tracking Systems (VTS) are used by Fleet operators for fleet management functions such as fleet tracking, routing, dispatching, on-board information and security. VTS technology is also used by the Municipalities to monitor schedule adherence of buses in service, trigger changes of busses' destination sign displays at the end of the line (or other set location along a bus route), and trigger pre-recorded announcements for passengers. Especially for routing, tracking, security, rescheduling and cost efficiency purpose, the public organizations such as ministries, military headquarters in big cities are highly encouraged to use VTS on their vehicles ranging from small cars to midibuses, buses and lorries in order to transport its personnel and equipment.

In this study, we aimed to find cost efficiency of using VTS on personnel service vehicles of a public organization. We selected 30 vehicles as a sample study. We put VTS on these vehicles and collected data by observing the vehicles during one year. According to this sample implementation, we aimed to compare the oil consumption and the expenditures of the accidents of the data does not fit a particular parametric family of distributions, specifically; a normal distribution. Therefore, we used Wilcoxon Signed Rank Test to find the results of our study. According to the results of the test, using VTS on vehicles is found to be meaningful to decrease the oil consumption but using VTS is not found cost-efficient on the expenditures of the accidents. We also proposed the optimal distances that will be cost-efficient to use VTS on the vehicles.

Keywords - Cost-Efficiency, Oil Consumption, Vehicle Tracking Systems, Wilcoxon Signed Rank Test.

INTRODUCTION

A vehicle tracking system combines the use of automatic vehicle location in individual vehicles with software that collects these fleet data for a comprehensive picture of vehicle locations [1]. GPS or GLONASS technology is the most common way used by Modern vehicle tracking systems for locating the vehicle; however other types of automatic vehicle location technology can also be used. The location of the vehicle can be followed on electronic maps via the Internet or other special software. Urban public transit authorities mainly in large cities and the organizations which have large number of vehicle fleets are increasingly common users of vehicle tracking systems.

The logistics departments of the big transportation organizations use vehicle tracking systems commonly for fleet management functions such as fleet tracking, routing, dispatching, on-board information and security. Along with public and private organizations and commercial fleet operators, urban transit agencies use the technology for a number of purposes, including monitoring schedule adherence of buses in service, triggering changes of buses' destination sign displays at the end of the line, and triggering pre-recorded announcements for passengers.

The American Public Transportation Association estimated that, at the beginning of 2009, around half of all transit buses in the United States were already using a GPS-based vehicle tracking system to trigger automated stop announcements [2].

Such programs are also used to provide customers with real-time information as to the waiting time until arrival of the next bus or tram/streetcar at a given stop, based on the nearest vehicles' actual progress at the time, rather than merely giving information as to the scheduled time of the next arrival [3]. Transit systems providing this kind of information assign a unique number to each stop, and waiting passengers

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can obtain information by entering the stop number into an automated telephone system or an application on the transit system's website [4].

Some transit agencies provide a virtual map on their website, with icons depicting the current locations of buses in service on each route, for customers' information [5], while others provide such information only to dispatchers or other employees.

In this study, we prepared a case study to strengthen the importance of using vehicle tracking systems by focusing on a public organization. We first define the problem and assumptions for the case study. Next, we prepared and design the study, give Statistical Analysis and Cost Efficiency Analysis for the problem. At the end of study we focused on the results of the study.

PROBLEM DEFINITION

In this study we focus on a public organization which has many vehicles and located in a big city in order to carry personnel and goods. This organization generally has four types of vehicles namely automobiles, minibuses (14 pax capacity), midi buses (25 pax capacity) and lorries (25 tones capacity). These vehicles are used very often. There is one control center which only sends vehicles and tracks them when they came back. This control center has no ability;

- to decide the route (only gives the destination),
- to follow the route whether the driver is on the right way or not,
- to have the information whether driver stopped the engine when the vehicle is not moving
- to control over speeding and abusing traffic lights.

The management of the organization thinks to install a vehicle tracking system in order to regulate the system of vehicles’ transportation and reduce fuel consumption.

In this study our main focus is to investigate whether installed vehicle tracking system is cost efficient generally by referring a case study in a public organization. Since it costs so high in order to install this tracking system to all the vehicles of the organization, some sample vehicles are to be selected to install the VTS for experimentation, analysis and evaluation. So, we chose 24 automobiles, minibuses and midi buses in the first group and 6 lorries for the second group.

Assumptions

- The parameters are going to be saved during the same period of the year.
- The parameters are going to be evaluated in two groups because lorries are not used often and the consumption differs so much according to the load weight.
- The vehicles are going to be used not less than the previous year.
- The cost of installing VTS on vehicles is aprox. 400 TRY per vehicle annually.
- The cost of fuel during the whole experimentation is 1.719 TRY per liter.
- Vehicles start their travel from and return to the control center.
- After VTS installation, the control center will have full control over the vehicles (e.g.: warn the vehicle about over speeding, route changes and engine stops.)

DESIGN AND ANALYSIS OF THE STUDY

Design of the Study

The control center has the statistics of; fuel used, the distances traveled and how many times vehicles start and returned from destination during the period of June 2014- June 2015. For this study the control center will collect records of distances, fuel consumption and the numbers of travels again starting from June 2015 to June 2016.

After having these two years' statistics whether a decrease in the consumption of fuel and decrease in the expenses in the accidents and bills are going to be investigated, compared and analyzed and assessed at the end. After this analysis, cost will be calculated and decided whether VTS is cost efficient.

In this scope of data, R and the Arena Input Analyzer [6] will be used for calculation. Arena Input Analyzer is a powerful software tool especially for graphical and mathematical calculation of distributions (W.David KELTON, Randall P.SADOWWSKI, David T.STURROCK, 2004).

Among bunch of vehicles 24 automobiles, minibuses and midi buses are accepted as first sample group and 6 lorries are selected as second sample group for the input of the study.

The monthly usage of a sample vehicle, fuel consumption and total distance traveled before and after VTS are shown in Table 1.

Table 1: Monthly Usage of a Sample Vehicle, Fuel Consumption and Total Distance Before and After VTS.

Month	**Before VTS**				**Month**	**After VTS**			
	# of Usage of the Vehicle	Total Distance (km.)	Fuel Used (lt.)	Fuel Usage per km.		# of Usage of the Vehicle	Total Distance (km.)	Fuel Used (lt.)	Fuel Usage per km.
June 2014	55	530	50	0.094	June 2015	36	3061.69	214	0.070
July 2014	13	250	28	0.112	July 2015	43	1904.34	154	0.081
August 2014	31	400	45	0.113	August 2015	63	3813.8	256	0.067
September 2014	35	380	47	0.124	September 2015	49	4376.35	176	0.040
October 2014	28	350	40	0.114	October 2015	56	4673.18	171	0.037
November 2014	30	375	47	0.125	November 2015	36	2979.61	99	0.033
December 2014	26	302	34	0.113	December 2015	52	3649.54	99	0.027
January 2015	33	385	48	0.125	January 2016	51	2250.2	154	0.068
February 2015	25	290	33	0.114	February 2016	83	4796.88	166	0.035
March 2015	31	375	41	0.109	March 2016	75	5785.3	312	0.054
April 2015	38	420	49	0.117	April 2016	77	5472.86	158	0.029
May 2015	42	505	53	0.105	May 2016	58	4781.29	140	0.029

All date is gathered for 30 vehicles as in Table 1. Table 2 and 3 can be examined in order to prove that assumptions are satisfied:

Table 2: Average Values for First Vehicle Group Before and After VTS.

	Before VTS (#)	After VTS (#)	Difference (%)
Monthly Usage (Tour) of Vehicles	76	84	11.7 %
Avarage Km. Per Tour	36	40	10.1 %

From Table 2, it can be seen that the assumption of "The vehicles are going to be used not less than the previous year" is satisfied for the first sample group of vehicles. Shortly, we can see that Monthly Usage of Vehicles increases 11.7 % and Average Km. per Tour increases 10.1 %.

Table 3: Average Values for Second Vehicle Group Before and After VTS.

	Before VTS (#)	After VTS (#)	Difference (%)
Monthly Usage (Tour) of Vehicles	2	3	40.5 %
Avarage Km. Per Tour	520	824	58.4 %

From Table 3, it can be seen that the assumption of "The vehicles are going to be used not less than the previous year" is satisfied for the second sample group of vehicles. We can easily see that second group vehicles are not used often on the contrary they travel too much distances per tour. Shortly, we can see that Monthly Tour of Vehicles increases 40.5 % and Average Km. per Tour increases 58.4 %.

Accident maintenance and repair costs allocated budget in one year data (for 2015 and 2016) are shown in Table 4.

Before VTS				**After VTS**	
Date	Repair Cost (TRY)	Date	Repair Cost (TRY)	Date	Repair Cost (TRY)
29.09.2014	80	27.06.2014	437.05	16.11.2015	758.12
17.07.2014	1072.94	18.09.2014	790.89	27.11.2015	88
18.09.2014	1532.61	27.03.2015	475.81	02.12.2015	180
17.07.2014	415.7	06.05.2015	1790.12	17.06.2015	3486.8
18.09.2014	493.19			04.01.2016	1389.02
Total			**7088.31**	Total	**5901.94**

After adopting VTS to the vehicles of the public organization, the number of accidents and repair cost were decreased respectively from 7088.31 TRY to5901.94 TRY. This decrease on repair cost encourages the organization to adopt VTS all of its vehicles.

Statistical Analysis

In this study two methods are used to determine whether data set fits normal distribution; one is as detailed below mathematical method (Shapiro-Wilk Normality test by using R software) and the other is graphical method by using Arena Input Analyzer.

Undoubtedly the most widely used model for the distribution of a random variable is a normal distribution. Whenever a random experiment is replicated the random variable that equals the average (or total) result over the replicates tends to have a normal distribution as the number of replicates become large. De Moivre presented this fundamental result known as the central limit theorem. in 1733. (Central Limit Theorem. De Moivre 1733) [7]

First of all in this context "Shapiro-Wilk Normality" [8] test is used to determine whether the data set is normal distribution. In this test if "p" (probability) value is so low then we can say data is not coming from a normal distribution. In other words, it is stated in the "Shapiro-Wilk Normality" test that low "p" value indicates data set applied does not fit normal distribution [9].

For the first group vehicles fuel consumption per kilometer before VTS installed. Shapiro-Wilk Normality Test result "p" value is **"p-value < 2.2 e-16"**.

For the first group vehicles fuel consumption per kilometer after VTS installed. Shapiro-Wilk Normality Test result "p" value is **"p-value < 2.2 e-16"**.

For the first group vehicles accident maintenance and reparement costs before VTS installed. Shapiro-Wilk Normality Test result "p" value is **"p-value < 2.2 e-16"**.

For the first group vehicles accident maintenance and reparement costs after VTS installed. Shapiro-Wilk Normality Test result "p" value is **"p-value < 2.2 e-16"**.

For the second group vehicles fuel consumption per kilometer before VTS installed. Shapiro-Wilk Normality Test result "p" value is **"p-value = 0.0003847"**.

For the second group vehicles fuel consumption per kilometer after VTS installed. Shapiro-Wilk Normality Test result "p" value is **"p-value = 1.296e-13"** are calculated.

As a result of this test, we can say that the fuel consumption per kilometer and the accident maintenance and repair costs data does not fit to normal distribution.

For the second group vehicles accident maintenance and repair costs we are not able to calculate because no data is obtained (no cost happened in this period of time).

As stated before, we use Arena Input Analyzer in order to determine graphical method whether data set is normal distribution. First of all, Histogram and Q-Q Plot Graphics are drawn and we observed the data set fits normal distribution. In histograms we observed and compared normal distribution curve with the data set visually. In the other visual method is Q-Q Plot. then Q-Q Plot is drawn and the data set is monitored whether they are near to the diagonal line.

For the first group vehicles fuel consumption per kilometer before VTS installed (Figure 1) and after VTS (Figure 2) histogram and Q-Q Plot are drawn.

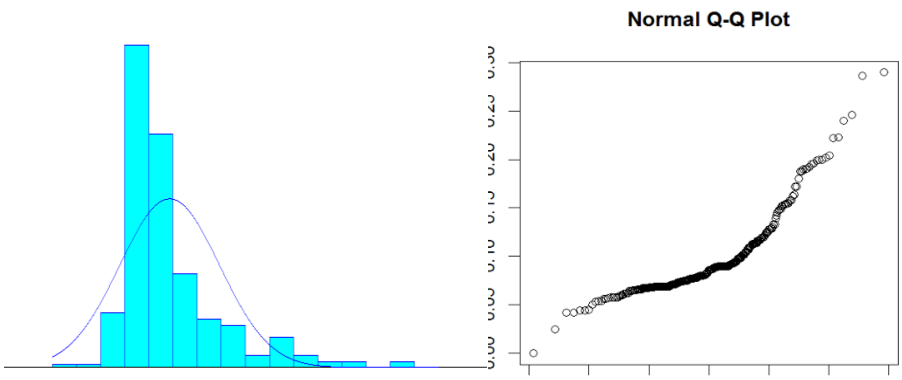

Figure 1: Histogram and Q-Q Plot For the first group vehicles fuel consumption per kilometer before VTS installed.

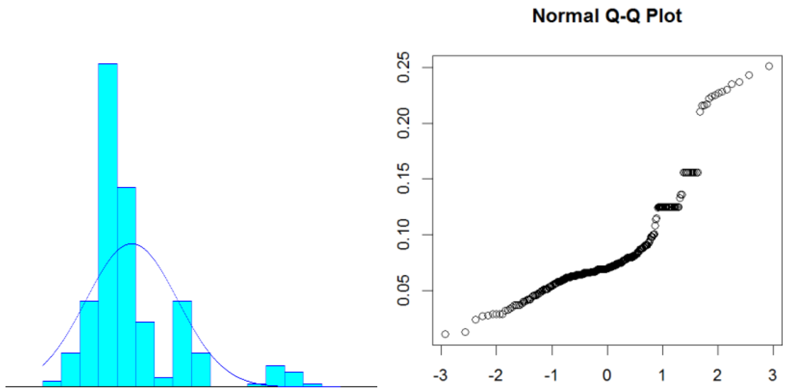

Figure 2: Histogram and Q-Q Plot For the first group vehicles fuel consumption per kilometer after VTS installed.

For the first group vehicles accident maintenance and repair costs before and after VTS installed histogram and Q-Q Plot are drawn in Figure 3 and 4.

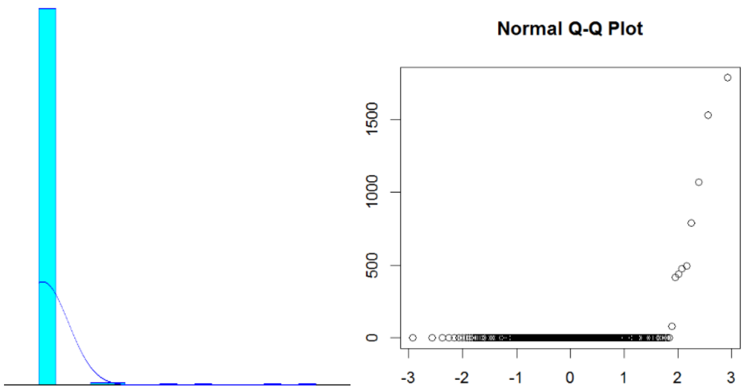

Figure 3: Histogram and Q-Q Plot For the first group vehicles accident maintenance and repair costs before VTS installed.

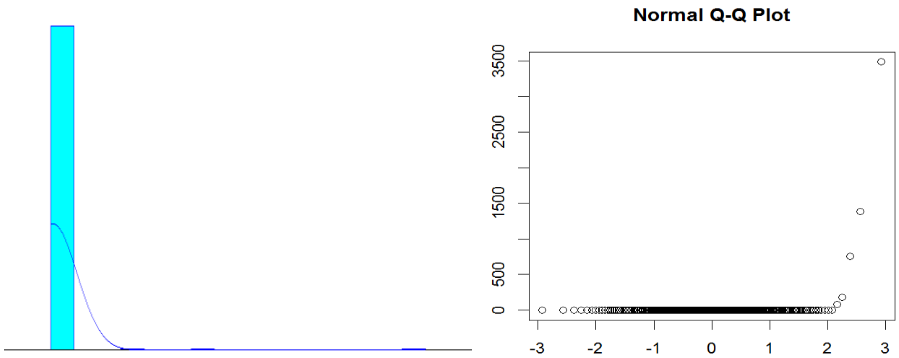

Figure 4: Histogram and Q-Q Plot for the first group vehicles accident maintenance and repair costs after VTS installed.

For the second group vehicles fuel consumption per kilometer before and after VTS installed histogram and Q-Q Plot are drawn in Figure 5 and 6.

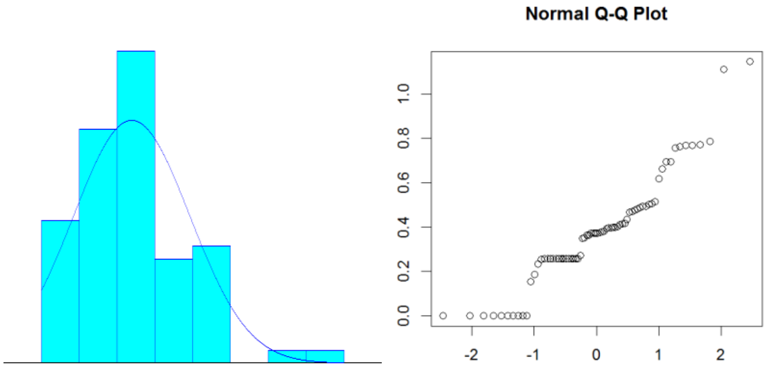

Figure 5: Histogram and Q-Q Plot for the second group vehicles fuel consumption per kilometer before VTS installed.

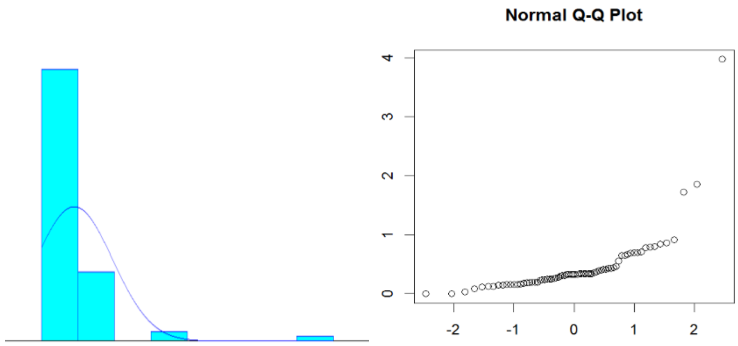

Figure 6: Histogram and Q-Q Plot for the second group vehicles fuel consumption per kilometer after VTS installed.

We can easily see that all histograms of data sets and the normal distribution curves are not fit together and the dots of data sets in the Q-Q Plots are not near the diagonal line. So it can be understood that data does not fit to normal distribution.

Since data does not fit to normal distribution so instead of using paired-t test for normal distributions we use one of the non-parametric tests "Wilcoxon Signed Rank Test" [10]. This test briefly compares the minus and plus values of observations with the sizes (Douglas C. Montgomery and George C. Runger. 2003).

For the first group vehicles we use Wilcoxon Signed Rank Test in order to understand if there exists a meaningful decrease in the data of the fuel consumption per kilometer.

"p-value = 3.742e-05" is calculated. That means there exists a meaningful difference and a decrease from 0.09637 Liters to 0.08364 Liters after VTS installed in the first group. It is drawn in Figure 7.

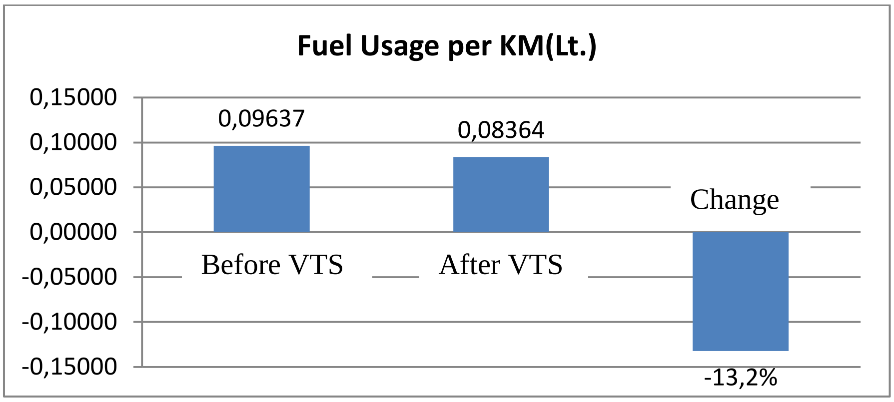

Figure 7: Fuel Usage per Km for First Sample Vehicles.

For the second group vehicles we use Wilcoxon Signed Rank Test in order to understand if there exists a meaningful decrease in the data of the fuel consumption per kilometer.

"p-value = 0.3037" is calculated. That means that there does not exist a meaningful difference and it is drawn a graphic below.

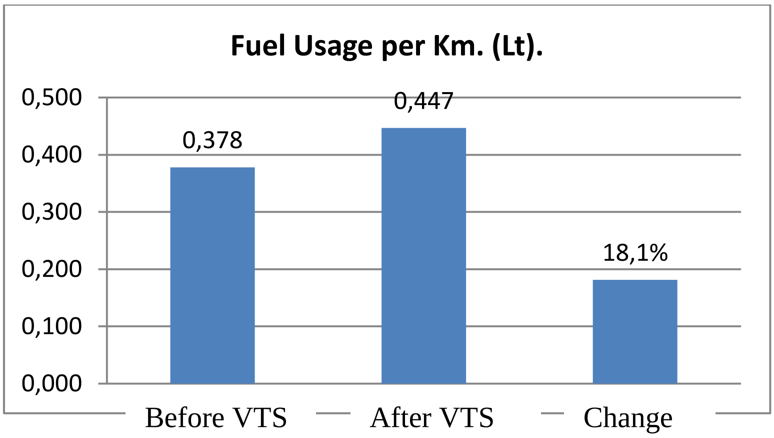

Figure 8: Fuel Usage per Km for Second Sample Vehicles.

For the first group vehicles we use Wilcoxon Signed Rank Test in order to understand if there exists a meaningful decrease in the data of the accident maintenance and repair costs. **"p-value = 0.3626"** is calculated. That means that, there does not exist a meaningful difference.

For the second group vehicles accident maintenance and repair costs, we are not able to calculate because no data is obtained (no cost happened in this period of time).

Cost Efficiency Analysis of the System

Saving on the average fuel consumption per vehicle per a kilometer is **13.2 %**. can be formulated as

$$\frac{\mathbf{0.09637 - 0.08364}}{\mathbf{0.09637}} = \mathbf{0.132}$$

If the average cost of fuel 1.719 TRY (since the organization is governmental, the price of the fuel does not include any tax or fee);

$$(\mathbf{0.09637 - 0.08364}) * \mathbf{1.719 = 0.022\ TRY}$$

is calculated as the average saving per kilometer per vehicle.

If the cost of installing VTS annually is 400 TL;

$$\frac{\mathbf{400}}{(\mathbf{0.09637-0.08364})*\mathbf{1.719}}=\mathbf{18.300\ km}$$

is calculated. That means if one vehicle travels 18.300 km. per month or more VTS installation is cost efficient.

RESULTS

After the analyzing the sample of 30 vehicles' data, it is understood that it is cost efficient only for the automobiles, minibuses (14 pax capacity), midibuses (25 pax capacity)) to install VTS. More tours and short distances that are traveled by vehicles (not 6 lorries) make savings on the fuel consumption like **13.2 %**.

Sample 30 vehicles' data showed that if a vehicle (not the lorry) travels more than approximately 18.300 km. a year. it is cost efficient to install a VTS.

The accident maintenance and repair costs are found not meaningful to test. That means there is no implication of decrease in the costs in this regard.

It will be a vise decision to advise managers to install VTS on the vehicles when it is thought that there are more than hundreds of vehicles in this organization. The more vehicles and tours the more organization' savings. Whenever the cost of the fuel consumption increases the cost efficiency of the VTS increases.

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OPERATIONAL FEASIBILITY STUDY OF AUTONOMOUS VEHICLES IN TURKEY

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Abstract - Recent advances in computational capabilities, communication architectures, sensing and navigation devices have made it possible to develop autonomous, single or multiagent systems in the face of dynamic and uncertain environments. Autonomous vehicles could revolutionize transportation by improving flow efficiency as much as eliminating the need for drivers. This paper examines the feasibility of autonomous vehicles (AVs) and describes their potential effects on Turkish transportation system. The research investigates the impediments, advices and offers federal policy suggestions for an effective transition. The paper also discusses the potential benefits and difficulties of AVs. This paper is concerned with the problem of implementation differences around the world and in Turkey, generating and executing a motion plan for autonomous vehicles technology in Turkey.

Keywords - Autonomous Vehicles, Feasibility Study.
Related Topics - Innovative Solutions, Logistics Management.

1. INTRODUCTION

Autonomous defines in literature as the vehicles or systems which have the ability to act without the user or driver. Their control is performed by robotic system and artificial intelligence and coding [1]. That means autonomous vehicles also called self-driving vehicles. Today industry appears close to substantial change, engendered by autonomous, or "self-driving," vehicle Technologies. This technology offers the possibility of significant benefits to social welfare such as saving lives; reducing crashes, congestion, fuel consumption, and pollution; increasing mobility for the disabled; and ultimately improving land use.

It is agreed that autonomous vehicles will soon be reality on the streets with widespread usage of driverless fleets of taxis, privately owned cars or commercial vehicles. Today four states in the US – Nevada, Florida, California and Michigan – currently permit operation of autonomous vehicles on public roads under certain conditions. The UK has allowed robotic cars to be used since 2013 [2].

The future of logistics will be shaped with The Self-Steering Trucks. There is a revolution on transportation sector. First application of this fact is Mercedes-Benz Future Truck 2025 rolls down the highway at 85 km/h. The tractor and trailer brake and accelerate with precision, riding in the middle of the right-hand lane in flowing traffic. Though the driver is seated behind the wheel, he is staring at a tablet computer, planning his next trip and then checking the condition of the freight stored on smart pallets in the semitrailer. The truck is being driven by an automated system called Highway Pilot. The human does the thinking and leaves the driving to the computer. Table 1.1 shows that autonomous vehicles equipment and requirements. Autonomous vehicles can be listed as Trucks, Aircraft, Unmanned Cargo ships, Submarine, Self-driving trains and Autonomous Cars. Autonomous Trucks will be examined with details in this study.

Table 1.1 Autonomous Vehicles Equipment and Requirements [3]:

1. Automatic Transmission
2. Various sensors for road and whether conditions
3. Wireless communication equipment and programs.
4. Navigation and GPS system.

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2. POTENTIAL EFFECTS AND DEVELOPMENTS ON TRANSPORTATION SYSTEM

Vehicle to Vehicle Communication: Especially among smaller vehicles, the process goes by the name of "car-to-car communication" (C2C), but the umbrella term used is vehicle-to-vehicle communication (V2V).

The near-standard study of an autonomously driven truck demonstrates that the vehicle can also handle special situations without a hitch: The truck automatically pulls into the left-hand lane to allow sufficient room to pass a car broken down on the side of the road. The truck and trailer then pull over to the right a little to allow room for an emergency vehicle approaching from the rear, which announced its presence by exchanging data with the truck.

Driverless Technology: In the meantime, the driver has found time to reserve a parking spot at the next rest stop, process orders and maintain contacts using a video telephony. Only when the truck leaves the highway does he take the wheel himself and steer the Actros to its destination. With the technologies demonstrated in the Future Truck 2025, it is setting the standard for the future of long-distance transport with driverless technology.

More safety by driver assistance: The Future Truck's innovations will have an impact on business models in the transport industry as well as on the demanding job of a truck driver. With factors such as sustained attention, tight schedules and high traffic density, everyday tasks behind the wheel of a big rig place extreme demands on truckers, the intelligent interlinking of the driver assistance systems down to the automated driving itself contributes significantly to vehicle safety.

The truck becomes office: The Future Truck makes the impact of modern technology tangible. In particular, monotonous long-haul routes lasting hours and hours on major highways, often with tight schedules, could be made easier very soon by trucks that drive themselves. During the trip drivers perform other tasks of considerable value to their companies, including, for example, flexible scheduling of the current trip, planning of upcoming trips and bookkeeping. A truck driver can completely count on the computer systems of his truck, which, thanks to its sensors and exchanging of data with its environment, safely and efficiently heads toward its destination.

Fully connected machine with a hive mentality: Although the Highway Pilot in the Future Truck steers, brakes and accelerates autonomously, the system does not make decisions simply based on information from its own sensors. Instead, the truck acquires a significant amount of information by exchanging data with other vehicles (V2V), with the infrastructure's stationary communication network (vehicle-to-infrastructure communication or V2I) and by using satellite navigation to determine its position.

The fourth industrial revolution: This principle of shared intelligence holds the future of not just the transport industry but industry as a whole. İt is featured in the "Mobility 4.0″ initiative, on the same level as digitally linked production processes and intralogistics. These kinds of processes, based on the flexible exchange of information between machines, vehicles, warehouses and other elements of industrial process chains, form the backbone of what is referred to as the "fourth industrial revolution."

From trucker to logistics expert: Autonomous commercial vehicles will change freight traffic, and that is a major opportunity for the logistics industry. After all, the transport industry has to face the two-fold challenge of a distinct lack of junior talent and the image of a trucker as a less-than-attractive career option.

3. AUTONOMOUS VEHICLES EQUIPMENT FEATURES

Autonomous vehicles perceive the world with laser, radar, lidar, GPS (Global Positioning System) and cameras. Radars use radio waves to determine the distance, height, direction and speed of objects, while the lids use optical lights for the same purpose. Advanced control systems use the signals from these sensors to identify appropriate driving routes and to identify nearby traffic elements (people, vehicles, roads, pavements, etc.).

Sensor data is used to update car maps, where dynamic objects that are not in the map system of the car and even static maps can be added to the map [3].

- **Radars:** It is used to detect nearby objects. The rear-end accident-prevention systems give an alarm signal when the vehicle detects objects in the blind spot.
- **Tape Tracking System:** The windshield-mounted cameras are designed to recognize the strips and recognize the contrast between the road surface, road edges and strips. If the car leaves its own lane unwittingly, the short-time vibrations sent to the steering warn the driver or system controllers.
- **Lidars:** On-board Lidar system, especially used by Google, provides a 360-degree point cloud image with up to 900 rpm (rotation per minute) of the 64 laser.
- **Infrared Cameras:** Night vision systems direct infrared rays that are not visible or reflected. The front screen-mounted receivers detect this light and detect it on the in-car screen, reflecting possible objects.
- **Stereo Cameras:** With the front screen-mounted cameras, real-time 3D images of the road in front of the vehicle can be extracted, where they are predicted where they will be in the future (in a few seconds) and are prevented from colliding with the vehicle
- **GPS:** The sensors know where the car is going and where it is located.
- **The Wheel encoders:** The Wheel mounted sensors can measure the vehicle's speed.

4. APPLICABILITY IN TURKEY

Foreseen implementation difficulties in the Turkish transportation sector can be sorted as inadequacies in road regulations, no special ways for autonomous vehicles, investment deficiencies, the lack of sufficient personnel and infrastructure in companies for the technology, traditional thinking approach and response to innovation. Table 4.1 gives both benefits and problems about autonomous vehicles applications.

The vehicles were able to follow each other closely and follow their lanes. Vehicle control is usually examined as two decoupled problems. These are steering control (lateral vehicle control) and speed control (longitudinal vehicle control) [4]. Possible problems are listed as:

Educational problems: Not giving education to police, company employees and other drivers about possible risks and strategies can cause major problems.

Road condition problems: Vehicles may not follow the same path while people are creating alternative routes in condition of road closures, transfer to another way, road works.

Security problems: People can damage the vehicle with curiosity. They may detain or assault the vehicle without regard to the company's rights.

Software problems: The car cannot decide when there is no internet connection. Most subways and tunnels in Turkey have no internet connection. In addition, there are interruptions throughout the country from time to time. People can hack the software and control the car.

Charging problems: Most autonomous vehicles are electrically powered. There are no electrical charging points on Turkish highways. These vehicles must be able to operate with a petroleum derivative fuel before entering the Turkish distribution sector. During the gasoline intake control of vehicles, waiting times and separation from the station can cause major problems.

Besides these challenges, studies are being carried out in our country for the establishment of technological infrastructure.

- "Clear and Clever" team from Marmara University for their innovative autonomous vehicle project. They create low-cost technology for a high speed, high-sensitivity infrared camera, whose implementation could facilitate largescale development of autonomous vehicles [5].
- The "Renovate" team from Istanbul University creates an idea for reducing urban traffic congestion with a dynamic system of pre-reserved journeys that are adjusted according to the number of users on the road [5].
- A team from Okan University creates a model for Simulation of an Autonomous Vehicle Using a Rule Based Algorithm and a Study on the Development Process about speed [6].

Table 4.1 Benefits and Problems about Autonomous Vehicles [3]

Benefits	Problems
Decrease drivers stress*:* The system provide resting or working while travelling.	***Increase costs:*** Vehicles need additional equipment.
Increase safety*:* Autonomous vehicle is robotic system so reduce accident risk caused by driver.	***Cause risk:*** Our vehicles may have system failures.
Decrease traffic problem*:* Traffic progress more regular.	***Social problems:*** Autonomous vehicles damage the other model vehicle and cause safety risk.
Supports shared vehicles: Vehicle owners can share with another human for a fee.	***Reduced employment and business activity:*** The drivers may be unemployed.
Provide fuel savings and reduce pollution: Less traffic allows that fuel savings and decrease pollution level.	***Misplaced planning emphasis:*** Focusing on autonomous vehicle solutions may discourage communities from implementing conventional.
Increase road capacity**:** In Autonomous system the vehicle groups move together.	***Security and Privacy problems:*** Autonomous has robotic control so control system is remotely connectable.

5. CONCLUSION

In this study it is analyzed that autonomous vehicles, their equipment, autonomous vehicle's potential effects and developments on transportation system. For turkey perspective benefits and problems about autonomous vehicles are listed. It seems that there is a lack of investment in this issue in Turkey. In Table 5.1 company forecasts for autonomous vehicles were examined and it is shown that most companies plan their future trends with 2020's. When the studies were examined in literature and academy it is clear that there is a revolution on transportation sector. The future of logistics will be shaped with The Self-Steering Trucks. However, the conditions of Turkey are not ready for this technology for the 2020s. Precautions should be taken and strategies should be developed to solve the potential problems. Technological investments should be increased and encouraged.

University laboratories should be established and developed, studies should be realized to adapt the vehicles to the country roads, company requirements must be added to the system. Studies in this area should be accelerated like European Countries and America.

Table 5.1. Company forecasts for autonomous vehicles

Company	Forecast	Year
Audi	Audi has announced that the next generation of their A8 limousine will be able to drive itself with full autonomy.	**2017**
Google	Google has made it clear that the company plans to have its driverless cars on the market no later than 2018. At the signing ceremony for California's autonomous vehicles law, they outlined Googles path towards commercialization of its driverless cars. Within 2013 Google plans to expand the number and users of their driverless cars to Google employees. Thereafter it will not take longer than 5 years to get the cars into the market.	**2018**
Delphi and MobilEye	Both companies have announced that they will bring a fully self-driving (SAE level 4) system on the market for use in a variety of cars in 2019.	**2019**
Volkswagen	Volkswagen expects the first self-driving cars to appear on the market by 2019. They did not claim that these would be Volkswagen models.	**2019**
NuTonomy	The company has just started trials of its self-driving taxis in Singapore's 1 North District. It plans to deploy self-driving taxis commercially in Singapore by 2018 and aims to be operational with fleets of self-driving taxis in 10 cities of the world by 2020.	**2020**
General Motor	General Motor's head of foresight and trends Richard Holman said at a confererence in Detroit that most industry participants now think that self-driving cars will be on the road by 2020 or sooner.	**2020**
Toyota	Toyota is starting to overcome its long-standing reluctance with respect to autonomous driving: It plans to bring the first models capable of autonomous highway driving to the market by 2020.	**2020**
Nissan	Nissan Motors Ltd., has announced that they will make fully autonomous vehicles available to the consumer by 2020. These cars will be able to drive in urban traffic. In contrast to Google's cars, they claimed that they will not need detailed 3D maps for local navigation.	**2020**

Ford	Ford expects that autonomous vehicles of SAE level 4 (which means that the car needs no driver but may not be capable of driving everywhere) will hit the market by 2020.	**2020**
	Mark Fields, Ford's CEO announced that the company plans to offer fully self-driving vehicles by 2021. The vehicles, which will come without steering wheel and pedals, will be targeted to fleets which provide autonomous mobility services. Fields expects that it will take several years longer until Ford will sell autonomous vehicles to the public.	**2021**
BMW	At their annual shareholder meeting, BMW CEO Harald Krueger said that BMW will launch a self-driving electric vehicle, the BMW iNext, in 2021.	**2021**
Baidu	Andrew Ng, the chief scientist of the Chinese search engine Baidu expects that a large number self-driving self-driving cars will be on the road within three years, and that mass-production will be in full swing by 2021.	**2021**
Tesla	Tesla estimates that "five or six years from now we will be able to achieve true autonomous driving where you could literally get in the car, go to sleep and wake up at your destination". He then added another 2 to 3 years for regulatory approval.	**2023**
Jaguar and Land-Rover	At the 2014 Paris Motor Show Dr. Wolfgang Epple, Jaguar and Land Rover's Director of Research and Technology said that about fully autonomous driving: "For Jaguar and Land Rover it will happen within the next 10 years".	**2024**
Uber	Uber CEO, Travis Kalanick, has indicated in a tweet that he expects Uber's fleet to be driverless by 2030. The service will then be so inexpensive and ubiquitous that car ownership will be obsolete.	**2030**
IEEE	Expert members of the Institute of Electrical and Electronics Engineers (IEEE) have determined that driverless vehicles will be the most viable form of intelligent transportation. They estimate that up to 75% of all vehicles will be autonomous by 2040.	**2040**

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SOFTWARE APPLICATION IN SUPPLY CHAIN MANAGEMENT AND EXAMINING OF PRODUCTIVITY EFFECTS OF USE “ERP” IN ENTERPRISES

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Abstract - Supply chain management is a global strategy for organizational success. Many software applications can be used for different steps of the supply chain management. This study aims to give general information about different supply chain software used for Supply Chain Management and their historical progress. In the meantime, this paper investigates why some companies do not prefer ERP software which is very common in the industry and whether they invest in such software or not. Moreover, this paper will provide information about how effective a company having ERP use this software and will examine whether they take expected strategic advantages or not.

Keywords - ERP, Supply Chain Management, Software, Productivity

INTRODUCTION

Supply chain that usually supply feedstock material in the channel extending to customers starting from supply sources, raw materials and supplies of other goods and / or products to transform and is a network, and it is the whole process of providing distribution to customers through the distribution channels of the products. [1] Supply Chain is a series of activities covering the entire life cycle of a product's design stage up to the consumption stage. The planning of these activities will be aligned with each other, execution, monitoring and control is the concern of supply chain management. [1]

Supply Chain Management (SCM), a structure that integrates supply and demand management within and between companies. It is required production, inventory, ensuring the integration of location information and handling in the supply chains. The right amount of the right product for an efficient supply chain, at the right time, right place, high flexibility with minimum total cost, it is necessary to ensure the shortest possible cycle time and at least the total stock levels. All that came to replace critical components and flow of updated information for the execution of simultaneous actions between the parties in the supply chain / share must be ensured. In this context, Information Technology (IT) recorded in the field of development, IT Information gathering, processing and supply chain parties to independently traditionally because of defusing the rule makes it easier to gain an integrated structure and appearance. [2]

The process begins with material planning software since the 1960s, today the entire supply chain using each specific area effectively wrapped in the body that coordinates the network in an integrated manner.

Supply Chain Management, in order to improve the supply chain and all the long-term performance of companies located in this chain, the business functions of the said companies, processes and plans, to cover all companies in the chain is a strategic and systematic management. [1]

The purpose of this study, to deal with a general framework used Software in the supply chain management it is investigate, unusing software ERP of bussinesses why don't prefer it that widely used in these software. However, it will examine the strategic advantages of the company which has achieved using the ERP system.

USED SOFTWARE IN THE SUPPLY CHAIN MANAGEMENT

In the 1995's, in subsequent years in supply chain MRP software are defined as optimization, MRP II and led to the largest companies in the supply chain management software in the ERP field which has emerged as the

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software. In recent years, software is quite rapid development of competition in the biggest factor in the rapid development of computer hardware and. especially large companies to adapt to evolving technologies have contributed to the development of the software industry. Today,such as software MRP 2, ERP, CRM, WMS and SCMin the MRP supply chain as well as many software in the internet of the host object inside, augmented reality and the concept of working instantly synchronize information such as robotics technology software are the trend of the world.

In the past, companies usually use their own in-house developed software programs and employees. This has led to many useful development, but also led to the development of separate and disconnected legacy systems with each other. In the last 10 years, many software provider metarial requirements planning (MRP) systems, advanced planning systems (APS), and enterprise requirements planning (ERP) systems containing focuses on developing software for specific applications by creating a product that many special software. That's why the market is ready to sell the software creates its own organizational structure of each company's products have been converted to selling software vendor. Even further development that has been open source software products.

HISTORICAL PROCESS OF SUPPLY CHAIN MANAGEMENT SOFTWARE

Supply chain management became a common term in the 1980s, mostly influenced by Japanese manufacturing processes such as those devolopped by Toyota, such as just-in-time (JIT) and lean manufacturing. [3]

Especially after 1960's, dependent on the structure of demand, taking into account applicable material requirements planning (materials requirement planning) system by moving a special importance with the spread of the production concept just in time, as the whole world has seen interest in Turkey. Dependent demand structure of the development process of considering ordering system applied is necessary to examine the major seven steps.[4]

- Gross/Lot Requirement Planning
- MRP:Material Requirement Planning
- Closed Loop MRP
- MRP II: Manufacturing Resources Planning
- Enterprise Resources Planning
- ERP II: Enhanced Enterprise Resources Planning
- SCM: Supply Chain Management

MRP and MRP II

Applicable requirements has long been linked to production planning is an ordering system. This plan, through a variety of techniques has reached a certain stage of an integrated production-Inventory Management Software System as MRP point. Material Requirements Planning (MRP: Material Requirement Planning) the striking difference between the supply and production actions in their system is a method that has been developed to respond to the basic material needs of the production environment.

MRP system, demand forecasting results and the way the master production schedule prepared in accordance with approved orders, stock information with this information, basic information about the product (BOM), and earlier by using the MRP results of the production order and purchase order software to prepare reports defined as the system. Especially taking advantage of the superior power of computers containing thousands of parts manufacturing company engaged in complex products, timely production and performs very low inventory levels that is the realization of an application integrated with production. Closed-loop MRP, MRP system is the biggest weakness of the developed software system for solving the problems of infinite capacity. After preparing the order plans, preparation of more realistic materials requirement plan based on a systematic closed-loop control is also worth figuring out whether the production capacity brought to possible situations. MRP II system while also seeing the results of their impact on the financial resources and other resources programs of production and thus a kind of simulation (simulation) by a software system that allows the preparation of more effective plans. [4]

ERP

In the 1990s, different types of manufacturing companies, established in different countries with different currencies, concurrently have been developed software systems in the planning and control of production resources and it is said Enterprise Resource Planning (ERP) to this system. Thus, the benefit from the synergies created by the planning of resources in different facilities at the same time. At the end of 1990's, it was born to be integrated through requirements that the company's ERP system of the customer's ERP system, "Customer Relationship Management" (CRM: Customer Relationship Management) and also with ERP systems suppliers "Supplier Relationship Management" (SRM: Supplier Relationship Management). The software in this direction has called ERP II software system. In the 2000’s, Supply Chain Management (SCM) is the main focus to look at all points along the chain of supply chain planning and make this approach and will provide significant advantages for SCM software has been developed to ensure traceability [4]

ERP systems are operating running systems that try to bring unite all the data and processes. Basically, ERP systems use a unified database of various data can be stored. Many software instead of using software and using a single standardized interface allowing the software ERP software system, all data are usually stowed in a database, easy to take and provides status reports and high power ratings. Usually, independently operated such as production in the ERP software, finance, customer relationship management, human resources, it is hosting a variety of modules and inventory management applications. [1]

The modular structure is the system software which allows real-time data access and storage within the organization, analysis and management functionality. In addition, ERP software can also support the private sector, it is critically important for international organizations with multiple currency and language support, such as oil chemical, banking, health care, aviation. One of the important features of the ERP system, the company's geographically different areas (domestic and external) for which units, all of these functions, as the center is that it allows managing and simultaneously. All the resources of a company located in multiple regions at national or international level in an effective and efficient way to conduct planning is possible with the ERP approach. In this context, in which the customer belongs to which fulfill the order in which the distribution center or which must be produced at the factory, it would be appropriate where the fulfillment of all plant materials and service needs, such as information, the machine in the hands of the factory, materials, labor energy it is jointly determined how coordinated the production and distribution of resources. In other words, it must be taken into account simultaneously in order to provide the customer orders as soon as possible, on the desiredquality and distribution of all united businesses the cost, and features of the manufacturing and capacity of supply sources.

The aim is to provide centralized management of some of the advantages of utilizing the inter-regional coordination and concurrently to integrate in line with the basic strategy of the institution.

Institutions; must quickly adapt to competitive factors such as globalization, faster customer response times and shorter product life spans. In such a competitive environment, companies follow best practices in the industry for succees it is difficult to obtain the strength of the strategic use of information in real time. There are many factors that make the necessary applications.It corporate resource that will provide the needs of company for coherent knowledge , the first attempt to reach a timely and reliable data, to integrate business systems under one roof as they are major. In addition, the ERP systems recently, not only to integrate the company internal business processes, but also among the company's suppliers and customers it is also preferred due to their ability to establish integration, independent of time and place through the internet. [5]

THE IMPORTANCE OF ERP FOR SME’s

Small and medium -sized enterprises constitute base foundation of the economy in developing countries.There is not a general description for SME's in the world; but there are some restrictions that are used to describe SME notion. Business capital, the number of employees, total asset value, the market value of the enterprise, the salaries of employees are some of which it is a part of these criterias. [6]

For our country, the following descriptions are defined that are used by KOSGEB in business.

- Between 1-50 employees capacity enterprises: Small- scaled industrial enterprises
- Between 51-150 employees capacity enterprises: middle- scaled industrial enterprises
- Higher than 150 employees capacity enterprises: Large - scaled industrial enterprises
- By an another foundation DİE (State Statistics Institute)
- 1-9 Between 1-9 employees capacity enterprises: Very Small- scaled industrial enterprises
- Between 10-49 employees capacity enterprises: Small- scaled industrial enterprises Between 150 employees capacity enterprises: Middle- scaled industrial enterprise
- Higher than 150-250 employees capacity enterprises: Large - scaled industrial enterprises
- Higher than 251 employees capacity enterprises: Very large- scaled industrial enterprises. [6]

It consists of some technologies that enable to be done processes such as Information technologies, recording and saving of the data, information production with going through a process, reaching these producted information, saving and transferring.

If the descriptions in the literature are researched, it can be seen that the concept of information technologies involves software, hardware and all the computer-aided machines. Information technologies are important in terms of productivity growth of enterprises, improvement of new products and services. [7] On the other hand, information technologies are also important in terms of making correct decisions by the enterprises.

Doubtlessly, with the functional capability of the system control software that also create the most important cost item takes place on the top of the information technologies. ERP (Enterprise Resource Planning) is the general name used in integrated administrative systems that provide productive usage of the resources such as machine, material, needed labor while the production of goods and services in the enterprises. Enterprise resources planning systems are the software that help to united all the data and processes of an enterprise. [8]

The main characteristic of the ERP is the availability of concurrently planning of the facilities in different locations (domestic or foreign), the suppliers, the distribution sites. [9] In order to accomplish the objectives making the operations change sensitive by the enterprises is only provided with ERP. Otherwise, acting actively in response to the changing dynamics of customers and the market cannot be possible.

INVESTIGATING THE USAGE OF ERP IN SME'S

There are issued ERP software in our country likewise in many world countries. Besides the foreign companies, domestic companies started to produce ERP software firstly in 1990s. But the main lack of the domestic software that were less expensive than the foreign ones, was their accounting based construction. [10]

Whether or not the usage of ERP system by the SME's, if it is used how much the effectiveness of this usage and will such an investment be done or not in the future were investigated in a study made in 2012 by Turkey Industry, Science and Technology Ministry. Fundamentally, these data are predicated, all the data and analysis methods are not included.

Generally, the purposed the study is:

- Determine the demographic specifications of the enterprises in the study

- Determine whether or not the use of any ERP system in these enterprises
- If not, define the reasons
- Detect the regulations of the working processes before move into the ERP
- Determine if a provided a strategic advantage gained or not by the enterprises that use ERP

A survey was conducted with 28 enterprises as a method of the study Industrial developed provinces were priorly preferred while selecting the enterprises. SPSS 18.0 packaged software was used in order to analyze the data. As a result of the study 154 survey was evaluated. [11]

Demographic Information About the Enterprises Associated with the Study

72,7% of the enterprises in the study is on manufacturing 3,9% of the enterprises is on energy industry, 11,7% is on service industry, 5,2% is on the building trade and the 6,5% is on the other sectors.

12,7% of the enterprises have 1-9 amounts of employees, the 34% have 10-49 amount of employees and the 53,3% have 50-249 employees.

The Data About the Use of ERP

There are 3 different questions about this issue in the survey and it has been found that 46,1% of the enterprises use ERP software.

Table 1. Data On Use of The ERP for Companies

Response	Count	%
Yes	71	46,1
No	83	53,9
Total	154	100

66 enterprises gave the information about their ERP software use. Totally 27 different ERP software usage was detected. Mainly preferred five software are, Netsis, Sap, CANIAS, Microsoft Dynamics Navision and analyze. [11]

Why ERP software is not used by 83 Enterprises can be seen on the following responds in the table below. [11]

Table 2. Reasons of Companies That Don't Use ERP

Reason	Count	%
High cost	19	25
Long adaptation time	10	13,2
Lack of technical infrastructure	16	21,1
There is no need	33	43,4
Due to a risk of result	1	1,3
The difficulty of system selection	6	7,9

Other	13	17,1

Another bottom line is, running the working processes though and redesign the lack points by the enterprises that will use ERP software before determine to use. As result of the survey, it has been detected that 70,6% of the enterprises succeeded to rearrange the working processes, 29,4% of them could not be carried out that. It was discussed that these ERP used enterprises gained a strategic advantage or not.

Table3. Strategic Advantages That Gained by the Usage of ERP

Strategic Advantage	Average
Correct communication	3,84
Efficient cooperation	3,79
Outbound logistics	3,76
Short circle time	3,73
Increase of efficient	3,72
Low operating cost	3,60
Inbound logistics	3,58
Increase of flexibility	3,53
Customer satisfaction	3,52
HR Management	3,48
Increase income	3,39
Higher profit margin	2,94

DISSUSSION

Today, all the companies who want to dominate the global market supply chains must manage effectively and efficiently. The key argument in management is used information technology. Businesses make good use Software and IT technologies and that adapted successfully to their supply network it can generate significant difference between competitors. Since 1990's, it has a vital role to play in managing the supply chain ERP software system that still continue the evolution emerges. Today, ERP software system for many companies has been beyond necessity rather than choice. However, it needn't to be ignored the essential issues that is considered also.

By analyzing the survey results, it was established that the more employees the increase in the rates of the use of ERP. The most important strategic advantage of the enterprises use the ERP was stated as healthy communication. They also reported that they had an improvement on distribution and inbound logistics.

In the point of the studies about the SMe’s in Turkey, it was found that there are so many factors must be taken into consideration in order to provide the expected good results. First, it is needed that determine such software is necessary or not for the enterprises, complete the lacks of the organizational culture and rearrange the working processes. Furthermore, it must not be ignored that adoption of ERP software may be really a very long term process.

When it is examined why businesses do not use ERP, the first reason seems to be the thought that it is not needed. Another important reasons are high cost and lack of technical infrastructure.

Currently, 53,9% of the enterprises do not use ERP software and this points that there are much more things essentially to do. On the other point, it must be also taken into consideration that software are such things that can be only bought one time, it is not possible to sold to an another facility in case of facing a failure, maintenance and hardware costs cause an important expense item. Because of these reasons it must be important to take the advantages of both the experiences of the succeeded enterprises and consider the experiences of the failed enterprises. On the other hand, it should also be taken into consideration that the consultancy and training services to be obtained from the enterprises using these software can overcome many problems.

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THE USAGE OF INFORMATION SOURCES IN CHARTERING OF SHIPS BY CHARTERERS

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Abstract – *The aim of this study is to explore the different information sources used by charterers within the framework of B2B services and determine their usage by charterers in their decisions. To reach this aim, previous literature regarding B2B and shipping services context was researched. Then a questionnaire developed from the relevant literature and the study was conducted on the sample of charterers in dry bulk shipping industry in Turkey. The findings of the study revealed that the most frequently used information sources in ship chartering are personal experiences, business emails, exclusive ship brokers, word of mouth, vessel traffic tracking websites and in-house ship brokers respectively. The study also found that there are significant differences between the groups of organization size, centralization in chartering decisions and respondent's experiences in the usage of various information sources.*

Keywords – *Information Sources, Chartering, Industrial Buying, B2B services*

1. INTRODUCTION

Chartering of ships requires a form of exchange of information between parties namely charterers and ship owners/operators for carriage of bulk cargoes. It is considered as B2B (business to business) service to cope with operational needs of charterers and it is one of the trades where the right information at the right moment is essential to be successful [1]. The parties involved in chartering acts are called as a collector, judge and distributor of information. However, one actor, namely ship broker, has an essential role in this context. A ship broker in chartering business is a member of information network to bring all parties in a chartering negotiation. The ship broker performs a complex task which could broadly be categorized in the following dimensions: (1) information acquisition and dissemination, (2) advisory role through knowledge of the market, (3) negotiations and representation and (4) informal arbitration/facilitation [2]. That's why charterer has an interest in the broker's sources of information, his knowledge, as well as his skill at negotiation.

Ship brokers communicate and use different sources of information about market developments. For the ship brokers, the information search has been long recognized as a key activity in the ship chartering and they have access to many different information sources, some of which will be more important depending on the business they are involved in. Many deals are published but some remain private. These are communicated only orally, usually over the telephone, through the informal networks of personal relationships. According to Akerlof [3], the effective usage of information source also helps to solve the information asymmetry which leads to take false chartering decisions by facing with adverse selection. In agency theory and economics, information asymmetry deals with the study of decisions in transactions where one party has more or better information than the other. Therefore, main purpose of study is to explore the different type of information sources used by ship charterers in chartering decisions and determine usage frequency of these information sources by charterers.

This paper is structured as follows. First, the researches on information sources in B2B services and shipping services is scanned from the relevant literature. Later, the research methodology is given. Third, the research findings are presented. The study concludes with the results and discussions of the study as well as limitations and further research.

2. LITERATURE REVIEW ON BUSINESS TO BUSINESS INFORMATION SOURCES

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In this study, the literature was reviewed in two streams: First, the literature focusing information sources in various B2B is researched. Later, the literature covering information sources used in shipping industry is scanned. In the industrial buying literature, Sheth [4] was the first to study the classification of information sources which create differential expectations among the individuals involved in the purchasing process, and then many other researchers [5,6,7,8] adopted Sheth's industrial buying models by adding information sources. Over the following years, Moriarty and Spekman [9] developed taxonomy of information sources along two dimensions: personal/impersonal and commercial/noncommercial. As shown in Table 1, personal commercial sources include salespeople and trade shows, whereas impersonal commercial sources include such things as advertising and direct-mail brochures. Personal noncommercial sources vary widely, and can range from internal and external colleagues to personal experience. Impersonal commercial sources include news articles and information from trade associations. Indeed, Moriarty and Spekman [9] investigated 14 information sources and found that 6 of the top 7 were personal sources, such as internal coworkers (other departments), salespeople, product users, and colleagues in other companies.

Table 1: Taxonomy of Information Sources Used By Industrial Buyers

	Personal	Impersonal
Commercial	• Sales People • Trade Shows	• Advertising in trade publications • Sales Literature
Non-commercial	• Personal experience • Top Management • Users • Outside Consultants • Colleagues • Other Departments	• News Publications • Trade Associations • Rating Services

Source: [9]

Other studies [10, 11, 12, 13] further detailed trade shows, conferences and sales literature as technical literature as important information sources. They examined the sources of information across industries from manufacturing to public administration. Patti [14] discovered that buyers in the capital equipment industry considered advertising to be as an important information source as sales people for obtaining product and service information. Bunn [15] revised the taxonomy dimensions by adding internal memos and internal commercial sources in the wide range of industries which were the member of National Association of Purchasing Management (NAPM). Although the different researches investigate the information sources in the literature, the classification needs to be developed due to the technological changes at an exponential rate. When information sources are shown to be much more versatile and internet is considered as the most important information source, the information sources used by industrial buyers need to be reviewed. Deeter-Schmelz [16] mentioned that developing effective web strategies require knowledge of the usefulness of the internet as an information source for industrial buyers, as well as knowledge of how buyers are using it for communication activities. Their study has a wide range of industries, including, such as, manufacturing, mining, and public administration. However, some researches [17,18] have different approaches to determine the information sources. They have divided information sources into two categories: internal and external. Source of internal information includes evaluations of previous experience with a service, and external information includes commercial and non-commercial information alongside with personal and impersonal sources of information. Over the past years, the classification of information sources had a wide variety and applied on many sectors. Makhita's study [19] on South African retailers argued that supplier based information should be useful to evaluate the purchasing decision prior to buy a service and he revised the classification by adding information from suppliers.

Although many studies in this topic already exist in literature for different business areas, there is a limited study on sources of information in shipping industry. Gorton [1] described the information sources in chartering as "information channels" and classifies the information into eight categories: orders, positions, market reports, general information, freight negotiations, information centers, information networks and means of communications. The party requesting chartering service is said to "place an order in the market" and will then await reactions from the tonnage that may be interested in the order. Positions which mean information where and when vessels are expected to become available (open) for new employment is circulated by owners and operators as a guide to brokers and charterers. Market reports are circulated by the large-scale shipbroking companies to owners, charterers, other brokers and agents, giving a concentrated picture of the prevailing situation for the day or the week. The most pieces of information are exchanged during freight negotiations between the parties involved.

Gorton [1] pointed out primary information centers in the distribution of shipping information as London, New York and Tokyo but also Oslo, Hamburg, Paris and Piraeus. Ship-owners who operate their ships world-wide are in daily contact also with shipping centers in many other countries. Information networks is of great importance for ship-owners, charterers, brokers and agents to establish a network of contacts which catches all interesting opportunities and by which adequate information is quickly transmitted. Means of communications is defined as various communication gadget used in day to day ship chartering. They are usually telex, tele-fax, emails and cell phones to gather all useful information from parties.

Apart from Gorton, there are several studies focusing on information sources in shipping. Granzin et. all [20] indicated that the sales person is an important source of information as the perception of shippers in logistics industry. They collect and present the information to the decision makers who are quite likely looking for solutions that will save time and money.

Although radical changes are occurring in the industrial marketing communications environment, much of the researches in this area were made before the digital technology era. Industry 4.0 aims to build the infrastructure of the information society [21] such as “internet of things”. Interestingly researches on business-to-business information sources, there are limited empirical studies [16, 22] focusing on communication technologies and the studies did not cover new information sources and communication channels in shipping industry. Therefore, main aim of this study is to explore the different information sources used by ship charterers in chartering decisions. Another aim of this study is to determine the usage frequency of different information sources in chartering as a business to business service. In addition to this, differences in the usage of information sources according to organizational and personal characteristic of the charterers are also investigated in the study. Hence, this study is designed to address the mentioned shortcomings in the literature by studying the following research questions:

RQ 1: What is usage frequency of different information sources used in chartering ships?

RQ 2: Is there any significant differences in the usage of information sources by charterers in terms of organizational and personal characteristics?

3. RESEARCH METHODOLOGY

3.1. Questionnaire Development

To investigate the aims of the study, a questionnaire was carried out on the dry bulk ship charters as buyers of the service. The questionnaire was developed based on the variables obtained from the relevant literature [9,15,16,18,19] and personal interviews carried out as pilot study with 15 charterer companies on the information sources used in chartering ships. So, the pilot study assessed the feasibility of the questionnaire and tested the adequacy of the research instrument. Considering the findings of the pilot study the final version of the questionnaire were completed.

A single page was attached to the first page of the questionnaire which included directions and instructions regarding the completion of the questionnaire. In the cover letter, it was requested that the questionnaire should be completed by general/deputy managers, chartering managers, ship brokers, and import/export managers in order to have robust findings according to their last voyage charter. The questionnaire consists of several sections. First and second section includes the profile of the companies and respondents. Following section consisted of twenty-eight questions with five-point likert scale on the usage frequency of different information sources.

3.2. Sampling and Data Collection

The population of this study consists of Turkish dry bulk charterers who purchase only voyage charter service and actively working in the sectors of steel, cement, wheat, mining and fertilizer. These sectors were chosen as sampling frame in this study since they are the leading sectors in terms of dry bulk chartering. Table 2 shows the export and import share of these goods in Turkey's trade. The size of the sampling frame was determined from data of Ministry of Turkish Foreign Affairs, Istanbul Chamber of Commerce, Turkish Exporters Assembly and Istanbul Minerals and Metals Exporters Association. After reviewing the data from above sources, 165 companies were selected by using judgmental sampling method.

The questionnaires were sent by e-mail and facsimile to 165 companies in the sampling. Due to low response rate, follow up phone calls were made to the remaining of the sample, and it was seen that some of the companies were involved in the management of the same company. This further reduced the actual sample size to 141 and the response rate for the questionnaire is 85 %.

Table 2: Major Import and Export Dry Bulk Cargo Types in Turkey in 2015 (Million US $)

Sectors	Export (USD)	Share in Total Export (%)	Sectors	Import (USD)	Share in Total Import (%)
1. Steel	6.556.416	%5,0	1. Mining (*)	7.315.840	%4
2. Mining (*)	4.026.734	%2,4	2. Steel	6.480.080	%3
3. Cement	2.252.783	%2	3. Fertilizer	1.250.909	%1
4. Fertilizer	134.435	%1	4. Wheat	608.080	>%1
5. Wheat	108.660	%1	5. Cement	265.638	>%1

Source: [21]
(*) Aluminum, Tin, Lead, Nickel, Copper and Zinc etc.

4. FINDINGS

4.1. Profile of the Respondents and Companies

Table 3 shows the profile of the respondents in the study. % 30.5 of the respondents has the position of import/export manager and 16.3 % of the respondents are chartering managers. Company owners constitute the % 12.1 of the respondents. The respondents in the "other" category include purchasing managers and logistics managers, and constitute % 29 of the respondents. In terms of the education level of the respondents, most the respondents have bachelor's degree (62 %) and master degree (32 %). % 85 of the respondents is at the ages between 40-49 years old and only 4 % of the respondents is between 50-59 years old. 54 respondents have been working in the industry between 12-17 years and 39 respondents have been in the industry between 6-11 years. This figure proves that the respondents have considerable experience in the industry.

Table 3: Profile of the Respondents

	F	%		F	%
Position			**Experience**		
Owner	17	12,1	0-5 years	36	26
General/Deputy Manager	9	6,4	6-11 years	39	28
Chartering Manager	23	16,3	12-17 years	54	38
Ship Broker	9	6,4	18-23 years	8	6
Operation Manager	11	7,8	More than 24 years	4	2
Import/Export Manager	43	30,5			
Other	29	20,6			
Education Level			**Age**		
High School	6	4	20-29	2	1
Bachelor	88	62	30-39	45	32
Master	45	32	40-49	85	60
Doctorate	2	2	50-59	6	4
			More than 60	3	3

Profile of the companies which the respondents have been worked in is shown in Table 4. Company categories in the sample in terms of sizes were distributed almost equal. There are 43 large scale companies which have more than 250 employees. The number of small size companies with fewer than 50 employees is 50. Almost one third (48) of the companies in the sample is the middle scale companies between 50-250 employees. In terms of degree of centralization in ship chartering decisions, almost one third of the companies in the sample (105 companies) have been working as tough hierarchical structures and others (36 companies) have a more flexible structure than centralized organizations.

21 companies have been in the industry between 1-10 years. Most the companies (% 86) have been in the industry more than 11 years and 14 % of companies have background between 1-10 years. One third of the companies in the sample are active in mining industry. The percentage of the companies in the business of steel and fertilizer industry is same with 21.3 %. In terms of types of trade, most of the companies (62 %) in the sample are actively involved in both export and import. The percentage of companies involved in export business is 26 and import business is 12. Regarding the types of dry cargo ships in terms of sizes 73 % of the companies uses ships under 10.000 DWT capacity in their chartering, namely coasters. This means that charterers usually preferred to carry their cargoes in small quantities.

Table 4: Profile of the Companies

	F	%		F	%
Size of the Organization			**Duration in the Industry**		
Small Sized	50	36	1-10 years	21	14
Middle Sized	48	34	11-20 years	50	36
Large	43	30	21-30 years	39	28
			More than 31 years	31	22
Types of Trade			**Degree of Centralization in Chartering Decision**		
Import	17	12	Centralized	105	74,5
Export	36	26	Decentralized	23	16,3
Import&Export	88	62	Mixed	13	9,2

Industry			Ship Tonnage (DWT)		
Steel	30	21,3	Under 5000	52	37
Mining	44	31,2	5001-10000	50	36
Cement	20	14,2	10.001 - 15.000	13	9
Fertilizer	30	21,3	15.001 - 20.000	7	5
Wheat	17	12,1	Over 20.001	19	14

4.2. Frequency of Different Information Sources' Usage in Ship Chartering by Charterers

To investigate the usage frequency of different information sources used by respondents, descriptive statistics including mean and standard deviation scores were calculated and presented in Table 5. Top six information sources in terms of usage frequency in chartering ships are "personal experiences", "business emails", "exclusive ship brokers, "word of mouth", "maritime tracking web sites" and "in-house ship brokers" respectively. "Personal experiences" had highest mean value. This finding is normal since judging the quality of the service is difficult prior to purchase and the reliance on one's own experience is important. Additionally, industrial buyers as source of information were frequently rated more useful than other information sources, possibly because these sources offer informational value without an added ''sales pitch'' [16]. "Business emails" were rated as the second most frequently used sources of information in ship chartering. Considering that emails is the main communication means between the parties involved in chartering process for sharing information, business e-mails are widely utilized information source in chartering ships. Since ship brokers have utilized business e-mails for a long time in their chartering transactions, charterer might consider business e-mails as one of the most frequently used information source. When used properly, such information source offers several advantages, including responding quickly to questions and building customer satisfaction [2].

"Exclusive brokers" is another important most frequently used source of information. Since most of the charterers have traditional relied on their service for a long time in finding appropriate ships it is normal to use exclusive brokers frequently in chartering decisions. Charterers may perceive exclusive brokers as more secure and accurate information sources than competitive brokers, because the relationship between charterer and competitive broker is not as strong as the relationship between charterer and exclusive broker. In addition to this it may be expected that competitive brokers could try to finish fixture as fast as possible without paying enough attention to charters' concerns. A trusted exclusive broker with direct and close contacts with charterer can provide better deals or service in for charterers, which in turn aids them to establish better relationship between parties as a continuous, repeated, long-term interaction. From ship-owners point of view, this would lead to do better screening and eliminating the adverse selection.

Table 5: Frequency of Different Information Sources Used by Charterers in Dry Cargo Ship Chartering

Rank	Information Sources	Mean	SD**
1.	Personal experiences	4,71	0,580
2.	Business emails (e-mail circulars, ship offers and freight negotiations etc.)	4,23	0,723
3.	Exclusive ship brokers	3,83	0,956
4.	Word of mouth	3,67	1,018
5.	Maritime traffic tracking web sites (marine traffic, AIS reporter etc.)	3,17	1,230
6.	In-House ship brokers	3,00	1,331
7.	Competitive ship brokers	2,90	1,084
8.	Ship owners' web site	2,90	0,873

9.	Dry cargo conferences (Rotterdam, Hamburg, Bosporus, etc.)	2,82	1,097
10.	Ship agents	2,79	0,841
11.	Business meetings	2,74	0,808
12.	Ship chartering internet portals (VTS, stem in order etc.)	2,72	1,076
13.	Internal records (Statement of Fact etc.)	2,53	0,833
14.	Maritime trade publications (Lloyd's list, Clarkson etc.)	2,48	0,983
15.	Marine insurance circulars	2,38	0,930
16.	Fairs and exhibitions	2,35	0,738
17.	Trade unions	2,30	0,744
18.	Ship owners' catalogues	2,27	0,901
19.	Electronic chat rooms, groups and soft wares (skype, yahoo etc.)	2,26	0,566
20.	Top management	2,23	0,733
21.	Shipping freight indices (ISTFIX, BDI, Clarkson etc.)	2,16	1,060
22.	Maritime business news (Deniz Haber etc.)	2,12	0,567
23.	Other colleagues from different charterers	2,11	0,684
24.	Social networking websites (Facebook, LinkedIn and Tweeter etc.)	2,05	0,730
25.	Ship owners' advertisements	1,73	1,027
26.	Outside consultants (Clarkson etc.)	1,66	0,764
27.	Other information sources	1,51	1,011
28.	Colleagues from charterer's organization	1,07	0,390

(*) 5-point scale, 1: Not at all, 5: Always,

"Word of Mouth" is an important information source that charterers and ship brokers can acquire unofficial preliminary, which gives competitive edge to the broker and charterer. Some information is not published or is published later or is spread only by word of mouth much later. The companies using "word of mouth" as source of information mostly consider themselves have advantageous over their competitors [24]. The telephone conversation widely used in all phases of a chartering process include word of mouth information as its characteristics make it very suitable for the direct, real-time, interactive, personal communication that is needed to support negotiations. However, new digital technologies push ship brokers to use more secure ways. They can send a secure email with digital signature which does not let anyone to impose copying or altering any messages. Hence, some of the ship brokers intend to use emails rather than talking on phone.

Respondents rated "maritime traffic tracking web sites" such as marine traffic, AIS reporter etc. very high. Thanks to the fact that the internet of things with industry 4.0 provides digitalization in shipping service and allows users to acquire information when needed. These internet platforms gather data of the vessels in a raw format from coastal stations interpret them to final data, store them in cloud storage for users and then spread the big data by their usage. Respondents might believe that this kind of information source is more objective and unbiased without any delay. Charters desire to follow the position of vessels to perform their operations by using internet platforms.

Respondents also rated "in-house brokers" as one of the most frequently used information source. Negotiations for dry cargo vessels are far more complex than those concerning other types of ships, as there are many terms and conditions to the negotiate. Hence, charterers might see in-house ship brokers diligent since they could place considerable trust and it could be better to employ this kind of ship brokers to keep the business safe. This kind of ship brokers try to improve information quality by eliminating manipulated information from ship owners. Therefore, there is a stage when the quality of information becomes more important than the quantity and it is the aim to improve the quality of their information networks. Competitive brokers may not obtain the same information as a dedicated broker [2]. The rest of the information sources were rated less than mean value of 3.00 which means that they are less frequently used as information sources by charterers.

4.3. ANOVA Analysis

Differences in the usage of the information sources in terms of organization size, degree of centralization and respondents' experience were explored with the One-Way ANOVA analysis. Significant differences which were observed between the groups in the usage of information source variables were presented in tables. To better explain the results obtained from the variance analysis, Post Hoc (Tukey-HSD) test was also conducted.

Table 5 shows that there are significant differences between the groups of the organization size in the usage frequency of information source variables which are fairs and exhibitions, business meetings, competitive ship brokers, ship owners' web site and ship owner's advertisement. In the table the variables having marked with significance value less than 0.05 demonstrate the significant differences between the small, medium and large scale companies in the usage of information sources. These findings support the study of Moriarty and Spekman [9]. Their study founded that smaller companies devote themselves so much more than medium and large scale companies in the usage of impersonal commercial information sources like seller's advertisements and websites, compared to medium scale companies who are likely to use personal commercial information sources.

Post Hoc (Tukey-HSD) test indicates the following significant differences between the groups in terms of company sizes in the usage of information sources in Table 6.

Table 5: One-Way ANOVA Analysis According to Organization Sizes

		Sum of Squares	df	Mean Square	f	Sig.
Fairs and exhibitions	Between Groups	4,011	2	2,006	3,830	0,024*
	Within Groups	72,258	138	0,524		
	Total	76,270	140			
Business meetings	Between Groups	5,046	2	2,523	4,037	0,020*
	Within Groups	86,245	138	0,625		
	Total	91,291	140			
Competitive Ship Brokers	Between Groups	8,166	2	4,083	3,601	0,030*
	Within Groups	156,444	138	1,134		
	Total	164,610	140			
Ship owners' web site	Between Groups	4,599	2	2,300	3,111	0,048*
	Within Groups	102,011	138	0,739		
	Total	106,610	140			
Ship owners' advertisements	Between Groups	7,457	2	3,729	3,667	0,028*
	Within Groups	140,302	138	1,017		
	Total	147,759	140			

Table 6: Post Hoc Test Results According to Organization Sizes

Information Sources	Groups	Mean Score	SD	Sig.	Findings
Fairs and Exhibitions	Group 1	2,28	0,784	0,990	
	Group 2	2,58	0,613	0,027*	

	Group 3	2,19	0,764	0,027*	The mean score of Group 2 (medium sized companies, M= 2.58, SD=0.613) is significantly different from Group 3 (large companies, M=2.19, SD=0.764) in terms of usage of this information source.
Business meetings	Group 1	2,62	0,805	0,049*	The mean score of Group 2 (medium sized companies, M= 3,00, SD=0.652) is significantly different from Group 3 (large companies, M=2.58, SD=0.906) in terms of usage of this information source.
	Group 2	3,00	0,652	0,034*	
	Group 3	2,58	0,906	0,034*	
Competitive ship brokers	Group 1	2,64	1,005	0,023*	The mean score of Group 3 (large companies, M= 3.23, SD=1.212) is significantly different from Group 1 (small sized companies, M=2.64, SD=1.005) in terms of usage of this information source.
	Group 2	2,88	0,981	0,520	
	Group 3	3,23	1,212	0,023*	
Ship owners' web site	Group 1	3,14	1,010	0,049*	The mean score of Group 1 (small sized companies, M= 3,14, SD=1.010) is significantly different from Group 2 (medium sized companies, M=2.73, SD=0.893 in terms of usage of this information source.
	Group 2	2,73	0,893	0,049*	
	Group 3	2,81	0,588	0,179	
Ship owners' advertisements	Group 1	2,04	1,177	0,041*	The mean score of Group 1 (small sized companies, M= 2.04, SD=1.177) is significantly different from Group 2 (medium sized companies, M=1.54, SD=0.874) in terms of usage of this information source.
	Group 2	1,54	0,874	0,041*	
	Group 3	1,58	0,932	0,077	

ANOVA analysis regarding the centralization of chartering decisions shows that there is significant differences between groups according to the degree of centralization (Group 1: Centralized, Group 2: Decentralized, and Group 3: Mixed) in ship chartering decisions (see Table 7) in following information sources; social sharing networks, trade unions, business news, ship owners' advertisements, ship agents, ship owners' catalogues and top management.

Table 7: One-Way ANOVA Analysis According to Centralization in Chartering Decisions

		Sum of Squares	df	Mean Square	f	Sig.
Social sharing networks	Between Groups	5,201	2	2,600	5,167	0,007*
	Within Groups	69,452	138	0,503		
	Total	74,652	140			
Trade unions	Between Groups	5,949	2	2,975	5,738	0,004*
	Within Groups	71,540	138	0,518		
	Total	77,489	140			
Maritime Business news	Between Groups	4,824	2	2,412	8,295	0,000*
	Within Groups	40,126	138	0,291		
	Total	44,950	140			
Ship owners' advertisements	Between Groups	9,579	2	4,790	4,783	0,010*
	Within Groups	138,180	138	1,001		
	Total	147,759	140			
Ship agents	Between Groups	7,858	2	3,929	5,946	0,003*
	Within Groups	91,178	138	0,661		
	Total	99,035	140			
Ship owners' catalogues	Between Groups	6,123	2	3,061	3,925	0,022*
	Within Groups	107,636	138	0,780		
	Total	113,759	140			
Top management	Between Groups	1,008	2	0,504	3,430	0,035*
	Within Groups	20,282	138	0,147		
	Total	21,291	140			

Post Hoc (Tukey-HSD) test reveals the following significant differences between the groups in terms of centralization in the usage of information sources (see Table 8).

Table 8: Post Hoc Test Results for Degree of Centralization in Ship Chartering Decisions

Information Sources	Groups	Mean Score	SD	Sig.	Findings
Social sharing networks	Group 1	2,16	0,681	0,029*	The mean score of Group 1 (Centralized, M= 2.16, SD=0.681) is significantly different from Group 2 (Decentralized, M=1.74, SD=0.752) in terms of usage of this information source.
	Group 2	1,74	0,752	0,029*	
	Group 3	1,69	0,855	0,066	
Trade unions	Group 1	2,30	0,664	0,028*	The mean score of Group 3 (Mixed, M= 2.85, SD=0.987) is significantly different from both Group 1 (Centralized, M=2.30, SD=0.664) and Group 2 (Decentralized, M=2.00, SD=0.798) in terms of usage of this information source.
	Group 2	2,00	0,798	0,028*	
	Group 3	2,85	0,987	0,003*	
Maritime Business news	Group 1	2,23	0,524	0,004*	The mean score of Group 1 (Centralized, M= 2.23, SD=0.524) is significantly different from both Group 2 (Decentralized, M=1.83, SD=0.576) and Group 3 (Mixed, M=1.77, SD=0.599) in terms of usage of this information source.
	Group 2	1,83	0,576	0,004*	
	Group 3	1,77	0,599	0,012*	
Ship owners' advertisements	Group 1	1,63	0,933	0,007*	The mean score of Group 3 (Mixed, M= 2.54, SD=1.330) is significantly different from both Group 1 (Centralized, M=1.63, SD=0.933) and Group 2 (Decentralized, M=1.74, SD=1.096) in terms of usage of this information source.
	Group 2	1,74	1,096	0,007*	
	Group 3	2,54	1,330	0,008*	
Ship agents	Group 1	2,68	0,753	0,004*	The mean score of Group 3 (Mixed, M= 3.46, SD=1.127) is significantly different from both Group 1 (Centralized, M=2.68, SD=0.753) in terms of usage of this information source.
	Group 2	2,96	0,878	0,295	
	Group 3	3,46	1,127	0,004*	
Ship owners' catalogues	Group 1	2,20	0,837	0,017*	The mean score of Group 3 (Mixed, M= 2.92, SD=0.954) is significantly different from both Group 1 (Centralized, M=2.20, SD=0.837) in terms of usage of this information source.
	Group 2	2,22	1,043	0,996	
	Group 3	2,92	0,954	0,017*	
Top management	Group 1	1,04	0,308	0,034*	The mean score of Group 2 (Decentralized, M= 1.26, SD=0.689) is significantly different from both Group 1 (Centralized, M=1.04, SD=0.308) in terms of usage of this information source.
	Group 2	1,26	0,689	0,034*	
	Group 3	1,00	0,000	0,939	

Similar to the findings of [25], the degree of centralization of the buying process influences the use of personal, commercial and media information sources (social sharing networks, maritime business news, ship agents, ship owner's advertisements and catalogues). For example, chartering managers can avoid using social sharing networks as an information source rather than to use the other information sources in centralized organizations in contrast to decentralized organizations which support chartering manager to get information or share it on social networks. In highly centralized organizations, key decision makers are limited and buying decisions have been taken individually. The organizations characterized by less centralization, which have wider array of members and constituencies, usually take group buying decisions. Top management in such organization is likely to be the role of supervisory as an information source during the chartering process. It is seen that Group 3 has a great impact in the usage of information source (such as trade union) than other groups. Trade union is expected to provide unbiased and more objective information for such companies.

Table 9 shows that there is a significant difference according to the experience of the respondents (Group 1: 0-5 years, Group 2: 6-11 years, Group 3: 12-17 years and Group 4: more than 18 years) in the usage of information source variables including internal records, personal experiences and marine traffic tracking websites.

Table 9: One-Way ANOVA Analysis for Respondents' Experience

		Sum of Squares	df	Mean Square	f	Sig.
Business Emails	Between Groups	4,304	3	1,435	2,849	0,040*
	Within Groups	68,973	137	0,503		
	Total	73,277	140			
Maritime trade publications	Between Groups	16,279	3	5,426	6,253	0,001*
	Within Groups	118,885	137	0,868		
	Total	135,163	140			
Business meetings	Between Groups	6,779	3	2,260	3,663	0,014*
	Within Groups	84,511	137	0,617		
	Total	91,291	140			
In-House ship brokers	Between Groups	18,766	3	6,255	3,738	0,013*
	Within Groups	229,234	137	1,673		
	Total	248,000	140			
Ship owners' web site	Between Groups	8,760	3	2,920	4,088	0,008*
	Within Groups	97,850	137	0,714		
	Total	106,610	140			
Ship owners' advertisements	Between Groups	18,201	3	6,067	6,416	0,000*
	Within Groups	129,558	137	0,946		
	Total	147,759	140			
Outside consultants	Between Groups	5,238	3	1,746	3,130	0,028*
	Within Groups	76,422	137	0,558		
	Total	81,660	140			
Other colleagues from different charterers	Between Groups	4,010	3	1,337	2,983	0,034*
	Within Groups	61,394	137	0,448		
	Total	65,404	140			
Ship chartering internet portals	Between Groups	11,520	3	3,840	3,491	0,017*
	Within Groups	150,692	137	1,100		
	Total	162,213	140			
Ship owners' catalogues	Between Groups	13,508	3	4,503	6,153	0,001*
	Within Groups	100,251	137	0,732		
	Total	113,759	140			

After finding out the significant differences between the groups, the Post-Hoc (Tukey-HSD) test was conducted in order to examine where these differences are (see Table 10).

Table 10: Post Hoc (Tukey-HSD) Test Results According to the Respondents' Experience

Information Sources	Groups	Mean Score	SD	Sig.	Findings
Business Emails	Group 1	4,120	0,707	0,040*	The mean score of Group 3(M=4.46, SD=0.811) is significantly different from Group 1 (M=4.12, SD=0.707 in terms of usage of this information source.
	Group 2	4,460	0,519	0,371	
	Group 3	4,460	0,811	0,040*	
	Group 4	4,750	0,500	0,310	
Maritime trade publications	Group 1	2,360	0,900	0,001*	

	Group 2	2,000	0,707	0,002	The mean score of Group 3 (M= 3.15, SD=1.156) is significantly different from Group 1 (M=2.36, SD=0.900) and Group 2 (M=2.00, SD=0.707) in terms of usage of this information source.
	Group 3	3,150	1,156	0,001*	
	Group 4	2,500	0,577	0,991	
Business meetings	Group 1	2,880	0,790	0,026*	The mean score of Group 1 (M= 2.88, SD=0.790) is significantly different from Group 3 (M=2.38, SD=0.752) in terms of usage of this information source.
	Group 2	2,380	0,870	0,150	
	Group 3	2,380	0,752	0,026*	
	Group 4	2,750	0,500	0,989	
In-House ship brokers	Group 1	2,780	1,381	0,029*	The mean score of Group 3 (M=3.58, SD=1,137) is significantly different from Group 1 (M=2.78, SD=1.381) in terms of usage of this information source.
	Group 2	3,620	0,961	0,128	
	Group 3	3,580	1,137	0,029*	
	Group 4	2,750	0,500	0,634	
Ship owners' web site	Group 1	2,780	0,844	0,040*	The mean score of Group 3 (M= 3.42, SD=0.902) is significantly different from Group 1 (M=2.78, SD=0.844) in terms of usage of this information source.
	Group 2	2,850	0,801	0,992	
	Group 3	3,420	0,902	0,040*	
	Group 4	2,750	0,500	1,000	
Ship owners' advertisements	Group 1	1,500	0,900	0,005*	The mean score of Group 3 (M=2.23, SD=1.032) is significantly different from Group 1 (M=1.50, SD=0.900) in terms of usage of this information source.
	Group 2	2,150	1,345	0,108	
	Group 3	2,230	1,032	0,005*	
	Group 4	2,750	0,957	0,061	
Outside consultants	Group 1	1,600	0,756	0,016*	The mean score of Group 4 (M= 2.75, SD=0.500) is significantly different from Group 1 (M=1.60, SD=0.756) in terms of usage of this information source.
	Group 2	1,770	0,725	0,873	
	Group 3	1,650	0,745	0,989	
	Group 4	2,750	0,500	0,016*	
Other colleagues from different charterers	Group 1	2,040	0,702	0,933	The mean score of Group 4 (M= 2.75, SD=0.500) is significantly different from Group 1 (M=2.04, SD=0.702) in terms of usage of this information source.
	Group 2	1,920	0,641	0,014*	
	Group 3	2,350	0,562	0,169	
	Group 4	2,750	0,500	0,014*	
Ship chartering internet portals	Group 1	2,570	1,065	0,026*	The mean score of Group 3 (M=3.23, SD=0.992) is significantly different from Group 1 (M=2.57, SD=1.065) in terms of usage of this information source.
	Group 2	2,620	0,961	0,999	
	Group 3	3,230	0,992	0,026*	
	Group 4	3,500	1,291	0,309	
Ship owners' catalogues	Group 1	2,080	0,755	0,015*	The mean score of Group 4 (M= 3.25, SD=0.500) is significantly different from Group 1 (M=2.08, SD=0.755) and Group 2 (M=2.85, SD=0.899) in terms of usage of this information source.
	Group 2	2,850	0,899	0,015*	
	Group 3	2,540	1,174	0,078	
	Group 4	3,250	0,500	0,041*	

According to results of the Post-Hoc test, the mean scores of commercial information sources (business emails, marine trade publications, ship owner's websites, ship owners' advertisements, ship chartering internet portals, ship owners' catalogues, in-house ship brokers) and non-commercial information source (outside consultants, other colleagues from different charterers) are significantly higher for experienced respondents. On the other hand, the findings demonstrate that mean scores of commercial information sources (business meetings) are also significantly higher for less experienced respondents.

5. CONCLUSION AND DISCUSSION

Information sources used in chartering decisions is very important due to the complex nature the service. This study investigated the different types of information sources used by charterers in dry bulk shipping within B2B framework. Moreover, the study attempted to identify the information sources used by charterers located in Turkey. The findings of the study showed that personal experience is the most frequently used information source in chartering process. This is not surprising because the intangible nature of business to business services makes it difficult to evaluate them prior to purchase. In that sense, our findings support Deeter-Schmelz [16] and Kohli [26] who also found that the personal experience is the top-rated information source because it offers informational value without an added ''sales pitch''. Previously Kohli [26] founded that personal information sources like personal experiences have a high degree of credibility and hence help reduce the perceived risk. Thus, although not measured, through an indirect relationship, ship brokers can reduce the risks associated with ship-owners via personal experiences. Therefore, it is of great importance that ship brokers can produce a charterer's satisfaction at the end of an assignment.

Business mails were also rated as frequently used information sources in shipping industry after the personal experiences which also supports previous literature stating that more technologically oriented small players find e-mail an inexpensive way to increase their circulation list [2]. Usually ship brokers have direct access to all emails and they use emails in such activities as gathering appropriate vessels for their jobs, searching for new ship owners, negotiating with ship owners and providing competitive information from market. However, the larger players discarded those e-mails as they were not interested in doing business with those agents.

Another important information source, which is ranked third by respondents in terms of the usage frequency, is exclusive ship brokers. Charterer may grant a broker exclusive representation of their interests, which means that any agreement concerning the charterer's cargo will go through that broker [2]. It is accepted that exclusive broker is to provide more objective and unbiased information in defending and promoting their clients' interests.

The study also founded that there are significant differences among organizational characteristics in using some information sources. For example, small, medium and large sizes of companies have significant differences in the usage frequency of fairs and exhibitions, business meetings, competitive ship brokers, ship owners' web site and ship owner's advertisement.

Apart from exclusive ship brokers, word of mouth communication is also another information source mostly used by charterers when they check the reliability of the ship owner which supports previous findings emphasizing an indirect effect of word of mouth on reputation of service providers and has a direct effect on customer satisfaction [27]. Some information may not be published, or may be published later, or may be spread only by word of mouth. Access to this information is critical, as it gives a competitive edge for the charterers.

With development of the information and communication technologies, the internet of the things becomes a reality. The maritime sector is likely to be no exception. The key element is the monitoring of every aspect of vessel's operations. Every vessel has a unique identifier to connect with an internet. All charterers can track the operations of the vessels (positions, speed, cargo etc.) from internet platforms like "maritime traffic tracking web sites". This becomes more important when charterer wants to reach reliable information without any manipulation from ship-owner.

Sample of this study consist of charterers in dry cargo freight market. Further researches can be carried out in tanker or other freight markets. In addition to this, apart from the charterers, ship broking companies can be studied in terms of information sources in chartering since they are experts in providing such a professional service.

Although there is large number of studies in different areas of consumer services, there are limited studies on the information sources used in business to business services like ship chartering services. This study is, to our knowledge, a pioneer which associates the usage frequency of information sources in chartering industry. This study covered various information sources used in chartering decisions. But there is a growing need to research the newly used information sources due to the enormous changes in digital and communication technologies.

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PLANNING OF SHUTTLE BUS IN GAZIANTEP UNIVERSITY CAMPUS: A GIS APPROACH

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Abstract−*This paper conducts a feasibility study to implement the shuttle bus transportation in Gaziantep University. Since there is a high growth rate of development and population in the university, there are many people traveling inside campus, mostly traveling by private vehicles. Hence, it encounters a huge amount of traffic travelling inside campus that it causes many problems of traffic congestion, traffic accident as well as air and noise pollution. To lessen these problems, a campus shuttle bus system is investigated in this study. To do so, a three step methodology is followed. Firstly, each demand point in campus is determined. Secondly, campus network with demand points and roads are processed in GIS software. Finally, different shuttle networks are analyzed using GIS network tools. This paper demonstrates that the proposed shuttle bus routes converge to the efficient solution, which is validated by the GIS software.*

Keywords− *Geographic information systems, Network planning, Shuttle bus planning, University campus.*

INTRODUCTION

The Campus Shuttles provide free transportation around campus for faculty/staff, students, and visitors in almost every university. This service becomes very important in especially widespread universities. University of Gaziantep (including a large hospital) is the largest and the most crowded university in southeastern Turkey. It is getting more crowded by the addition of Syrian students.

The shuttle in University of Gaziantep operates from 8 a.m. until 5 p.m. on weekdays. It does not operate on weekends or holidays. But it remains idle mostly, because of its travel time and complicated & ineffective route. Also an ineffective shuttle route affects managing and maintaining campus traffic. In this case, people travel by their own vehicles, bicycles, and motorcycles. Hence, it encounters a huge amount of traffic travelling inside campus that it causes many problems of traffic congestion, traffic accident as well as air and noise pollution. The noise and air pollution directly affect the health of students and quietness of the classrooms. All costs associated with campus transportation services are also forming a minus economically. Thus, the shuttle bus route should be optimized to effectively.

When the literature is analyzed, we reach many studies related to shuttle/bus routing problems. Bowerman et al. [1] introduces a multi-objective approach to model the urban school bus routing problem and describes an algorithm for generating a solution to this problem. The proposed technique first groups students into clusters using a multi-objective districting algorithm and then generates a school bus route and the bus stops for each cluster using a combination of a set covering algorithm and a traveling salesman problem algorithm. Numerical results show that decision makers can generate a set of school bus routes that are both economically efficient and politically acceptable to the public by using this model. Braca [2] investigate various issues related to the development of a computerized system to help route and schedule school buses throughout the five boroughs of New York City. It analyzes various aspects of the problem including the generation of routes in the Borough of Manhattan and provides a solution requiring far fewer buses than are currently in use. Peng and Huang [3] present a distributed Web-based transit information system that integrates Internet GIS into the system design so that the user interface is map-based. Ngamchai [4] propose a new model showing how genetic algorithms can be manipulated to help optimize bus transit routing design, incorporating unique service frequency settings for each route. In this example, seven proposed genetic operators are designed for this specific problem to facilitate the search within a reasonable amount of time. The model is applied on a benchmark network to test its efficiency, and it is shown that the proposed model is more efficient than the binary-coded genetic algorithm benchmark. Jerby and Ceder [5] propose automated methods for designing circulated shuttle bus routes. The

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optimal model and its heuristic alternative are compared in different scenarios on a small real-life road network. It was shown that the heuristic algorithm indeed provides good results. Park and Kim [6] study on a review paper that aims to provide a comprehensive review of the school bus routing problem. In this paper, the various assumptions, constraints, and solution methods used in the literature are summarized. A list of issues requiring further research is also presented. Ledesma and Gonzalez [7] introduces a generalization of the vehicle routing problem called the multi-vehicle traveling purchaser problem, modeling a family of routing problems combining stop selection and bus route generation. A cutting plane algorithm is implemented and tested on a large family of symmetric and asymmetric instances derived from randomly generated problems, showing the usefulness of the proposed valid inequalities. Park et al. [8] aims to develop a mixed load algorithm for the school bus routing problem and measure its effects on the number of required vehicles. When mixed load is allowed, students of different schools can get on the same bus at the same time. In this paper, they present a new mixed load improvement algorithm and compare it with the only existing algorithm from the literature. The proposed algorithm outperforms the existing algorithm on the benchmark problem instances. Johnson et al. [9] examine the 2014 Special Olympics USA Games which is hosted in New Jersey. More than 4,000 athletes competed in 16 sports hosted across 10 locations within a 30-mile radius. They designed timely, convenient, easy-to-follow, and reliable bus routes and schedules to assist thousands of people with intellectual disabilities and their coaches to attend games and special events. Ellegood et al. [10] provides a general strategic analysis using continuous approximation models to assess the conditions under which mixed loading is likely to be beneficial. They also present a case study for a semi-rural Missouri school district to illustrate the application of the models in practice. Results show that mixed load routing is more beneficial for larger districts. Lima et al. [11] address a capacitated rural school bus routing problem featuring mixed loads, a heterogeneous fleet, and the same school starting time. Five meta-heuristic based algorithms are devised to solve the problem, and evaluated on solving four different datasets, one of them being based on a real case from Brazil.

In this paper, the shuttle bus routing problem in University of Gaziantep is taken into account. To solve the problem, a three step methodology is followed. Firstly, each demand point in campus is determined. Secondly, campus network with demand points and roads are processed in GIS software. ESRI ArcGIS 10.2 software is used as a GIS. Finally, different shuttle networks are analyzed using GIS network tools. Introduction section defines the problem and gives brief information about related literature. Analysis section gives details about our problem, application area and GIS analysis, while conclusion section summarizes the study respectively.

ANALYSIS

The objective of this study is to solve shuttle/bus routing system in Gaziantep University with GIS. In this part, six sub-sections are handled to give more information about application and GIS.

Geographic Information System (GIS)

GIS is a group of procedures that provide data input, storage and retrieval, mapping and spatial analysis for both spatial and attribute data to support the decision-making activities of the organization. In this sense, GIS can support logistic and marketing managers to evaluate placement options [12]. Currently, the use of Geographic Information Systems (GIS) is widespread and used in many applications such as decision support systems [13]. There are two kinds of data models used in GIS: raster and vector. The raster data model divides the study area into a regular grid of cells, and each cell has a single value that corresponds to a characteristic or feature. The vector data model can represent the feature by using points, lines, and areas [14-15].

Application Area

In this study shuttle/bus routing problem of university of Gaziantep is handled. University area is about 1.6 km^2 in southeastern Turkey and shown in Figure 1.

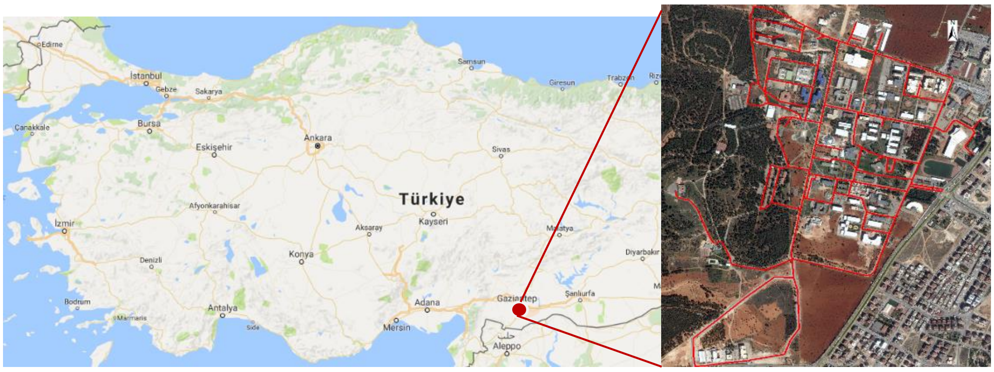

Figure 1. Study Area

Demand Points

Demand points are the places where students/personnel and buses meet each other. These locations are selected and vectorized via GIS software. Selected demand points and number of the student are shown in Table 1. In this table, number of student column shows the number of demanding students of each stop.

Table 1. Demand Points in University of Gaziantep

No	Name	Number of Student
1	Yolcu Bindirme Duragi	-
2	Rektörlük Duragi	5
3	Kongre Merkezi	10
4	Ögrenci Yemekhane	20
5	Meslek Yüksek Okulu	5
6	Tip Fakültesi	20
7	Personel Yemekhane	20
8	Fen Edebiyat	10
9	Cami	3
10	Bilgi Islem	2
11	Yurtlar	16
12	Hobi Bahçesi	3
13	Idare	5
14	Beden Egitimi	3
15	Lojmanlar	10
16	Havuz	2
17	Seyir Terasi	4
18	Teknokent	10
19	Egitim Fakültesi	20
20	Gida Mühendisligi	10
21	Mühendislik F. Dekanlik	2
22	IIBF	20

Data

In this study, two kinds of GIS data, demand points as a point layer and roads as a line layer, are used. Road data is also used as network data set in GIS environment. For this reason, at first, university road map is collected as line data. Then, line-shape road layer is used to generate network between all bus stops. Figure 2 shows the road network of Gaziantep University and demand points.

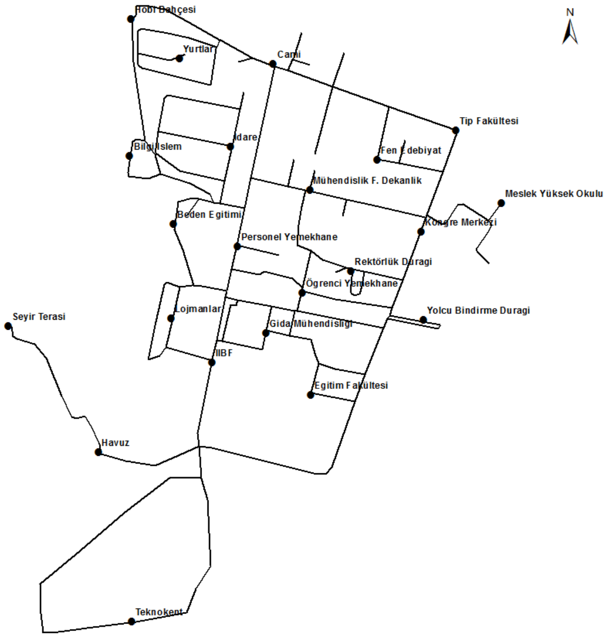

Figure 2. Road Network and Demand Points

Route Generation

In route generation, following rules are applied.

- Maximum capacity of the bus is 40 personnel,
- Maximum number of bus is 6,
- Speed limit is 30 km/h.
- Duration time of each demand point is 0.2 minutes.

Following these rules, three route analyses are performed by changing maximum travel time criteria. In the first analysis, a maximum travel time of each bus is selected as 7.5 minutes. Generated routes of each bus are shown in Figure 3 and detailed information is given in Table 2.

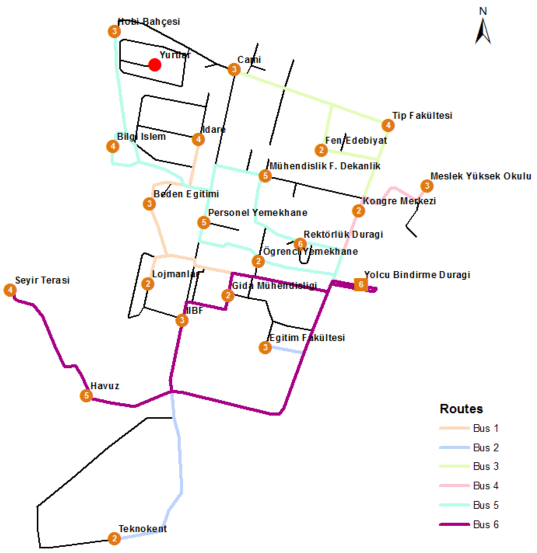

Figure 3. Route Analysis of 7.5-minute Travel Time

Table 2. Detailed Information about 7.5-minute Travel Time

Bus No	Capacity	Students Transported	Stops	Duration (min.)	Distance (m.)
1	40	38	Lojmanlar Beden Egitimi İdare Personel Yemekhane	6.1	2646
2	40	30	Teknokent Egitim Fakultesi	7.4	3548
3	40	33	Fen Edebiyat Cami Tıp Fakultesi	5.7	2546
4	40	15	Kongre Merkezi Meslek Yuksek Okulu	3.3	1485
5	40	32	Yemekhane Hobi Bahçesi Bilgi İşlem Muh.Fak.Dekanlık Rektorluk	7.4	3445
6	40	36	Gıda Muh IIBF Seyir Terası Havuz	7.5	3623
		TOTAL		**37.55**	**17365**

In this analysis, one of the demand points, Yurtlar, is not reachable in selected criteria and total travel time is 35.55 minutes and length is 17365 meters long. In the second analysis, a maximum travel time of each bus is selected as 10 minutes. Generated routes of each bus are shown in Figure 4 and detailed information is given in Table 3.

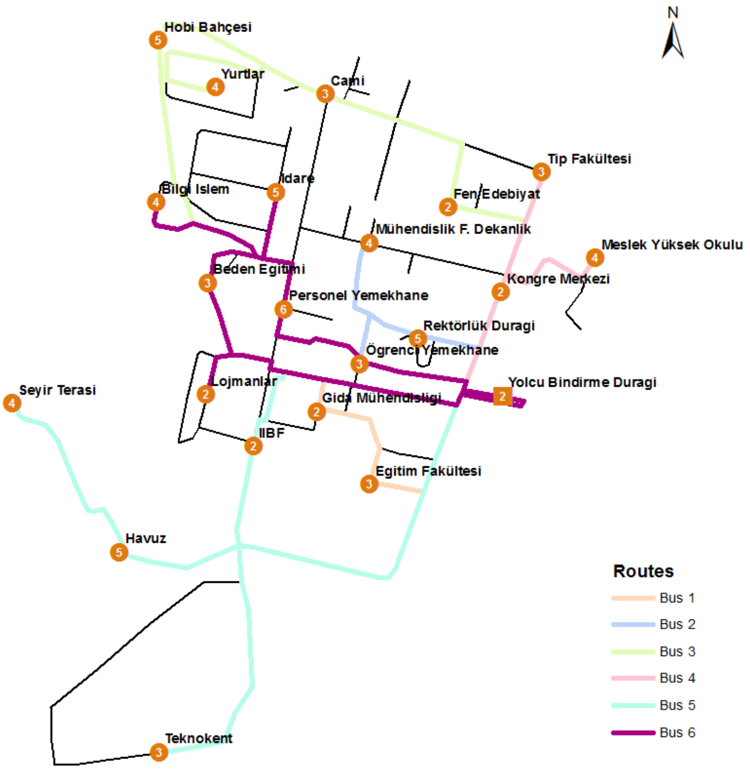

Figure 4. Route Analysis of 10-minute Travel Time

Table 3. Detailed Information about 10-minute Travel Time

Bus No	Capacity	Students Transported	Stops	Duration (min.)	Distance (m.)
1	40	30	Gıda Muh Egitim Fakultesi	3.2	1418
2	40	27	Yemekhane Muh.Fak.Dekanlık Rektorluk	3.7	1551
3	40	32	Fen Edebiyat Cami Yurtlar Hobi Bahçesi	9.2	4184
4	40	35	Kongre Merkezi Tıp Fakultesi Meslek Yuksek Okulu	4.6	2003
5	40	36	IIBF Teknokent Seyir Terası Havuz	10.0	4909
6	40	40	Lojmanlar Beden Egitimi Bilgi İşlem İdare Personel Yemekhane	7.6	3300
		TOTAL		**38.3**	**17365**

In this analysis, all of the demand points are reachable, and total travel time is 38.3 minutes and length is 17365 meters long. In the third analysis, a maximum travel time of each bus is selected as 15 minutes (Figure 5, Table 4).

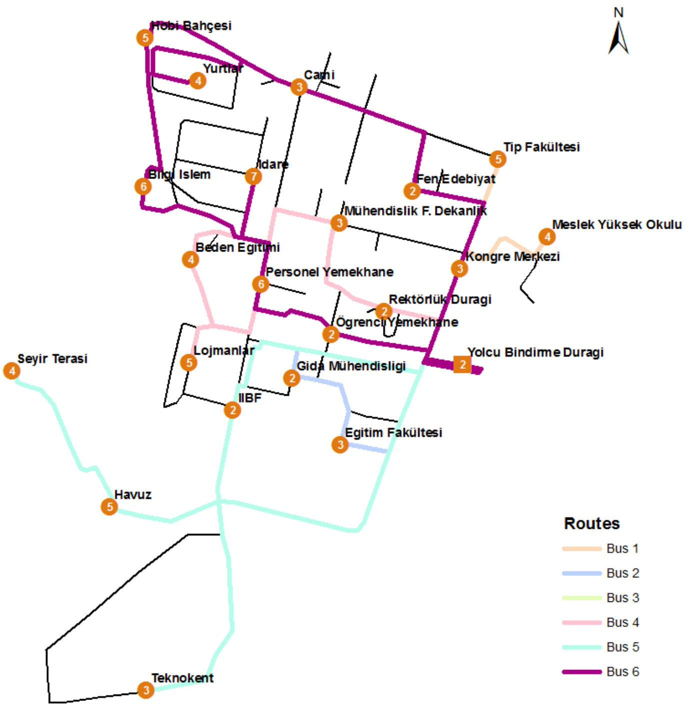

Figure 5. Route Analysis of 15-minute Travel Time

Table 4. Detailed Information about 15-minute Travel Time

Bus No	Capacity	Students Transported	Stops	Duration (min.)	Distance (m.)
1	40	35	Kongre Merkezi Meslek Yuksek Okulu Tıp Fakultesi	4.6	2003
2	40	30	Gıda Muh Egitim Fakultesi	3.2	1418
3	40	20	Yemekhane	2.0	896
4	40	40	Rektorluk Muh.Fak.Dekanlık Beden Egitimi Lojmanlar Personel Yemekhane	6.2	2705
5	40	36	IIBF Teknokent Seyir Terası Havuz	10.6	4909
6	40	39	Fen Edebiyat Cami Yurtlar Hobi Bahçesi Bilgi İşlem İdare	10.5	4632
TOTAL				**35.6**	**16563**

In this analysis, all of the demand points are reachable, and total travel time is 35.6 minutes and length is 16563 meters long. In the last analysis, a maximum travel time of each bus is selected as 20 minutes (Figure 6, Table 5).

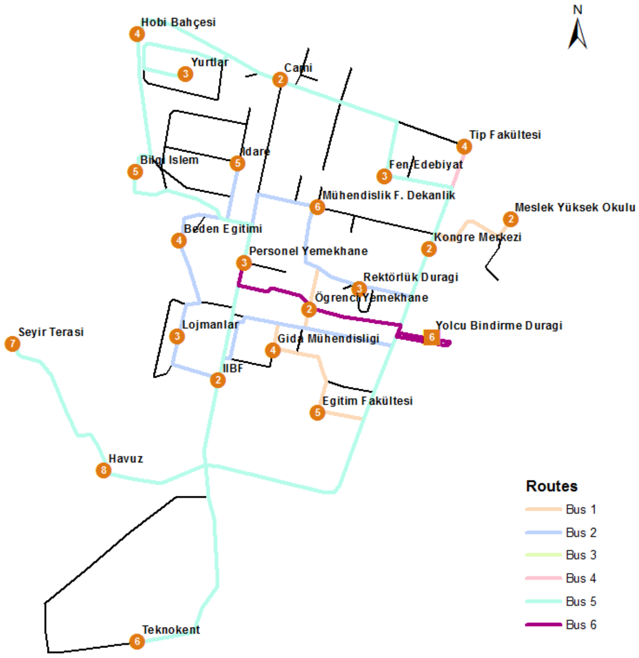

Figure 6. Route Analysis of 20-minute Travel Time

Table 5. Detailed Information about 20-minute Travel Time

Bus No	Capacity	Students Transported	Stops	Duration (min.)	Distance (m.)
1	40	40	Meslek Yuksek Okulu Rektorluk Gıda Muh Egitim Fakultesi	6.1	2655
2	40	40	IIBF Lojmanlar Beden Egitimi İdare Muh.Fak.Dekanlık	6.9	2971
3	40	40	Kongre Merkezi Fen Edebiyat Tıp Fakultesi	4.2	1811
4	40	40	Cami Yurtlar Hobi Bahçesi Bilgi İşlem Teknokent Seyir Terası Havuz	17.4	7980
5	40	40	Yemekhane Personel Yemekhane	3.4	1493
		TOTAL		**38.0**	**17365**

In this analysis, all of the demand points are reachable with five buses, and total travel time is 38 minutes and length is 17365 meters long.

RESULTS AND FINDINGS

These analyses show that all demand points can be reached minimum 10 minutes. If there is no limitation about travel time and capacity, one bus can travel all the bus stops in 26.3 minutes and 11080 meters (Figure 7).

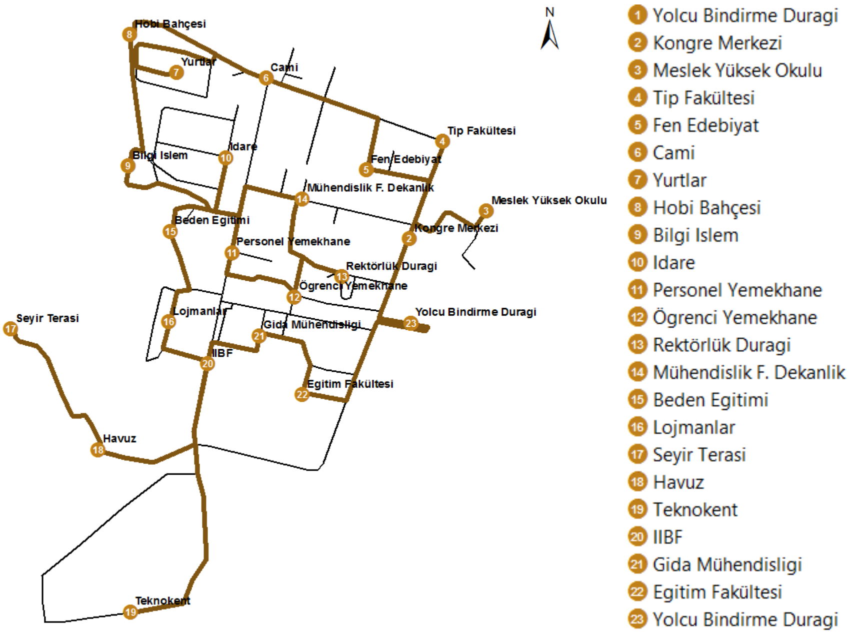

Figure 7. Bus Route with One Bus

CONCLUSION

In this paper, the shuttle or bus routing problem in University of Gaziantep is evaluated in terms of GIS. To do so, road data and bus stops data are collected and transformed to GIS. Then, network data is generated, and bus route analyses are performed with selecting different criteria. In case of, shuttle or bus services will be active, these can be lessened the traffic inside the campus and solved many problems such as air and noise pollution. Analyses results show that all the demand points can be reached minimum 10 minutes with six buses. If travel time is more than 20 minutes, five buses can meet all the demand points with full capacity.

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A CONCEPTUAL FRAMEWORK FOR THE INTERNET OF THINGS AND WAREHOUSE MANAGEMENT SYSTEM INTEGRATION

Yunus Kaymaz[1], Haluk Soyuer[2]

Abstract – *Storage activities, provision of warehouse location, handling of products, and removal of warehouses according to customer demand are important points affecting supply chain performance. The optimal placement of the products in the warehouse provides the advantage of customer satisfaction and cost minimization at the point of responding more quickly to the demands of the customers for the enterprises. Considering the high impact on the total warehouse costs of manual operations in warehouses, both time and cost enterprises prefer various automatic systems. At this point, automated storage and retrieval systems (AS / RS) are important for the supply chain by providing space, time and cost advantages. In this study a case for the integration between the IoT and the warehouse operations was conducted. A conceptual framework for the relationship and the integration of two notions was discussed.*

Keywords – *Internet of Things, Warehouse Management System, Automated Storage and Retrieval Systems*

1. INTRODUCTION

The transformation of 3rd Industrial revolution to the 4th Industrial revolution and its reflections to the both production and service environments reveal that, there is a close relationship between the Industry 4.0, IoT and supply chain activities. In this context, Brettel et al. identified that the 4th industrial revolution have been triggered by the internet. Kagerman et al. (2013) argued that the Industry 4.0 includes the cyber-physical systems (CPS) furthermore, there is a connection between the CPS and manufacturing and logistics industry. With a holistic view, the Industry 4.0, CPS, Internet of Things (IoT) and IoS (Internet of Services) concepts tells us that not only an increased interaction among human and machine communication both also a machine to machine interaction might be available. In this context, a conceptual framework for the warehouse management systems in the operations of automated storage and retrieval systems (AS/RS) was constructed.

2. THE CONCEPT OF INTERNET OF THINGS

Today we are all surrounded by the enormous data which connects us to the both physical and the cyber world. It can be said that Internet of Things (IoT) connects accessible objects to anyone at any time. Wang and Zhou (2010) stated that IoT connects things through information sensing equipment to exchange information and to communicate in order to recognize, position, trace, monitor and administrate smartly. IoT uses autonomous decisions and embeds intelligence to the system thus it processes object specific information connects the real world to the cyber world (Huang and Li, 2010). The main idea of the connectivity of the things determined by the Radio-Frequency Identification (RFID), tags, sensors, mobile phones, hand held devices etc. which and interaction among them is realized and a cooperation with their neighbors to achive certain objectives (Atzori et al.,2010). Shrouf et al. (2014) specified the characteristics of smart factories under Industry 4.0 speaking of a few of these features, the authors have stated that they need to start the value creation process with large data for the factory, and that the IOT can bring out new services. Apart from these, interconnected supply chains are also characterized by proactive maintenance activities. Figure 1 depicts the system of IoT perception, network and application level.

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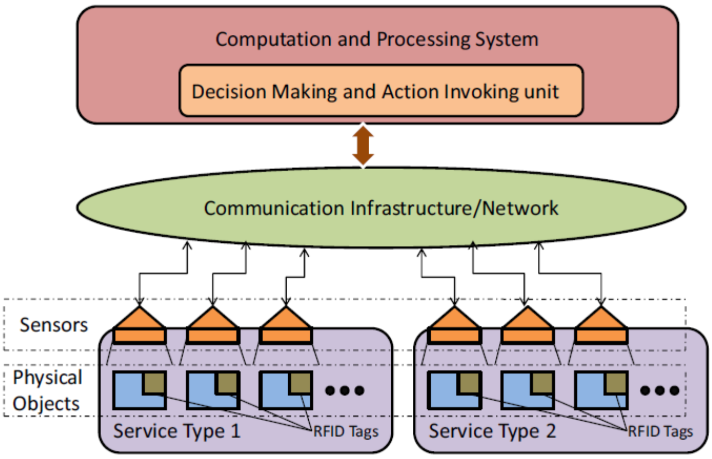

Figure 1: IoT system (Khan et al. 2012)

In the context of supply chain, logistics and warehouse logistics it can be determined that some of the elements in perception, network and application levels can vary. In Figure 2, it can be seen that, there are different levels for the architecture for IoT. Simply, in perception layer, wireless sensors, RFID, beacon and other devices are going to be used to connect and gather related information and data and eventually perceive the environment that surrounds them. Thus, data gathered form the bottom level, in the network layer the relevant information steams through the servers, cloud, and other communication mediums and eventually in the application layer, the relevant data is going to be transformed to information and used in the application level.

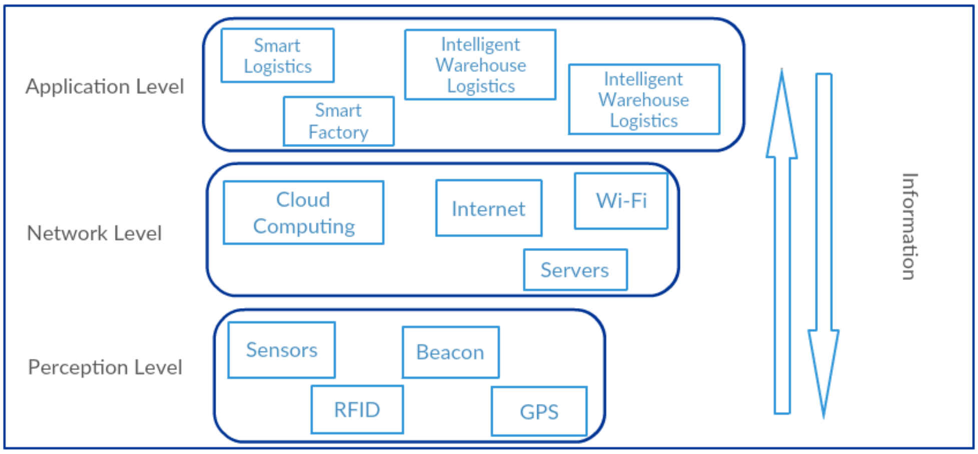

Figure 2: Architecture for IoT

According to Gubbi et al (2013) the IoT concept introduced first in 1999 by Kevin Aston with the context of supply chain and through the time it included healthcare, transport, utilities ec. Furthermore, the authors introduced the elements of IoT as RFID, Wireless Sensor Networks, Addressing Schemes, Data storage and analytics, Visualization. Huang and Li (2010) argued about the semantic meaning of the IoT and states the differential features as: Things information, Universal Identification/Electronic Product Code, RFID tag and RFID reader.

3. WAREHOUSE MANAGEMENT SYSTEM

Warehouses are one of the most critical elements for the whole supply chain and also for logistics activities. Warehouses not only utilized by the manufacturers but also by exporters-importers, retailers and other related parties. Furthermore, warehouses include various operations and in order to arrange the arrival and the handling of goods with an efficient manner. Shiau and Lee (2010) indicated that a warehouse management sstem (WMS) is a computer application with a database in order to improve efficiency of warehouse. Poon et al. (2009), highlighted that the operations in the warehouses affect the operations costs and WMSs are used to collect data to solve the material handling and other related problems. Furthermore, the authors also state that because current WMSs contain no real time data so they are incapable of providing accurate operations information. According to Gu et al. (2007), the increasing trend of the information technologies enables real time control, high level of automation and increased communication through parties in supply chain via radio frequency, barcode and WMSs. Apak et al. (2016) listed some of the advantages of the WMSs as reduction in inventory ad labor cost, increased customer service and storage capacity and increased inventory accuracy. In their studies, Xiaoguang and Wei (2008) introduced a novel perspective to the current WMSs with RFID and wireless sensor networks in order to eliminate the incapability such as poor communication and inflexible network structures.

3.1 AUTOMATED STORAGE AND RETRIEVAL SYSTEMS

Since 1950s, Automated Storage and Retrieval Systems (AS/RS) have been used in distribution and manufacturing environment with the aim of reduction the handling cost, increasing storage capability and to increase customer service. . Considering that storage operations are done with automatic and manual systems, the manual processes constitutes the %55 of the total warehousing costs (Coyle et al. 1996; Tompkins et al. 1996). Soyaslan et al. (2012) stated that businesses in today's industries need to maintain their competitiveness in order to maintain their sustainability and survive, and AS/RSs are an important place in the supply chain by providing space and time advantages. As a result of integration of storage technologies, automation technologies and logistics technologies, AS/RSs have emerged and these systems are being used intensely in the logistics industry. The greatest advantage of AS/RSs might be listed as high efficiency in storage area, efficient use of storage area, storage and transport of products without damage (Li et al., 2009). AS/RSs are sensitive systems designed to place items on the shelves and bring them back very quickly on demand. It is generally preferred for storage of large volumes and heavy loads in order to increase storage density due to the inadequate storage area. Warehouses become a crucial element than ever in the supply chain system. One of the most basic reasons for this is the increase in the quantity and variety of products and the necessity of applying the necessary value added operations. In the Figure 3, a typical AS/RS can be seen. In this system the basic equipment are racks, storage modules, pick up/drop off stations, storage and retrieval machine, main conveyor, shuttles.

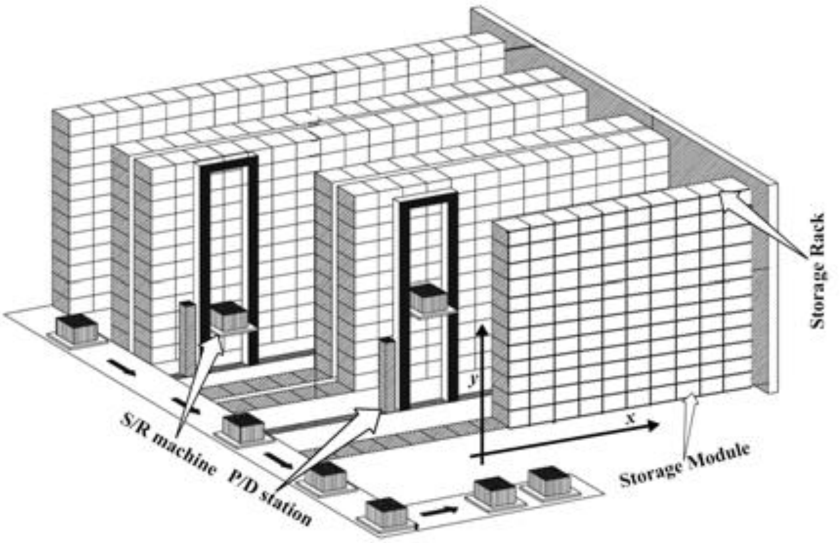

Figure 3: A typical AS/RS (Xing et al., 2010)

In this sense, it is vital to increase the supply chain performance through increasing warehouse performance by reducing the handling time within this system and reducing the availability time of products for buyers. Accoring to Atmaca and Özgür (2013) the increasing costs, the ever increasing technology and ever changing customer demands affect the warehousing strategies of companies and with this context, storage and retrieval policies of companies have a direct impact on company performance. On the other hand, there are some researches on optimizing the AS/RSs in order to increase the order picking and storing. Bottani et al. (2015) examined the intelligent algorithms for warehouse management and listed the advantages and the disadvantages of genetic algorithm, simulated annealing, neural networks, ant colony, particle swarm optimization models.

3.2 THE IOT AND WMS INTEGRATION

There are various studies which consider the tracking activities of goods and vehicles within the waehoue. rg and Spieker (2008), uses wireless sensor networks in a warehouse to track the transportation activities in a warehouse. The authors use sensors to determine the position of the manually used storage and retrieval of load carries. In another study conducted by Xiaoguang and Wei (2008), a communication framework for and warehouse management system is proposed with the combination of RFID and WSN Technologies. This study also considers the manually operated systems in warehouses. Zhijun et al. (2010) introduced a solution for improving the performance of warehouses by collecting information with sensor nodes, active and passive tags so, vehicles and personnel within the warehouse managed effectively. Juntao and Minbo (2016) described various technologies such as sensors, RFID, GPS, video recognition and stated that in order to use IoT in logistics warehouse management system a good implication of sensing technology, RFID technology and embedded technologies are necessary. In the context of the relationship between IoT and WMS, this study constructed a conceptual framework. The relevant studies above mentioned mostly the use of RFID and in some cases WSNs. However, with the increasing debates about the Industry 4.0, today, not only manufacturing companies but also service companies try apply machine to machine connections. The concept of Industry 4.0 introduced that the cyber-physical systems are able to connect with each other with the help of internet of things, m2m connection and internet of services. Although many researches highlighted the integration of RFID and WSNs to vehicles and manual equipment, it is necessary to underline the connection with the WMSs and AS/RSs. AS/RSs actually works with a connection to a WMSs. In this case, a solid connection and communication between AS/RSs and WMS as well as equipment used to construct such a connection i.e. RFID tags, barcodes, sensors, and beacons. The operations of typical AS/RSs include scanning goods according to required specifications of the width and heights of the racks, sending them to a randomly specified storage module with a crane. However, during the operations there might be breakdowns due to the overtime. Furthermore, in some occasions, some operations need to be prioritized and sequenced firstly or delayed. For such decisions, a proper communication with AS/RS and WMS through a user friendly application was considered for this study.

4. CONCLUSION

The increasing information and communication capabilities the warehouse management systems are going to be able to identify the necessary data and communicate with each other. While using technologies such as barcode, the processes evolved themselves to wireless environment with RFID, WSN, Wide Area Network and beacon technologies. The WMSs together with the relevant information and communication technologies is going to be adopt the intelligent operations, real time communication in order to fulfill the improve handling capacity as well as increasing operational efficiency in warehouse logistics. In this context, concept such as IoT and IoS are going to facilitate the integration and the relationship between M2M communication and data transfer. In this study, a conceptual framework for the integration mentioned above was constructed. A case study with implication of this framework might be useful to detail the future researches.

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MARKETING STRATEGY SELECTION FOR LOGISTICS COMPANIES

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Abstract *– Marketing strategies are very important for a logistics company to be successful. Nowadays, marketing approaches are very customer-focused and products are oriented to satisfy customer needs. Products gain value in order to find new markets and the purpose of marketing is to create an efficient production process. At this point, a logistics company is forced to use correct marketing strategies to differentiate itself from its competitors and to provide the best customer satisfaction. Selecting the right marketing strategies will decrease companies' costs, increase customer satisfaction and improve the competitive capacity. Considering the complex profile of the marketing strategy selection problem with many conflicting objectives, different criteria need to be taken into account for deciding on the suitable strategy. Multi criteria decision making (MCDM) is a powerful tool widely used for evaluating problems containing multiple and usually conflicting criteria. This study proposes the logistics company's marketing strategy selection as an MCDM problem, and presents a simple and selective approach to solve it. After determining the evaluation criteria, two MCDM methods are used in the evaluation procedure. AHP (Analytic Hierarchy Process) is used for determining the importance of each criterion and calculating their weights. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is applied for evaluating as well as ranking marketing strategy alternatives from the best to the worst. Finally, a real case study is provided in order to demonstrate the potential of the proposed approach.*

Keywords –Marketing strategy, Logistics sector, MCDM, AHP, TOPSIS

INTRODUCTION

Nowadays, marketing approach is customer focused and products are directed according to the needs for the customer. To find markets for products and services is a mission of marketing. Marketing aims an efficient production process. Hence, it establishes a communication network between producers and consumers. The success of the producer is directly connected to importance of the desires of the consumer. The Marketing, which is a long process, needs organization and management and due to that need, the term "marketing strategy" is widely used in logistics sector.

For a logistics company, the decisions concerning the determination of marketing strategy depend on determiners to the market as well as the big consumer portfolio or the target market of the company, the financial and organizational structure of the logistics company itself and the characteristics of the product. Marketing strategies should consider a large number of complex factors by estimating and choosing marketing strategies, so it is a multi-criteria decision making (MCDM) problem.

The multi-criteria decision making refers to the fact of making decisions in the presence of multiple and usually contradictory criteria. The MCDM is one of most popular solution method preferred by researchers in the literature. MCDM refers to find the best opinion from all of the feasible alternatives in the presence of multiple, usually conflicting, decision criteria. Priority based, outranking, distance-based and mixed methods could be considered as the primary classes of the current methods [1]. One of the most outstanding MCDM approaches is the Analytic Hierarchy Process (AHP) [2] which has its roots on obtaining the relative weights among the factors and the total values of each alternative based on these weights. This study uses AHP to determine the criteria weights from subjective judgments of the decision maker group. The rating of each alternative and the weight of each criterion, which are calculated using the AHP, are then passed to the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which is a distance-based MCDM method [3]. This technique is based on positive and negative-ideal solutions, which are determined in respect to the distance of each alternative to the best and the worst performing alternative, respectively.

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The purpose of this study is to estimate the strategic factors of marketing and to choose the best solution of marketing strategy in logistics companies while taking into account preferences of three experts. This study looks for the answers of questions why the marketing strategy is necessary to be implemented for logistics companies.

The remainder of the paper is structured as follows. The related studies are summarized in the next section. The following section presents the evaluation criteria and marketing strategies. The next two sections introduce the methods using to compute the criteria weights and select the best marketing strategy, respectively. A numerical illustration will be given in latter and finally the concluding remarks will be given in last section.

LITERATURE REVIEW OF THE MARKETING STRATEGY

Marketing is a critical function that helps corporations in surviving crises. For the past 20 years, greater emphasis has been placed on the role of marketing considerations in the managerial process, underscoring the important role that marketing plays in contributing to a firm's competitive success [4].

In the literature, during the last years, many studies have been published about marketing strategy selection. Rekik et al. [5] proposed a MCDM support system to aid the marketing strategy selection in e-commerce. Wu et al. [6] modeled the marketing strategy decision making problem and implemented the integration of the Analytic Network Process (ANP) and TOPSIS to determine the appropriate marketing strategy. Wierenga [7] formulated interesting and relevant research questions about marketing decision making. Tsai et al. [8] proposed an integrated model for evaluating airlines' websites effectiveness which is based on the perspectives of ''marketing mix 4Ps'' and ''website quality'' for the web-based marketing using the ANP. Liao [9] proposed a method that will guide the product development team to select the best marketing strategy by taking into account the price level and product/market segmentation. Mohaghar et al. [10] presented an integrated fuzzy approach for selecting a marketing strategy with AHP and VIKOR methods. Wang [11] provided a reference for planning brand marketing with a hybrid MCDM model combining the Decision Making Trial and Evaluation Laboratory (DEMATEL) with ANP and VIKOR methods. Gurbuz et al. [12] analyzed marketing strategies and marketing decisions in the new product development process in a macro level with AHP and fuzzy metric distance methods.

In order to propose a marketing strategy selection model, marketing and marketing strategy should be defined. The essence of marketing is an exchange intended to satisfy human needs and wants. Marketing is not just an activity of a department in a company; it is a management requiring process. Marketing consists of five main steps [13]:

- research,
- segmentation, market targeting, positioning,
- marketing mix constitution,
- implementation of the strategy and
- control.

The typical marketing assets include corporate name and reputation, customer relationship, distribution network, relationship with critical supplier, market knowledge, information system, customer database, legal patent, innovation skills, and optional managerial resources. The ideal profiles of marketing resources and capabilities for marketing strategies are posited and the superior performance for enterprises always results from marketing resources and capabilities that are in fit with the marketing strategy [10]. Marketing strategy focuses on manipulations of marketing mix variables: product, price, place and promotion and strategic marketing planning becomes more and more important in today's competitive conditions. Another definition of strategy in marketing with a broader perspective of strategy claims that strategic market planning is a four-step process: defining the business, setting a mission, selecting functional plans for marketing, production, and other areas, and budgeting for those plans [14].

EVALUATION CRITERIA AND ALTERNATIVES

The marketing department has overall responsibility for growing revenue, increasing market share and contributing to company growth and profitability. For a logistics company, marketing strategy evaluation criteria and sub-criteria are determined with a literature survey [3-18] and discussion with industrial experts. There are four main criteria which are “customer (C1)”, “service (C2)”, “market (C3)” and “company (C4)”. The definition of their sub-criteria as summarized as follows.

Levels of customer satisfaction (C11): The degree of satisfaction provided by the goods or services of a company as measured by the number of repeat customers.

Level of raising sensitization of the rights of the consumers (C12): Consumer behavior is remarkable criteria to dial the Middle of Marketing. The company aimed to increase sales should satisfy the consumer. After the provision of customer satisfaction, the company creates a brand image supported by the brand's reliability.

Loyalty of customer (C13): Customer loyalty is both an attitudinal and behavioral tendency to favor one brand over all others, whether due to satisfaction with the product or service, its convenience or performance, or simply familiarity and comfort with the brand. Customer loyalty strategies aimed at top clients of a brand and that these best customers deserve a treatment that was proportional to the value of the relationship between the consumer and the brand.

Service costs and sales (C21): The costs related to making or acquiring services that directly generates revenue for a company.

Service quality (C22): The group of features and characteristics of a saleable service which determine its desirability and which can be controlled by the company to meet certain basic requirements.

Low price (C23): A pricing strategy in which a company offers a relatively low price to stimulate demand and gain market share. In cost strategy and differentiation strategy, firms might be in a superior position to achieve cost decrement, if they acquire and develop the necessary resources immediately after deciding on a strategy.

Competitive position (C31): Position a company occupies in a market, or is trying to occupy, relative to its competition.

Size of market/ market growth rate (C32): The number of consumers in the company’s target market. The increase in size or sales observed within a given consumer group over a specified time frame. When the management of a business is reviewing the success of a service, it needs to deduct the overall market growth rate from the observed service sales growth.

Types of the promotions (C33): Promotion refers to raising customer awareness of a service or brand, generating sales, and creating brand loyalty.

Image and position in the market (C41): Positioning is the place a product occupies in consumers’ minds relative to competing products. An effort is to influence consumer perception of a brand relative to the perception of competing brands. Its objective is to occupy a clear, unique, and advantageous position in the consumer's mind.

Methods used for communication (C42): The promotions that the company uses to persuasively communicate customer value and build customer relationships.

Target group of company (C43): A target market is a group of customers a company has decided to aim its marketing efforts and ultimately, it is the goods to.

For marketing strategy alternatives, Porter introduced a typology of three generic strategies-including overall cost leadership, differentiation, and focus strategies for creating a sustainable position and outperforming competitors in a given industry [19]. With regard to cost strategy, firms might be in a superior position to achieve cost decrement, if they acquire and develop the necessary resources immediately after deciding on a strategy. In the differentiation strategy, the resource-based theory of the firm suggests that similarities in resource requirements among rival companies may increase competition [17]. On the basis of Porter’s focus strategy, investigated the impact of the major beliefs about marketing and suggested that market segmentation is a fundamental precursor to a focused strategy and thus, an important product-market strategy [19].

Kotler [13] based on the marketing concept proposed; mass marketing strategy, product-variety marketing strategy and target marketing, and developed the market leader strategy, market challenger strategy, marketing follower strategy, and market niche strategy basing on the perspectives of competitive position. In this study, there are four alternatives to select the marketing strategy. These alternatives:

Strategy of cost leadership (A1): This strategy involves the firm winning market share by appealing to cost-conscious or price-sensitive customers. This is achieved by having the lowest prices in the target market segment, or at least the lowest price to value ratio (price compared to what customers receive). To succeed at offering the lowest price while still achieving profitability and a high return on investment, the firm must be able to operate at a lower cost than its rivals [20].

Strategy of service leadership (A2): Service leadership as a competitive strategy aims to build a culture that continuously brings superior service to market. Here service leaders achieve premium market prices thanks to the experience they create for their customers [21].

The strategy of differentiation (A3): A differentiation strategy is appropriate when the segment of the target market is not sensitive to price, the market is competitive or saturated, clients have very specific needs that may be underserved, and the company has the resources and capabilities that enable it to meet these needs in a unique way that is difficult to copy [20].

The strategy of the niche market (A4): A niche market is the subset of the market on which a specific service is focused. The market niche defines as the service features aimed at satisfying specific market needs, as well as the price range, service quality and the demographics that is intended to impact. A typical service marketed using a niche strategy will be easily distinguished from other services, and it will also be produced and sold for specialized uses within its corresponding niche market [21].

THE AHP METHODOLOGY

AHP is developed by Saaty [2] and it is probably the best-known and most widely used model in decision making. AHP is a powerful decision making methodology in order to determine the priorities among different criteria. To make a decision in an organized way to generate priorities we need to decompose the decision into the following steps:

Step 1. Define the problem and determine the kind of knowledge sought.

Step 2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

Step 3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

The matrix A is a $m \times m$ real matrix, where m is the number of evaluation criteria considered. Each entry a_{jk} of the matrix A represents the importance of the j^{th} criterion relative to the k^{th} criterion. If $a_{jk} > 1$, then the j^{th} criterion is more important than the k^{th} criterion, while if $a_{jk} < 1$, then the j^{th} criterion is less important than the k^{th} criterion. If two criteria have the same importance, then the entry a_{jk} is 1. The entries a_{jk} and a_{kj} satisfy the following constraint:

$$a_{jk}.a_{kj} = 1. \tag{1}$$

Obviously, $a_{jj} = 1$ for all j.

Table 1. Table of relative scores

Value of a_{jk}	Interpretation
1	*j* and *k* are equally important
3	*j* is slightly more important than *k*
5	*j* is more important than *k*
7	*j* is strongly more important than *k*
9	*j* is absolutely more important than *k*

To make comparisons, we need a scale of numbers that indicates how many times one element is more important or dominant over another one with respect to the criterion or property and with respect to which they are compared. Table 1 exhibits the scale [2].

Once the matrix *A* is built, it is possible to derive from *A* the normalized pairwise comparison matrix A_{norm} by making equal to 1 the sum of the entries on each column, i.e. each entry a *jk* of the matrix A_{norm} is computed as:

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{i=1}^{m} a_{jk}}. \tag{2}$$

Finally, the criteria weight vector w (that is an m-dimensional column vector) is built by averaging he entries on each row of A_{norm},

$$w_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m}. \tag{3}$$

Step 4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained [22].

Step 5. AHP also calculates an inconsistency index (or consistency ratio) to reflect the consistency of decision maker's judgments during the evaluation phase. The inconsistency index in both the decision matrix and in pairwise comparison matrices could be calculated with the equation:

$$\mathrm{CI} = \frac{\lambda_{max} - N}{N-1}. \tag{4}$$

EVALUATING MARKETING STRATEGY ALTERNATIVES BY TOPSIS

The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method is presented in Chen and Hwang with reference to Hwang and Yoon [3]. The basic principle is that the chosen alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution. The ideal solution is the solution that maximizes the benefit and also minimizes the total cost. On the contrary, the negative-ideal solution is the solution that minimizes the benefit and also maximizes the total cost [3].

The TOPSIS procedure consists of the following steps:

Step 1. Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{J} f_{ij}^2}}, \; j = 1, \ldots, J; \; i = 1, \ldots, n. \tag{5}$$

Step 2. Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as

$$v_{ij} = w_i r_{ij}, \; j = 1, \ldots, J; \; i = 1, \ldots, n, \tag{6}$$

where w_i is the weight of the i^{th} criterion and $\sum_{i=1}^{n} w_i = 1$. (7)

Step 3. In this step, the ideal and negative-ideal solutions are determined.

$A^* = \{v_1^*, \dots, v_n^*\} = \{(jmax v_{ij}|i\in I'),(jmin v_{ij}|i\in I'')\}$, (8)

$A^- = \{v_1^-, \dots, v_n^-\} = \{(jmin v_{ij}|i\in I'),(jmax v_{ij}|i\in I'')\}$, (9)

where I′ is associated with benefit criteria, and I″ is associated with cost criteria.

Step 4. Calculate the separation measures using the n-dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as

$$D_j^* = \sqrt{\sum_{i=1}^{n}(v_{ij} - v_i^*)^2}\text{ , } j = 1, \dots, J. \quad (10)$$

Similarly, the separation from the negative-ideal solution is given as

$$D_j^- = \sqrt{\sum_{i=1}^{n}(v_{ij} - v_i^-)^2}\text{ , } j = 1, \dots, J. \quad (11)$$

Step 5. The next step consists of the calculation of the relative closeness to the ideal solution. The relative closeness of the alternative a_j with respect to A* is defined as

$$C_J^* = \frac{D_j^-}{(D_j^* + D_j^-)}\text{ , } j = 1, \dots, J. \quad (12)$$

Step 6. At the final step, the preference order is ranked.

In TOPSIS method, the chosen alternative has the maximum value of C_j^* with the intention to minimize the distance from the ideal solution and to maximize the distance from the negative ideal solution.

CASE STUDY

There is a logistics company, ABC, which wants to select its best marketing strategy to gain competitive advantage in the market. There are four possible alternatives to select the strategy: A1 is a strategy of cost leadership, A2 is a strategy of service leadership, A3 is a strategy of differentiation and A4 is a strategy of the niche market. The company must take a decision according to the four criteria and twelve sub-criteria explained in the previous section.

Table 2. The pairwise comparison matrix of the sub-criteria

	C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	C43
C11	1,00	5,00	0,33	0,20	3,00	0,14	7,00	5,00	7,00	3,00	9,00	0,33
C12	0,20	1,00	0,11	0,20	0,14	5,00	3,00	0,20	0,33	0,33	3,00	0,14
C13	3,00	9,00	1,00	5,00	0,20	3,00	5,00	7,00	5,00	5,00	5,00	7,00
C21	5,00	5,00	0,20	1,00	0,33	0,33	3,00	0,20	5,00	7,00	9,00	5,00
C22	5,00	7,00	5,00	3,00	1,00	3,00	9,00	9,00	7,00	5,00	7,00	5,00
C23	7,00	0,20	0,33	3,00	0,33	1,00	7,00	7,00	9,00	9,00	9,00	5,00
C31	0,14	0,33	0,20	0,33	0,11	0,14	1,00	5,00	3,00	0,33	7,00	3,00
C32	0,20	5,00	0,14	5,00	0,11	0,14	3,00	1,00	3,00	3,00	5,00	0,33
C33	0,14	3,00	0,20	0,20	0,14	0,11	0,33	0,33	1,00	0,20	0,33	0,11
C41	0,33	3,00	0,20	0,14	0,20	0,11	3,00	0,33	5,00	1,00	5,00	0,33
C42	0,11	0,33	0,20	0,11	0,14	0,11	0,14	0,20	3,00	0,20	1,00	0,14
C43	3,00	7,00	0,14	0,20	0,20	0,20	0,33	3,00	9,00	3,00	7,00	1,00
Sum	25,13	45,87	8,06	18,39	5,92	13,30	41,81	38,27	57,33	37,07	67,33	27,40

The decision matrix, which is based on Saaty's nine-point scale, is constructed. The decision maker uses the fundamental 1–9 scale to assess the priority score. In this context, the assessment of 1 indicates equally important, 3 slightly more important, 5 more important, 7 strongly more important and 9 indicates absolutely more important (Table 1). The AHP methodology first necessitates the pairwise comparisons of the criteria and the sub-criteria in order to determine their weights. These consistent comparison matrices are shown in Table 2. The weights of criteria are calculated using the equations (2) and (3). The weighted normalized decision matrix of the alternatives calculated by multiplying the normalized decision matrix and the weights is represented in Table 3. The normalized decision matrix is calculated using equations (5), (6) and (7).

Table 3. The weighted normalized decision matrix

	CRITERIA											
ALTERNATIVES	C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	C43
A1	0,056	0,014	0,098	0,064	0,084	0,114	0,025	0,041	0,012	0,027	0,006	0,072
A2	0,072	0,033	0,054	0,027	0,152	0,063	0,018	0,024	0,002	0,027	0,010	0,072
A3	0,040	0,024	0,033	0,046	0,084	0,038	0,018	0,008	0,007	0,016	0,006	0,051
A4	0,056	0,024	0,098	0,046	0,084	0,038	0,025	0,041	0,007	0,027	0,006	0,092
IDEAL	0,072	0,033	0,098	0,064	0,152	0,114	0,025	0,041	0,012	0,027	0,010	0,092
WORST	0,040	0,014	0,033	0,027	0,084	0,038	0,018	0,008	0,002	0,016	0,006	0,051

Furthermore, the computed distances of each alternative to ideal solution (D*) and the ones to non-ideal solution (D−) have been shown in Table 4. These distances are calculated with the equations (10) and (11). The last step of the TOPSIS methodology consists of ranking the alternatives according to their relative closeness to the ideal solution, as shown in Table 4.

Table 4. The distances of each alternative to the ideal solution and the non-ideal solution and their relative closeness to the ideal solution

ALTERNATIVES	Dj*	Dj-	Cj
Strategy of cost leadership (A1)	0,075	0,115	0,607
Strategy of service leadership (A2)	0,081	0,089	0,522
The strategy of differentiation (A3)	0,137	0,021	0,133
The strategy of the niche market (A4)	0,105	0,089	0,458

Ultimately, the strategy of cost leadership (A1) has become the most desirable strategy among four alternatives with the final performance value of 0,607; while the strategy of product leadership (A2), the strategy of differentiation (A3) and the strategy of the niche market (A4) have positioned at the second, third and fourth ranks with 0,522, 0,458 and 0,133 as the final performance values, respectively.

CONCLUSION

Nowadays, the marketing approach centered on the clients and products. Since the marketing is a long process which needs organization and management, becomes a key factor of success for logistics companies in competitive market conditions of today. The marketing strategy is essential in the development of new products and it is influenced by numerous factors. A decision of marketing strategy can be classified as a multi-criteria decision making problem. Marketing strategists should consider a large number of complex factors by estimating and choosing marketing strategies. The purpose of this study was to estimate the strategic factors of marketing and to choose the best solution of marketing strategy. Consequently, at first the basic concepts of the marketing strategy were reviewed. Then the criteria and the alternatives were determined for evaluation of marketing strategy. The AHP and TOPSIS methods were applied. There were four alternatives for selection of marketing strategy. The determined most desirable marketing strategy for the ABC Logistics Company is A1, which is strategy of cost leadership.

The utility of the models was observed by their effect on the decision-making process in the choice of a solution suited for marketing strategies. The models supply a useful abstract frame to estimate the marketing strategies of alternative solutions and the people can use approaches to make their strategic decisions.

Considering the complexity of marketing related issues, many companies make use of a group of decision makers (DMs-experts) instead of a single DM to accomplish the given tasks successfully. The group decision making (GDM) consists of multiple individuals interacting to reach a decision. One of the perspectives for future work can be to consider the GDM approach for decision making process. Another perspective can be to consider the dependence of the criteria, the interaction between the criteria, and to extend our analysis by applying the analytic network process approach [23].

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HOW GOOD ARE THE CONTAINER TERMINALS IN TURKEY AT DIGITAL MARKETING CHANNELS: AN EXPLORATORY STUDY

Bayram Bilge Sağlam[1], Durmuş Ali Deveci[2], Okan Tuna[3]

Abstract- Due to the constantly increasing external and internal influences, container terminals are now operating in a more and more competitive environment. This increase in competition drives container terminals to differentiate themselves from their competitors and to use effective marketing communication methods to keep existing customers and attract new ones. In line with this strategy, container terminals have begun to pay more attention on marketing communication activities. Apart from traditional media channels, container terminals have carried out their communication activities through digital channels such as social media and websites in order to gain a greater level of accessibility. This study aims to evaluate container terminals' digital marketing platforms. In accordance with this purpose the access and engagement ratios of container terminals' official websites and social media accounts were investigated.

Keywords: *digital marketing, port marketing communication, social media, website*

INTRODUCTION

Technological developments, especially in the last decade, have changed the marketing approaches of the businesses in a broad sense. Thanks to the digital platforms, firms now have access to numerous new channels to carry out their marketing communication activities with lowest costs and at the highest success levels possible. In addition to this, digital environment made it much easier for the firms to measure their marketing effectiveness and collect real time data from these platforms [1]. Particularly for large-scale companies which can only handle a small proportion of communications face-to-face, digital marketing channels have provided an invaluable opportunity to spread their activities to a broader community with much less effort. In other words, these channels have become the primary platforms where firms can create relationships, mutual value and presence in an attempt to introduce themselves [2].

Similar to many other B2B markets, shipping and logistics have paid a significant attention on digital marketing channels. According to "2016 Social Media Impact Report" released by TrackMaven, shipping and logistics industry is ranked as 9th in follower growth and 11th in engagement ratio among 17 industries [3]. Since container terminals are essential nodes of shipping and logistics industry, they are forced to maintain marketing communications with a vast array of stakeholders and a sheer number of customers. To gain a competitive position, this communication should be maintained effectively and on a continuous basis.

Considering that digital platforms have significantly increased its role on B2B marketing, this study focuses on how container terminals in Turkey are involved in digital marketing channels and aims to reveal how they perform in these channels. Within this context, first section provides an overview of the port marketing communications literature. Second section explains the research methodology. Third section reveals and discusses the findings of the study on digital marketing channel performance of container terminals in Turkey.

PORT MARKETING COMMUNICATIONS AND DIGITAL MARKETING CHANNELS

Ports as organizations having an important role on global supply chains are obliged to maintain close relations with various strategic stakeholders including customers (shippers, carriers, etc), employees, local community, social interest groups and government bodies [4]. For the commercial purposes of the ports, the relations with the stakeholders should be managed carefully considering that it will have a crucial impact on determining the competitive position of the port against its competitors. In order to achieve this desired position, carrying out marketing communication activities becomes an essential task for the ports. By accomplishing these activities, ports create the opportunity to enable effective communication with current and potential customers [5]. To gain

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a deeper understanding, Bernard's (1995) itemization of ports' objectives on promotion would be helpful. According to Bernard (1995), the following objectives can be achieved through maintaining effective promotion activities at ports;

- enlarging the renown of the port;
- paving the way for sales;
- improving the port's image;
- increasing the port's recognition;
- highlighting the port's quality elements.

Due to the dynamic environment of the ports, many changes which customers should be aware of occur at ports. For instance, any improvement on service quality may have a potential to change customer's negative opinion to positive [6]. At this point, the role of communication channels should be taken into consideration and it should be designed in a way that shows congruity with port's promotion objectives. Another important issue is to decide on the channels that the communication will take place. In the context of B2B marketing, brochures and printed publications, magazines and newsletters, seminars, forums and exhibitions constitute the major traditional channels. However, compared to the traditional ones, digital channels including websites, social media, mailing and search engines have increased their importance as they are now more commonly used [7][8].

In parallel with the scarcity of researches on port marketing communication channels, papers that focused on the digital channels are quite few (see [5][9][10]). As there is a gap in the literature on this very particular subject, our study centers its aim on the role of digital channels on container terminal marketing activities.

RESEARCH METHODOLOGY

Methodologies for studying the digital marketing channels, especially the social media phenomenon, are still emerging and being tested by researchers. Although it is hard to say that it is an entirely unknown area, stating that it is under-researched would be reasonable. In this sense, we designed our research as an exploratory study with aim of providing an insight on the characteristics of the phenomenon [11].

In this study, population was the privately operated container terminals in Turkey since public ports do not have any presence on social media platforms. Out of this population, we have selected the top ten terminals based on handling volumes in 2015. Thus, this purposive sampling allowed us to reach to a sample size which is suitable to make comparison [12].

In order to conduct an exploratory study on the digital marketing channel performance of container terminals in Turkey, we carried out our research in two phases. In the first phase, we examined the official websites of the container terminals, focusing on the performance parameters namely global ranking, daily time on site, daily page views per visitor, bounce rate and SEO score. These rates were obtained from Alexa Rank which is a website that specializes in providing commercial web traffic data gathered via various toolbars and web browser extensions [13]. In the second phase of the research, we investigated the social media performance of the container terminals through their presence, quantity of followers and engagement rates. In order to select the digital media platforms, we checked seven platforms (Facebook, Twitter, Linkedin, Youtube, Instagram, Pinterest and Google+) to see which of them are used by the container terminals. As Youtube, Pinterest and Google+ were not preferred by any of the container terminals, we excluded them from our research. To measure the engagement rates the following formula was used:

$$Engagement\ Rate = \frac{\text{Total Follower Interaction per day}}{\text{Total Followers}} \times 100$$

Engagement rate is a commonly used formula for quantifying the success of the social media accounts. According to this measurement, engagement rates higher than 1 reflects a successful account while rates between 0,5 and 0,99 are considered to be mediocre and rates below 0,5 represents an unsuccessful account [14]. In order to identify follower interactions, we counted likes, comments, shares, replies and retweets on

Facebook, Twitter, Linkedin and Instagram accounts of the container terminals covering the posts shared within 6 months period (between the dates of 17.04.2016 and 17.10.2016).

RESEARCH FINDINGS

In the first phase of our study, we investigated the container terminals' official websites in terms of their rankings and performance statistics collected from Alexa Rank and Seo Centro. Global rank of a website represents a rough estimate of the website's popularity. Alexa Rank calculates this rank by using a combination of average daily visitors to this website and page views on the website over the past 3 months. As it is seen in the Table 1, MIP's official website is ranked 858,538th which is significantly higher than the rest of the terminals' websites. Considering that websites of the top 10 (based on TEU handled) container terminals worldwide are ranked between 300,000 and 1.000.000.This result can be considered as a success. Apart from the global rank, daily time on website and daily page views (per visitor) statistics are good metrics to see if the content of the website is good enough to attract the visitors. The websites which have a rich content and interactive sections are more likely to increase their score on these rankings. Considering that these two metrics are calculated on per visitor basis, they provide comparable information. As seen in Table 1, MIP's website again maintains its leading position with the average of 5.49. When MIP's website is examined, it is found that the content is rich with interactive modules such as weighing report and storage fee calculation. Beside the interactive modules, the website includes many downloadable features like tariff rates, quay plan and work process related documents which are useful and/or necessary for port users. Another metric that gives an insight on the websites' content is the bounce rate. Bounce rate is the percentage of visits that go only one page before exiting a website. In general, a good bounce is anything under 50% [15]. On this view, the website of Marport (34,5%), MIP (14,7%), Kumport (21,20%) and Borusan (25%) are found to be successful examples.

Table 1:. Statistics on Container Terminals' Websites (based on the data collected on 17.10.2016)

Top 10 Terminals	Global Rank	Daily Time on Site	Daily Page Views per Visitor	Bounce Rate	SEO Score	Mobile Device Adaptation	Mobile Application
Marport	1,824,790	03:28	2,6	34.50%	35%	+	+
MIP	858,538	05:49	6,7	14.70%	46%	+	-
Kumport	1,772,360	03:14	3,8	21.20%	41%	+	+
Evyapport	2,511,282	03:05	1,8	64.90%	44%	-	-
Gemport	3,569,469	01:22	1,5	71.90%	34%	+	-
Yılport	2,927,050	02:21	1,9	64.30%	44%	+	-
Mardaş	2,520,468	02:23	2,2	51.20%	34%	+	-
TCE Ege	5,983,284	01:32	1,4	61.50%	36%	+	-
Nemport	20,346,344	n/a	1,5	n/a	47%	+	-
Borusan	4,497,285	01:38	1,9	25.00%	38%	+	+

SEO (search engine optimization) score is another important tool that should be considered while evaluating the success of terminals' websites. SEO involves creating or modifying a web site in a way that makes it easier for search engines to both crawl and index its content [16]. As seen on Table 1, SEO scores of the container terminals in Turkey are below 50%.

Today as more people use mobile devices mobile adaptability of websites and providing mobile applications for maintaining interactive work processes become very crucial for all kinds of firms. When the websites of terminals in our sample in examined with this respect, it is revealed that all of the terminals except Evyapport have their websites adapted for mobile devices. However, when it comes to mobile applications, it is found that very little importance is given on this particular issue since only three of the terminals (Marport, Kumport and Borusan) have their applications on service.

In the second phase of the study, we focused on the social media platforms. Table 2 shows which social media platforms the container terminals are present and the number of followers they have. When we look through the overall view of the table, it is explicitly seen that container terminals in Turkey are not adequately present in social media platforms. Out of 10 container terminals that are under investigation, only 5 of them have Facebook accounts while only 4 of them are present on Twitter and just one terminal on Instagram. However, Linkedin comes into prominence as the most preferred social media platform with 8 of the terminals being present as the platform differentiates itself as a business and employment-oriented social networking website. When the number of followers is examined, social media accounts with the highest followers differ from terminal to terminal. For instance, while Marport and Evyap have higher followers on Facebook than the rest of their social media accounts, for MIP, Kumport and Mardaş the highest number of followers is achieved on their Linkedin accounts.

Table 2: Container Terminals' Social Media Presence and the Number of Followers

Top 10 Terminals	Facebook	Twıtter	Lınkedın	Instagram
Marport	3506	242	71	847
MIP	257	-	2041	-
Kumport	235	-	1.309	-
Evyapport	705	66	312	-
Gemport	-	-	1538	-
Yılport	-	-	3057	-
Mardaş	-	94	116	-
TCE EGE	-	-	-	-
Nemport	-	-	419	-
Borusan	667	561	71	-

In order to show to what extent container terminals use their social media accounts, Table 3 presents the engagement rates and total number of posts within 6 months. A salient point is that even though container terminals have their accounts on some social media platforms, they do not have any posts within the 6 months period. Especially Linkedin, despite being the most preferred social media platform for container terminals in our sample, stands out as the social media platform with lowest number of posts. In other words, rather than using Linkedin accounts with the aim of performing marketing communication practices, container terminals are only aiming to be present on that social media platform.

Table 3: Total Number of Posts and Engagement Rates on Social Media

Top 10 Terminals	Facebook		Twitter		Linkedin		Instagram	
	Total Number of Posts	Engagement Rate	Total Number of Posts	Engagement Rate	Total Number of Posts	Engagement Rate	Total Number of Posts	Engagement Rate
Marport	104	1,56	137	0,91	20	1,12	69	2,2
MIP	0	0	-	-	0	0	-	-
Kumport	14	0,57	-	-	12	0,05	-	-
Evyapport	11	0,39	767	0,07	10	0,18	-	-
Gemport	-	-	-	-	0	0	-	-
Yılport	-	-	-	-	25	0,2	-	-
Mardaş	-	-	4	0,05	2	0,08	-	-
TCE Ege	-	-	-	-	-	-	-	-
Nemport	-	-	-	-	0	0	-	-
Borusan	31	1,26	12	0,1	-	-	-	-

When we compare container terminals with each other, it is easily seen that Marport is the most prominent terminal as they are maintaining their digital marketing communication on all four social media platforms and achieving the highest engagement rates. Especially 2.2 engagement rate that they have achieved on Instagram is found to be highly above the engagement rates that they have achieved on other social media platforms. As Marport shares posts with similar content on all their accounts, this high engagement rate on Instagram proves the strength of the platform on getting more interaction from followers. Interestingly, despite the findings reveal that Instagram has a potential on high follower interaction, none of the container terminals other than Marport seem to have considered managing an account necessary on this platform.

Furthermore, our findings provide valuable insights on the content of the posts and its relation to the engagement rate. As seen in Twitter account of Evyapport, although total number of posts are much more than any other container terminals, the engagement rate achieved is at a very insufficient level. This finding shows that the content of the posts that the terminal shared does not provide a basis for follower interaction. Therefore, for an effective digital marketing communication, important role of the posts' content should be considered as it will determine whether the followers will be willing to interact or not.

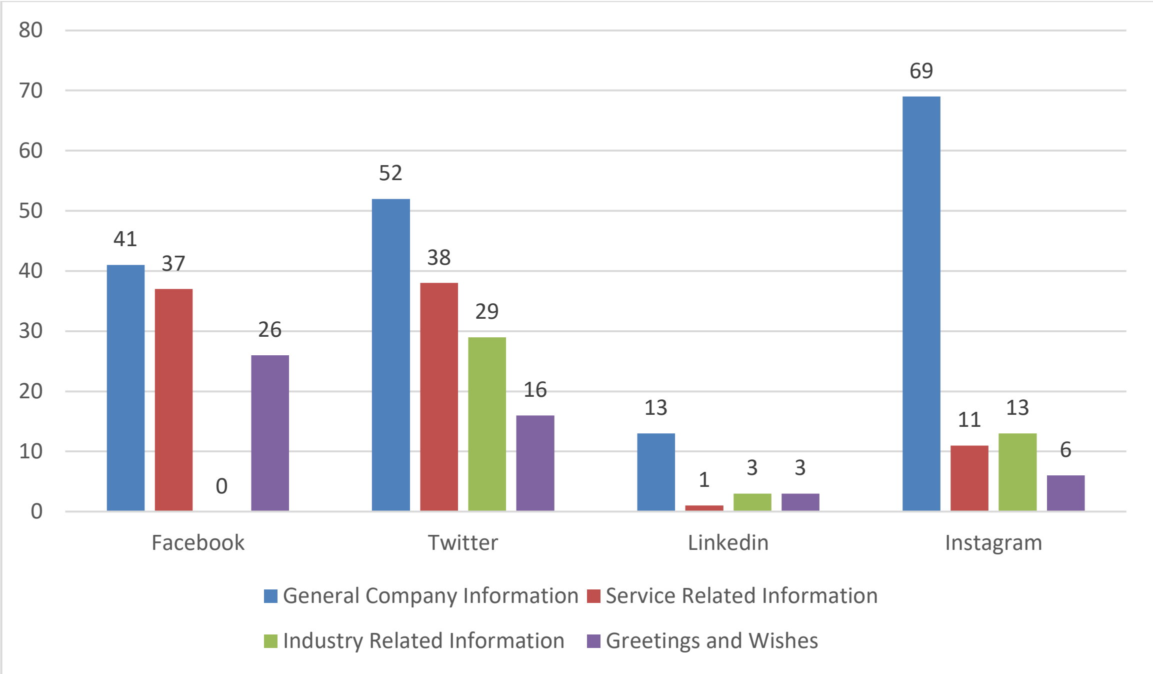
To gain a clearer understanding on the relation between content of the posts and the interaction they achieve, we expanded our research by investigating Marport's posts on all four social media platforms. Marport was chosen as their total number of followers are above others and the posts they shared have the highest engagement rates, meaning that it is the most successful terminal on managing social media accounts. In order to analyze the content of the posts, we categorized them into four as general company information, service related information, industry related information and greetings-wishes. General company information included the posts that are shared with the purpose of giving general news from the company. Service related information included the ones that inform the followers about the services that the terminal carries out and the developments in that area. Industry related information covered the posts that are shared in order to share knowledge on the industrial terms and other industrial topic that the terminal believes that it is useful for their followers. Greetings and wishes included the greeting messages on special days such as national and religious holidays. Ttable 4 provides some examples of posts on each content category.

Table 4. Categorization of the Posts' Content

Content Category	**Examples of Posts**
General company information	• We are supporting the TOC Europe events at Hamburg between 14-16 June with our sponsorship. • As Turkey's Green Port, we care about the environment. • We conduct Work Health and Safety Trainings for port workers every week.
Service related information	• We are at your service with our 92 terminal towing trucks. • We continue our operations faster with 41 Rubber Tyred Gantry Cranes (RTG). • Containers which are loaded onto ships are weighed with 12 weighbridges during entries and exits.
Industry related information	• "Portainer" a generalized trademark name for Paceco Inc's line of quayside cranes which is developed by the brand in 1950. • Bill of lading is a document title which shows the possession of cargo. The consignee cannot receive the good without this document. • Verified Gross Mass (VGM) is one of the regulation of SOLAS.
Greetings and wishes	• We wish all the fathers there a happy father's day. • Happy eid al-adha. • Have a nice weekend.

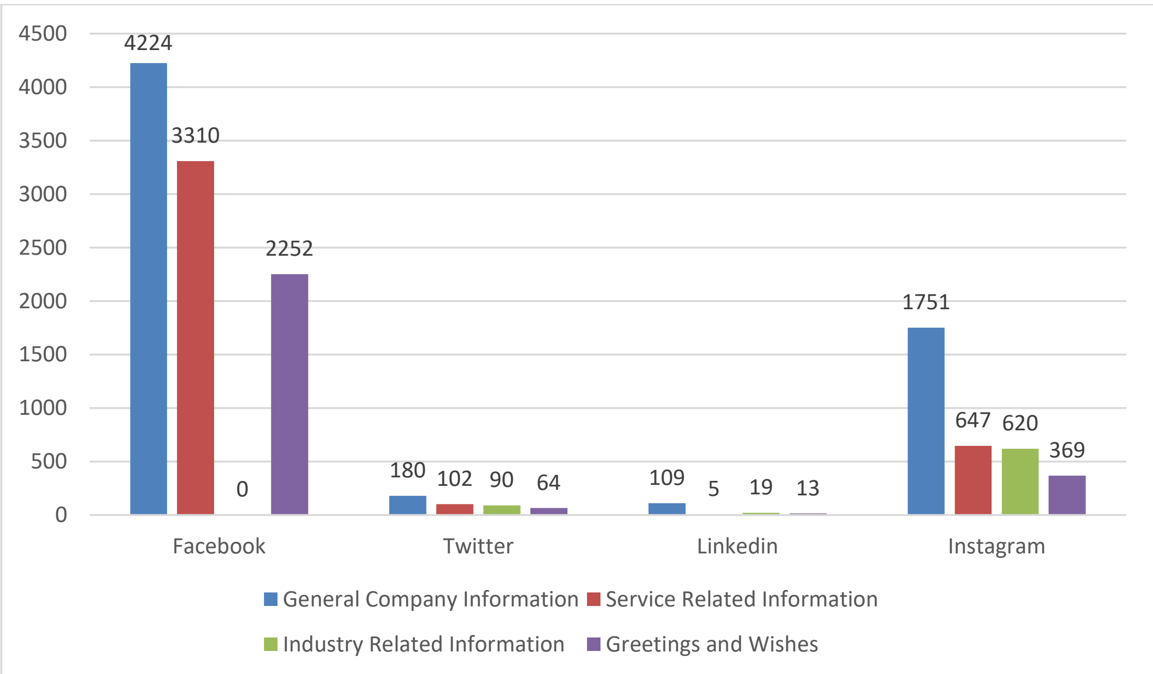
Based on this categorization, number of posts on each social media platform is shown in Figure 1. When the platforms are examined as whole, general company information constitutes 49 percent, service related information constitutes 25 percent, greetings/wishes constitute 14 percent and industry related information constitutes 12 percent of the total number of posts. When we focus on each social media platform in order to see if there is a difference in the share of the content categories, it is seen that the shares differ on each social media account. Even though general company information is the category with the largest share on all four social media, share of the other content categories are in different levels depending upon the social media platform. For instance, while posts on industrial information are posted on Twitter, Instagram and Linkedin, it is seen that Facebook is not used for sharing posts with such content.

Figure 1: Number of Posts by Content Categories



When posts of Marport are examined on the social media platforms in terms of the interactions they get it seen that especially Facebook and Instagram are the platforms with dense interaction. Although Twitter is the platform with highest number of posts, interaction is found to be at a very low level.

Figure 2: Number of Interactions by Content Categories



As the number of posts on each category differs to a great extent, it is more feasible to make a comparison on per unit basis. In accordance with this purpose, Table 5 shows interactions per posts on each content category.

Table 5: Interactions Per Post

Posts	Facebook	Twitter	Linkedin	Instagram
General Company Information	103	3,4	8,3	25,3
Service Related Information	89,4	2,6	5	58,8
Industry Related Information	0	3,1	6,3	47,7
Greetings and wishes	86,6	4	4,3	61,5

Information in this table reveals that the interaction level achieved by a content category varies on each social media platform. For instance, while the category of greetigs and wishes is at the lowest position on Facebook and Linkedin compared to other content categories, it is found to be at the highest position on Instagram and Twitter. Very similar to this finding, general company information posts provides the highest interaction shares on Facebook and Linkedin. However, on the Instagram this category is seen as he least successful content type in terms of interaction.

CONCLUSION

Successful usage of the marketing communication channels is one of the key elements in maintaining good relations with existing customers and attracting the new ones. Considering that container terminals in Turkey are large-scale companies operating in a highly competitive environment, the marketing communication activities that they carry out is expected to be dense and effective. Today, digital marketing platforms, mainly websites and social media platforms, have increased its importance. Thus, the presence on web should be considered as a necessity rather than luxury for the companies. Beyond all that, these presence should be powerful by maintaining the communication activities with a rich content and on a regular basis.

Our study focusing on the digital marketing channel usage of the container terminals in Turkey determined that there are few successful examples among container terminals using digital platforms as a marketing communication channel. Among the official websites of the terminals, only the website of MIP is observed as a prospering example as their rankings are as high as top 10 terminals on the global scale. However, SEO scores of the terminals' official websites are found to be significantly low. Considering these low SEO scores, it is recommended to update the content more frequently in order to attract the visitors. On the other hand, providing interactive modules and downloadable features on the websites has significant value on the website rankings. In terms of social media platforms, it would be again hard to state that Turkish container terminals are doing well as most of the terminals are not present or not active on these platforms. However, Marport should be considered as a good example with their successfully managed social media accounts. Owing to the rich content (diversified into four content categories namely general company information, service related information, industry related information and greetings/wishes) social media accounts of this terminal sets an important example on how social media accounts should be managed within port marketing communication.

The limitation of this study is that the sample size is limited to 10 container terminals. However, this study is an exploratory study that will guide further researches on this area and this industry. Especially, increasing the size of the sample and digital features will improve the efficiency of this research. In addition to that, we strongly advice for the further researches to apply longitudinal studies. We do expect that comparisons will have an importance on guiding greater practices in this field.

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SUPPLY CHAIN PERFORMANCE: MEASURING THE IMPACT OF SUPPLY CHAIN ORIENTATION AND BRAND EQUITY

Ebru SÜRÜCÜ[1], Gül DENKTAŞ ŞAKAR[2]

Abstract – *Recent studies show that strong brands are counted as important competitive advantage for firms during customers' evaluation and choice procedure. Even though, there is considerable research on branding of consumer goods, there are still few studies related to branding in the context of business-to-business markets (B2B) and in supply chain management literature as well. Since, there is a gap about how brand related factors affects supply chain performance, this study aims to fulfill this gap by extending existing brand theory with new setting. Another considerable gap in the literature is the lack of understanding regarding the importance of suppliers in building a strong supply chain within the context of performance, orientation, and brand equity. Although there is research on the manufacturer's supply chain performance focusing on the companies' brand equity factors, the impact of companies' suppliers on the supply chain performance from the view point of supply chain orientation and suppliers' brand equity factors is widely neglected. Hence, this study also aims to reveal the perspectives of manufacturing companies regarding their most important suppliers in terms of supply orientation, suppliers' brand equity and supply chain performance. For this purpose, an online questionnaire is prepared and sent to supply chain managers of manufacturing companies in Aegean region. Lastly, study findings as well as limitations of the study are explained and directions for future research are offered.*

Keywords – *Brand Awareness, Brand Equity, Brand Image, Brand Trust, Supply Chain Orientation, Supply Chain Performance*

INTRODUCTION

In the global networked business environment, effective supply chain management is essential to the survival and success of the enterprise; but acquiring and maintaining the performance is becoming increasingly difficult [21]. Brands are important market-based (intangible) assets that help firms to create external relationships in the marketplace [34]. Brand is *"name, term, sign, symbol, or design, or a combination of them, which is intended to identify the goods and services of one seller or a group of sellers and to differentiate them from those competitors"* [54]. Marketing scholars have offered that firms, which can successfully manage their brand, can only achieve satisfying level of supply chain performance. This new level of supply chain competition brings completely new challenges. Today's business-to-business markets, brands, and their power is critically important and linked to the concept of firm performance [50] - [85]. Brand equity is an important consideration for service marketers [20] - [46] - [47] and should be managed like an asset [3] - [20]- [50]. For modern business environment, intangible firm assets like brand and brand related factors, which is sustainable added value to brand name, has been a major focus area since early 1990s [50] - [98]. These factors are brand equity, brand awareness, brand image and brand trust [53].

Although there is considerable research on consumer brands an increasingly body of literature on industrial and service brands, there are few studies of how a supplier's brand affects overall supply chain performance. Thus, as an exploratory study, this study examines the relationships between specific characteristics of a supplier's brand equity factor within supply chain orientation and supply chain performance of manufacturing companies. This study is unique since it investigates the relationship between a supply chain orientation, supplier's brand equity and supply chain performance. The study offers the brand literature with empirical evidence that the supply chain orientation improves supplier's brand equity. In this manner, brand equity is considered to include three dimensions as; brand awareness, brand image and brand trust. For the supply chain performance literature, this study relates a firm's supply chain performance to a key marketing tool, the supplier's brand. The next section describes the constructs contained in the model and outlines the overall conceptual model. Then research methodology is described which is followed by the study findings. Following the discussion, limitations and suggestions for the future research are provided.

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LITERATURE REVIEW

Supply Chain Orientation

Supply chain orientation (SCO) is defined as *"the recognition by a company of the systemic, strategic implications of the activities and processes involved in managing the various flows in a supply chain"* [67]. SCO affects directly firm performance, whilst developing and building sustained relationships with supply chain partners [68]. So, if a firm wants to maintain a positive relationship with their supply chain partners, it should have supply chain orientation. Firm's characteristics like trust, commitment, the sharing of common relationship-building foundations, compatibility between organizations and the support of executive-level management, help to develop firm's SCO [92]. SCO enables creating value for firm, while maintaining a desired level of customer service [70]. SCO elements, which are credibility, benevolence, commitment, corporative norms, organizational compatibility, and top management support, are the main behavior elements that help firms to create supply chain management philosophy [68]. Credibility is defined as "*the belief that a trading partner is an expert and reliable in conducting transactions effectively*" [87]. Within the supply chain members, a firm must be trusted and credible. Firms that want to trust their supply chain partners must demonstrate an expertise within their field and be a reliable source of knowledge to their upstream and downstream partners [33]. Benevolence is described as a firm's belief that its partner is interested in the firm's welfare, is willing to accept short-term dislocations, and will not take unexpected actions that would have a negative impact on the firm [4] - [56] - [93]. When trust achieved between two firms, it will lead to positive working relationships that also leads to generate profitable results for both firms. Commitment, which is the third behavioral element, is "*a multi-dimensional construct reflected by the belief in and acceptance of the organization's goal and values, a willingness to exert effort on behalf of the organization, and a strong desire to maintain membership in an organization*" [76]. This relationship creates such a satisfaction that firm does not receive additional benefits by switching supply chain partners [28]. Corporative norms are defined as "*the perception of the joint efforts of both the supplier and distributor to achieve mutual and individual goals successfully while refraining from opportunistic actions"* [12] - [87] - [93]. Cooperative norms help to establish working procedures for how firms will manage problems and share rewards [92]. Organizational compatibility is defined as *"complementary goals and objectives, as well as similarity in operating philosophies and corporate cultures"* [10]. Firms that want to be compatible organizationally, must operate with similar operating principles, employ a similar cultural environment, and utilize comparable management techniques [92]. Top management support, which includes leadership and commitment to change, is an important antecedent to supply chain management, and the absence of it is a barrier to supply chain management [44] - [58] - [62] - [93]. Without the support of executive-level managers, it is possible that the buy-in needed by a firm's employees to support changes in procedures or processes many not occur [92]. In the light of the critical importance of suppliers' brand factors for suppliers' supply chain orientation the following hypotheses and sub-hypotheses are generated in the study.

Hypothesis 1: Suppliers' supply chain orientation affects suppliers' brand factors positively.

- **Hypothesis 1.1:** Suppliers' supply chain orientation affects suppliers' brand awareness positively.
- **Hypothesis 1.2:** Suppliers' supply chain orientation affects suppliers' brand image positively.
- **Hypothesis 1.3:** Suppliers' supply chain orientation affects suppliers' brand trust positively
- **Hypothesis 1.4:** Suppliers' supply chain orientation affects suppliers' brand equity positively.

Brand Awareness

One of the components of brand equity is brand awareness (BA), which is defined by Aaker (1991) *"the ability of a potential buyer to recognize or recall that a brand is a member of a certain product category* [1]*"*. Keller (1993) defined brand awareness as *"the customers' ability to recognize the brand as reflected by their ability to identify the brand under different conditions and to link the brand name, logo, symbol and so forth to certain associations in memory* [45]*"*. The most fundamental element of brand awareness is brand name [22] and most of the time B2B firms only focus on their brand name familiarity without developing a more comprehensive brand identity [41]. This is why, for many B2B firms creating brand awareness –ability to recognize or recall a brand- is the key branding strategy [15] - [74]. Building brand awareness allows the formation of brand associations, which consist of attributes and benefits about a brand, which are relevant to the industrial buyer [34]. In B2B context, knowledge about brand can be enhanced by brand awareness [48]. Since brand awareness can be used as a heuristic purchasing decision (Hoyer and Brown, 1990; MacDonald and Sharp, 2000), it can increase supply chain performance which brand is included. Brand awareness acts as a strong signal of product quality and supplier commitment [42] - [59] - [66] because high levels of supplier investment (exhibitions, advertising or packaging) are usually necessary to build high brand awareness [41]. Thus, high-quality firms can only meet high amount of investments for having brand awareness [29] - [69]. Moreover, brand awareness can be the reflection of presence and substance since high levels of awareness means that firm has been in business for a long time and firm's products has been widely distributed [1] - [42].

Since brand awareness is one of the components of brand equity, it is expected that changes in brand awareness affect brand equity [77]. Moreover, supplier's brand with higher levels of awareness within supply chain is expected to affect supply chain performance overall compared with unknown supplier's brand. Researchers argue that relationship between supplier's brand awareness and supplier's brand equity in consumer context will be in the same vein as it is in B2B service context [1] - [22] - [35]. Moreover, it is argued in this study that supplier's brand awareness affects overall supply chain performance as well. Based on the relevant literature, the hypotheses for brand awareness are proposed as below:

Hypothesis 2.1: Suppliers' brand awareness affects suppliers' brand equity positively.
Hypothesis 2.2: Suppliers' brand awareness affect supply chain performance positively.

Brand Image

Marketing researchers suggested that brand image is a vital element of brand equity [45]. Brand image (BI) is defined as a subjective and perceptual phenomenon formed through consumer interpretation; including certain characteristics of the product or service's symbolic meanings [26] - [75]. Brand image describes the consumer's thoughts and feelings towards the brand [82]. Brand image can be seen as the overall mental image that consumers have of a brand, and its uniqueness in comparison to the other brands [30]. Moreover, brand image plays an important role in B2B markets where tangible quality features are harder to distinguish [72]. In B2B market relations, such as supply chain relationships, brand image becomes really important because every interaction between a focal company and its stakeholders becomes an input for brand image [23]. Aaker (1996) stated that, firm attributes like experience and reputation are centered in B2B brand image are generally a company's most valuable but underused assets [2]. Some of the researchers mention that brand image is an important industrial marketing tool [63] - [84] - [86] - [89] - [73]. However, there is little evidence about that B2B customers are influenced by emotional associations they make with their supplier [81].

It is hard to imitate and it becomes costly to compete for other firms when a firm has positive and strong brand image in customers' mind [13]. Focal firms with strong brand images can also have this favorable position. Moreover, supplier's brand with higher levels of image within supply chain is expected to affect supply chain performance overall compared with unknown supplier's brand. It is argued that supplier's brand image affects overall supply chain performance. The hypotheses for brand image are proposed as below:

Hypothesis 3.1: Suppliers' brand image affects suppliers' brand equity positively.
Hypothesis 3.2: Suppliers' brand image affects supply chain performance positively.

Brand Trust

Brand trust (BT) is a component of brand equity [53] and *"perhaps the single most powerful relationship marketing tool available to a company"* [7]. BT consists of past experience and previous interactions [78] - [79]. BT is defined as *"the willingness of the average consumer to rely on the ability of the brand to perform its stated function"* [16], and comprised of after consumers' evaluation of firms' offerings. If firms are able to give belief of safety, honesty and reliability about their brands to consumers, brand trust can be achieved [27]. Brand trust has two dimensions; fiability and intentionality [25]. First dimension is related to the satisfying consumers' needs and demands; while creating idea on consumers' mind that brand accomplishes its value promising [24]. Moreover, this dimension focuses on satisfying consumers' needs in consistently positive ways. Second dimension, intentionality is covered with the belief that the brand will not take advantage of the consumer's vulnerability [25]. Trust is an important variable in building strong supply chain networks [83] and it is related with brand equity [53]. In the supply chain, partners develop trust in a brand based on positive beliefs considering their expectations and future performances of firm [5]. The domain of trust in this study is how it affects suppliers' brand equity and how suppliers' brand trust affects supply chain performance overall. Since brand trust one of the components of brand equity, it is expected that changes in brand trust affect brand equity.

Moreover, supplier's brand with higher levels of trust within supply chain is expected to affect supply chain performance overall compared with unknown supplier's brand. Moreover, we argue that supplier's brand image affects overall supply chain performance as well. Based on the literatures, the hypotheses for this research is proposed as below:

Hypothesis 4.1: Suppliers' brand trust affects suppliers' brand equity positively.
Hypothesis 4.2: Suppliers' brand trust affects firms' supply chain performance positively.

Brand Equity

Brand equity (BE) has been viewed from a variety of perspectives, which are marketing and finance [71]. Brand equity is the "added value" with which a brand endows a product, whilst imparts competitive advantage to the firm [31]. For the financial perspective, brand equity is defined as "*the incremental cash flow that accrue to branded products over unbranded products"* [88]. Most widely cited brand equity conceptualizations are those of [1] and [45]. Aaker (1991) defined brand equity as *"a set of brand assets and liabilities linked to a brand, its name and symbol that add to or subtract from the value provided by a product or service to a firm and/or to that firm's customers* [1]*".* According to Aaker (1996), brand awareness, brand association, brand loyalty, and perceived quality are the sources of brand equity knowledge structure [2]. Keller (1993) defined as *"the differential effect of brand knowledge on consumer response to the marketing of a brand"* and developed the behavioral concept of consumer-based brand equity (CBBE), which consists of the two dimensions of brand awareness and brand image and is defined as the differential effect of brand knowledge on customer response to the marketing of the brand [45]. According to Keller (1993), brand equity consists of brand awareness, brand image and brand loyalty [45]. Both scholars offered that the strength of brand can be measured by examining consumers' associations with a brand and their positive responses to the brand [15]. In the literature, measurement of consumer-based brand equity has been studied with five dimensions – brand awareness, perceived quality, brand association, brand image and brand loyalty- [18]. Those five dimensions have been used partially or wholly in studies [11] - [14] - [45] - [46] - [49] - [51] - [53] - [64] - [95] - [96] - [97]. In this study, brand awareness, brand image and brand trust are used as dimensions of brand equity. In B2B marketing, brand equity is a critical competitive driver, as it is in consumer marketing [55] - [73] - [94]. When a brand's strength increases, B2B market buyers become more likely to repurchase and pay a price premium [6] - [43] - [52] - [80] - [91]. Supplier's brand with higher levels of equity within supply chain is expected to affect supply chain performance overall compared with unknown supplier's brand. Thus, it is argued that supplier's brand equity affects overall supply chain performance of the company. The hypotheses are proposed as below:

Hypothesis 5: Suppliers' brand equity affects supply chain performance positively.

Supply Chain Performance

While measuring performance in the supply chain, the measurement system may reflect a system of measuring the immeasurable. In supply chain performance measurement, control is no longer based on ownership only, but rather on networking across interfaces. Activities that are not under control of an individual company (manufacturer) have to be measured and controlled (by the manufacturer and its supply chain partners), making the supply chain transparent, to a level not experienced before and leading the way for performance improvements [38] - [40]. Researchers and practitioners have developed and improved measures that can be used to establish supply chain performance, since importance of management of supply chain has been increased. The measurement of supply chain performance requires the creation of inter- and intra- organization assessment system. These systems can be used to identify opportunities for improved supply chain efficiency and competitiveness, to help understand how companies operating in supply chains affect each other's performance, to support the supply chain in satisfying consumer requirements and to assess the results of an implemented initiative [65]. In the literature, there are many different types of measurement for supply chain performance [36] - [60]. A framework can include three major categories of metrics: service measures, cost measures and return on assets measures. Considering service, firms can use systems to measure specific elements like order cycle time, order fill rates, damage rates, error rates in picking orders, achievement of the "perfect order" and so on [9] - [90]. For cost measures, firms can use cost per order, logistics cost per unit and cost per unit for each functional area of logistics (storage cost per unit, per square foot). For return on asset measure, firms generally determine the extent to which their investment in logistics assets is earning the desired financial returns [9].

Supply chain performance measurement can be done in strategic, tactical, and operational levels [37]. Also, different types of supply chain performances are used in literature [17] - [19] - [21] - [57] - [60] - [61]. As a performance measures; average finished goods inventory, demand fulfillment [61]; order cycle time, order completeness [17]; delivery performance, lead time, level of defects and responsiveness [57]; material inventory, work in process inventory, fill rates, stock out frequencies and lead time [19]; inventory levels, inventory investment, order fill rate, line item fill rate and average number of days late [21]; inventory turns, line item fill rate, order item fill rate, total order cycle time, total response time to an order, average backorder levels and average variability in delivery [60] are employed by the researchers. However, it is clear that researchers haven't reached a consensus about stable set of measures that is used for measuring performance of the supply chain for all types of studies [8].

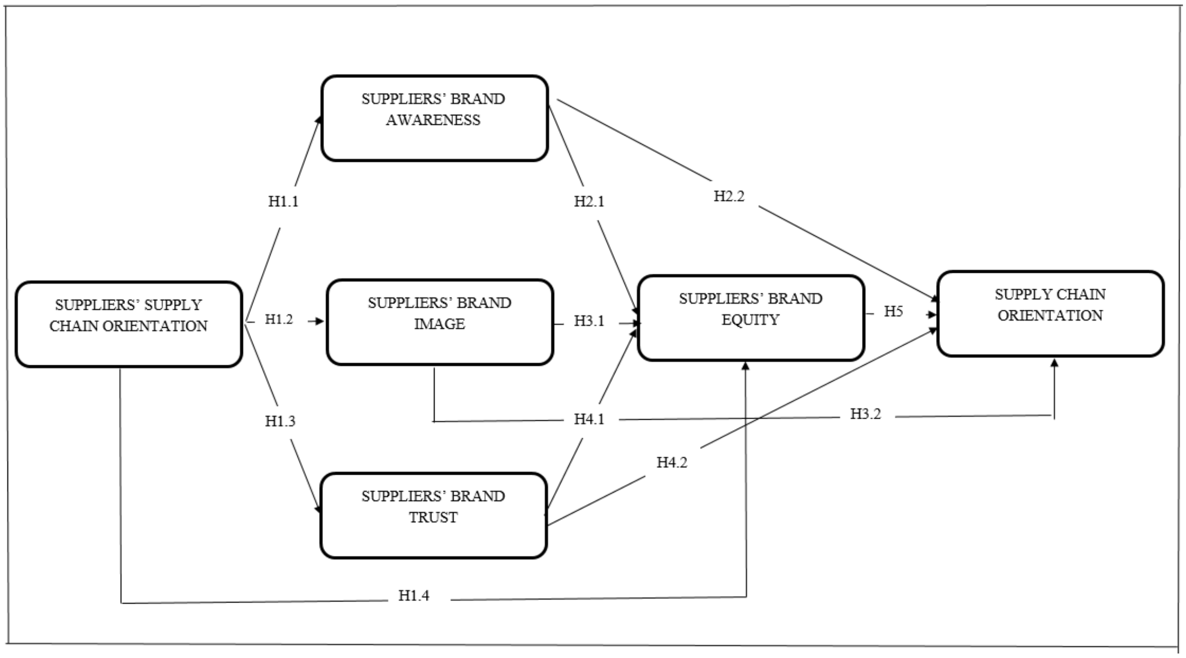
METHODOLOGY

A survey method is employed to test measures of supply chain orientation, brand factors- brand awareness, brand image, brand trust and brand equity-, in the context of supply chain performance. Measurement items were drawn from existing scales as reported in the following section.

Scale Development

Measurement items for each construct are borrowed from the relevant literature. Moreover, interviews have been made with logistics industry experts to identify appropriate language for adopting measurement items to the supply chain management context. The questionnaire included five parts. First two parts included basic demographic information about firm and respondents. Third, fourth and fifth parts were used to gather information about assessing market orientation, brand related factors and supply chain performance, respectively. All items except demographic information were measured on a 5-point Likert-type scale from "strongly disagree" (1) to "strongly agree" (5). The informants were asked to answer questions according to their perception of brand related factors. Third part measures SCO with the help of credibility, commitment and corporative norms elements. The items for credibility and commitment were adopted from [87], and cooperative norms from [12]. Fourth part measures brand equity factors. Items for brand awareness are adopted from [23] - [96] while the items for brand image are adopted from [23]. Measurement items for brand trust are adopted from [39]. Lastly, items for brand equity are adopted from [23] - [50]. The last part of the questionnaire measures supply chain performance. For supply chain performance, lead-time, inventory management, time to market, quality, customer service and flexibility [8] and order fill rates, error rates in picking orders [9] - [90] variables were employed. Also, during the interviews, opinions of logistics industry and supply chain experts about the supply chain performance measurement items were taken, and according to their suggestions, five more variable were added to supply chain performance measurement scale as cost, delivery on time, delivery on right place, delivery on right amount of product and high accuracy of order estimation. In accordance with the relevant literature and the items employed in the questionnaire, a conceptual model visualized in Figure 1 is suggested.

Figure 1. Conceptual Model



Sample and Data Collection

This study examines supply chain performance at the business unit level. The most appropriate informant for this study was considered as the supply chain manager, and in cases where firms did not have a supply chain manager, procurement/purchasing manager, marketing manager and general/vice managers were added as potential participants. Four-week deadline has been set and within this duration, 35 managers responded to the survey. Online survey was sent to the mailing list of Aegean Exporters' Association, ESBAS Aegean Free Zone and Manisa Organized Industrial Zone. Although reminding e-mails were sent to these mailing lists, only a total of 35 usable questionnaires are collected. All analyses have made with SPSS 21.0. Table 1 shows the characteristics of the participant firms.

Table 1. Characteristics of Sample

Company Characteristics	Number of Respondents (percent)
Industry:	
Mining	2 (5.7)
Textile	3 (8.6)
Chemistry, petrol, plastic	3 (8.6)
Energy	3 (8.6)
Metal	3 (8.6)
Machine & equipment	1 (2.9)
Automotive	11 (31.4)
Food	4 (11.4)
Others	3 (8.6)
Tota	35 (100)
Annual Sales:	
≤ 100 million TL	15 (42,9)
100,000,001 TL – 500 million TL	8 (22,9)
500,000,001 TL – 1 billion TL	1 (2,9)
1,000,000,001 TL – 5 billion TL	4(11,4)
Not Reported	7 (20)
Total:	35 (100)
Number of Employees:	
≤500	27 (77.1)
501 – 1,000	3 (8.6)

1,001-5,000	4 (11.4)
>10,001	1 (2.9)
Total	35 (100)

Reliability and Validity

Cronbach's Alpha value was 0.822 for SCO variables, 0.893 for suppliers' brand factors and 0.944 for SCP factors. Since Cronbach's Alpha values are greater than 0.7, all items were considered reliable in the study.

Table 2. Reliability Statistics

	Cronbach's Alpha	N of Items
Supply Chain Orientation	.822	5
Suppliers' Brand Factors	.893	18
Supply Chain Performance	.944	13

Factor Analysis Results

SPSS 21.0 software is used to analyze the data. Data is examined in the SPSS output for Kaiser-Meyer-Olkin (KMO) on 35 samples for SCO, suppliers' brand factors and SCP. As a result, which is shown in Table 3, the KMO measure indicated a very high sampling adequacy and good preconditions for factor analyses. In addition, results of Bartlett's Test for Sphericity had significant differences. According to the below test results, the samples were suitable for factor analyses.

Table 3. KMO and Bartlett's Test of SCO, Suppliers' Brand Factors & SCP

	SCO	Suppliers' Brand Factors	SCP
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.788	.650	.847
Bartlett's Test of Sphericity			
Approx. Chi-Square	59,304	416,067	342,829
Df	10	153	78
Sig.	,000	,000	,000

An exploratory factor analysis PCA (Principal Component Analysis) and varimax rotation was conducted. Factors are listed in the Table 4.

Table 4. Factors for SCO

Factors		Alpha	Mean *	Std.	I**	II
Factor 1: Corporate Norms-Related Orientation		**.763**				
SCO4	Our most important supplier is willing to make cooperative changes with our supply chain.		3.80	.759	.910	
SCO5	Our most important supplier views its business as a value added piece of work to whole supply chain.		3.86	.974	.793	
Factor 2: Credibility & Commitment Related Orientation		**.757**				
SCO2	Our most important supplier is knowledgeable regarding our products and/or services when they are doing business with our supply chain members.		4.11	.583		.830
SCO1	Promises made to our supply chain members by our most important supplier is reliable.		3.94	.802		.777

SCO3	Our most important supplier is patient with supply chain members when they make mistakes that cause trouble to suppliers but are not repeated.		3.71	.860		.768

*Five-point scale 1: poor 5: excellent
**The Roman numerals refer to the number of factors
(Source: Authors)

Factor 1 measures whether the suppliers try to achieve mutual and individual goals while avoiding opportunistic actions and the factor is named as "corporate-norms related orientation". According to factor analysis results, this factor contains two variables. The highest factor loading is 0.910, which measures corporative norms. SCO5 is the second variable that has the 0.793 factor loading and it measures corporative norms. Cronbach's Alpha value is 0.763 for the Factor 1. **Factor 2** measures whether the supply chain partner is a reliable and sees the supply chain as an organization and behaves on behalf of organization's favor. The factor is named as "credibility and commitment-related orientation". According to factor analysis results, this factor contains three variables. SCO2 has the highest factor loading is with 0.830 point, which measures credibility. SCO1 is the second variable that has the 0.777 factor loading measures credibility and lastly SCO3, which measures commitment, has 0.768 factor loading. Moreover, Cronbach's Alpha value is 0.757 for the Factor 2.

Factors for suppliers' brand factors are shown in Table 5.

Table 5. Factors for suppliers' brand factors

Factors		**Alpha**	**Mean ***	**Std.**	**I****	**II**	**III**	**IV**	**V**
Factor 1: Suppliers' brand image		**.892**							
BI2	We can reliably predict how the most important supplier in our supply chain will perform.		3.77	.910	.864				
BI1	The most important supplier in our supply chain is known as a firm that takes good care of its trade partners.		3.83	.822	.851				
BI5	The most important supplier in our supply chain is a prestigious firm.		4.11	.718	.829				
BT1	The most important supplier in our supply chain meets its obligations to us.		4.00	.767	.801				
BI3	In comparison to other suppliers, the most important supplier in our supply chain is known to consistently deliver very high quality.		3.86	.845	.614				
Factor 2: Suppliers' brand equity		**.823**							
BE5	We feel strong emotional connection to our most important supplier's brand.		2.71	1.017		.873			
BE1	We are willing to pay more in order to do business with our most important supplier.		2.80	.964		.648			
BE3	The most important supplier' brand gives us an advantage over our competitors.		3.17	1.175		.625			
BE2	The most important supplier's brand is different from other suppliers.		3.74	.741		.488			
BE4	We perceive our most important supplier's brand as prestigious.		3.57	1.092		.482			
Factor 3: Suppliers' brand awareness		**.744**							
BA4	Compared to other suppliers, our most important supplier is a leading brand in the industry.		4.09	.742			.869		
BA1	The name of our most important supplier is well-known in our industry.		4.34	.873			.772		

BA2	The most important supplier in our supply chain is the industry leader in brand awareness.		3.73	1.017			.631		
Factor 4: Suppliers' brand trust		**.654**							
BT2	The most important supplier in our supply chain is trustworthy.		3.89	.900				.732	
BA3	Our most important supplier is recognized by other members of our supply chain as a strong trade partner.		3.66	.906				.668	
BI4	The most important supplier in our supply chain has rich brand history.		3.71	.710				.605	
Factor 5: Suppliers' brand communication		**.847**							
BE7	We pay attention advertising and the information that comes from our most important supplier.		3.37	.973					.954
BE6	We remember adverting and information that comes from our most important supplier.		3.23	1.140					.855

*Five-point scale 1: poor 5: excellent
**The Roman numerals refer to the number of factors

Factor 1 measures whether supplier takes good care of its partners (BI1), produce high quality products constantly (BI3), fulfil its responsibilities (BT1), is a respected firm (BI5) and manufacturer's trust about its future performance (BI2). Factor 1 named as "suppliers' brand image". **Factor 2** measures whether a manufacturer feels emotional attachment to supplier (BE5), ready to pay more to continue doing business with that supplier (BE1), gets an edge over competitors by working with that supplier (BE3), feels prestigious by working with that supplier (BE4) and the brand of supplier is different than competitors' brand (BE2) and the factor is named as "suppliers' brand equity". **Factor 3** measures whether the supplier is a leading brand in the industry (BA4), supplier's name is a well-known (BA1) and supplier's brand is a well-recognized (BA2). For these reasons, factor is named as" suppliers' brand awareness". **Factor 4** measures whether the supplier has a rich brand history (BI4), has a trustworthy brand (BT2) and is powerful partner (BA3) from the perspective of manufacturer and it is named as "suppliers' brand trust". **Factor 5** measures whether manufacturer gives attention (BE6) and remembers (BE7) the information and advertisements sent by supplier. Even though these variables were considered as brand equity variables at the beginning stage of the study, factor analysis results showed that, they are grouped under different factor and it is named as "suppliers' brand communication".

In the paper, an exploratory factor analysis PCA (Principal Component Analysis) and varimax rotation conducted on responses from 35 individuals for each item. The Kaiser rule is to drop all components with eigenvalues under 1.0. However, according to anti-image matrix results, it is seen that SCP6, SCP9, SCP12 and SCP13 MSA value smaller than 0.5 [32]. Thus, those variables are expelled from analysis. Factors for SCP is shown in Table 6.

Table 6. Factors for Supply Chain Performance

Factors		**Alpha**	**Mean ***	**Std.**	**I****	**II**
Factor 1: Cost and Service-Based Performance		**.897**				
SCP11	Working with the most important supplier in our supply chain enhances supply chain performance with regard to flexibility.		3.83	.785	.882	
SCP10	Working with the most important supplier in our supply chain enhances supply chain performance with regard to customer service.		3.69	.932	.851	
SCP5	Working with the most important supplier in our supply chain enhances supply chain performance with regard to requested amount delivery.		3.97	.857	.774	

SCP1	Working with the most important supplier in our supply chain enhances supply chain performance with regard to cost.		3.89	.900	.747	
SCP8	Working with the most important supplier in our supply chain enhances supply chain performance with regard to time to market.		3.77	.910	.632	
Factor 2: Time and Operation-Based Performance		**.870**				
SCP2	Working with the most important supplier in our supply chain enhances supply chain performance with regard to on time delivery.		3.97	.747		.841
SCP4	Working with the most important supplier in our supply chain enhances supply chain performance with regard to delivery on right place.		3.80	.833		.807
SCP7	Working with the most important supplier in our supply chain enhances supply chain performance with regard to smallest error rates in picking order.		4.00	.728		.786
SCP3	Working with the most important supplier in our supply chain enhances supply chain performance with regard to lead-time.		3.89	.832		.771

*Five-point scale 1: poor 5: excellent
**The Roman numerals refer to the number of factors

Factor 1 measures supply chain performance with flexibility (SCP11), customer service (10), requested amount delivery (SCP5), cost (SCP1) and time to market (SCP8) and this factor is named as "cost and service-based performance". **Factor 2** measures supply chain performance with on time delivery (SCP2), delivery on right place (SCP4), smallest error rates in picking order (SCP7) and lead-time (SCP3).

Although a preliminary conceptual model is given in the previous section, there was a need for modification in the conceptual model since SCO factor was divided into two as *"corporate norms-related and credibility"* and *"commitment-related orientation"*; while supplier's brand factors were divided into 5 factors as *"supplier's brand image", "supplier's brand equity", "supplier's brand awareness", "supplier's brand trust"* and a new factor of *"supplier's brand communication"* was added. Moreover, in the SCP part, two new factors, which are *"cost and service-based performance" and "time and operation-based performance"* were added. Thus, modified conceptual model and hypotheses are shown below.

H1. Suppliers' supply chain orientation affects suppliers' brand factors positively.

H.1.1. *Suppliers' corporate norms affects brand factors positively.*

H1.1.a *Suppliers' corporate norms affects brand image positively.*

H1.1.b *Suppliers' corporate norms affects brand awareness positively.*

H1.1.c *Suppliers' corporate norms affects brand trust positively.*

H1.1.d *Suppliers' corporate norms affects brand communication positively.*

H1.2. Suppliers' credibility & commitment affects brand factors positively.

H1.2.a *Suppliers' credibility & commitment affects brand image positively.*

H1.2.b *Suppliers' credibility & commitment affects brand awareness positively.*

H1.2.c *Suppliers' credibility & commitment affects brand trust positively.*

H1.2.d *Suppliers' credibility & commitment affects brand communication positively.*

H2. Suppliers' supply **chain orientation affects suppliers' brand equity positively.**

H2.1 *Suppliers' credibility & commitment affects brand equity positively.*

H2.2 *Suppliers' corporate norms affects brand equity positively.*

H3 Suppliers' brand factors affects suppliers' brand equity positively.

H3.1 *Suppliers' brand awareness affects suppliers' brand equity positively.*

H3.2 *Suppliers' brand image affects suppliers' brand equity positively.*

H3.3 *Suppliers' brand trust affects suppliers' equity positively.*

H3.4 *Suppliers' brand communication affects suppliers' brand equity positively.*

H4 ***Suppliers' brand equity affects supply chain performance positively.***

H4.1 *Suppliers' brand equity affects supply chain's cost & service-based performance.*

H4.2 *Suppliers' brand equity affects supply chain's time & operation-based performance.*

H5 ***Suppliers' brand factors affects supply chain performance positively.***

H5.1 ***Suppliers' brand awareness affects supply chain performance positively.***

H5.1.a *Suppliers' brand awareness affects supply chain's cost & service-based performance.*

H5.1.b *Suppliers' brand awareness affects supply chain's time & operation-based performance.*

H5.2 ***Suppliers' brand image affects supply chain performance positively.***

H5.2.a *Suppliers' brand image affects supply chain's cost & service-based performance.*

H5.2.b *Suppliers' brand image affects supply chain's time & operation-based performance.*

H5.3 ***Suppliers' brand trust affects supply chain performance positively.***

H5.3.a *Suppliers' brand trust affects supply chain's cost & service-based performance.*

H5.3.b *Suppliers' brand trust affects supply chain's time & operation-based performance.*

H5.4 ***Suppliers' brand communication affects supply chain performance positively.***

H5.4.a *Suppliers' brand communication affects supply chain's cost & service-based performance.*

H5.4.b *Suppliers' brand communication affects supply chain's time & operation-based performance.*

Correlation Analysis Results (Hypotheses Testing)

In the study, parametric tests are implemented to see whether there is a relationship between demographic variables (industry, firm size and ownership structure) and supply chain performance. To see whether there is a difference between industry type and supply chain performance, first Levene test is applied which controls homogeneity. After, Levene test is applied, SPSS cannot able to perform tests because of low variable size.
To see whether there is a difference between firm size and supply chain performance, again Levene test is applied and results showed that it is applicable for one-way ANOVA. After, seeing Levene test result is proper, then one-way ANOVA is applied however, it is found that there is no difference according to firm size for supply chain orientation.
Moreover, to see whether there is a difference between ownership structure and supply chain performance, again Levene test is applied and results showed that it is applicable for one-way ANOVA. After, seeing Levene test result is proper, then one-way ANOVA is applied however, it is found that there is no difference according to ownership structure for supply chain orientation.

In this study, suppliers' orientation and suppliers' brand equity factors affects supply chain orientation hypotheses tested with regression analysis. Before starting to form regression model, assumptions are tested. For this purpose, the assumption of normality for dependent and independent variables checked and it is observed that normal distribution is not degenerated. After that, by controlling homoscedasticity matrix, it is seen that the assumption of constant variance is proper.

After verifying assumptions, recommended hypotheses tested with regression analysis and results are shown in Table 8, Table 9, Table 10, Table 11 and Table 12. According to regression analysis results, H1.1.a, H1.1.c, H1.2.a, H1.2.c, H2.1, H3.3, H4.1, H5.2.a, H5.2.b, H5.3.a and H5.3.b found validated respectively. Suppliers' corporate norms affects suppliers' brand image ($R^2 = 0.528$, $p = 0.001 < 0.05$), suppliers' brand trust ($R^2 = 0.439$, $p = 0.008 < 0.05$) and suppliers' brand equity positively ($R^2 = 0.343$, $p = 0.044 < 0.05$); while suppliers' credibility & commitment affects suppliers' brand image ($R^2 = 0.439$, $p = 0.008 < 0.05$) and suppliers' brand trust positively ($R^2 = 0.586$, $p = 0.000 < 0.05$). According to results, suppliers' brand trust affects suppliers' equity positively ($R^2 = 0.349$, $p = 0.040 < 0.05$). Moreover, it is seen that suppliers' brand equity affects supply chains' cost & service-based performance positively ($R^2 = 0.526$, $p = 0.001 < 0.05$). Thus, it is seen that suppliers' brand image affects supply chain's cost & service-based performance ($R^2 = 0.396$, $p = 0.018 < 0.05$) and supply chains' time & operation-based performance positively ($R^2 = 0.059$, $p = 0.000 < 0.05$). Lastly, it is found that suppliers' brand trust affects supply chain's cost & service-based performance ($R^2 = 0.512$, $p = 0.002 < 0.05$) and supply chains' time & operation-based performance positively ($R^2 = 0.607$, $p = 0.000 < 0.05$).

Table 8. Results of Hypothesis Tests (H1)

Hypothesis		Pearson Correlation
H1.	**Suppliers' supply chain orientation affects suppliers' brand factors positively.**	
H.1.1.	***Suppliers' corporate norms affects brand factors positively.***	
H1.1a	*Suppliers' corporate norms affects brand image positively.*	**.528****
H1.1.b	*Suppliers' corporate norms affects brand awareness positively.*	.188
H1.1.c	*Suppliers' corporate norms affects brand trust positively.*	**.439****
H1.1.d	*Suppliers' corporate norms affects brand communication positively.*	.064
H1.2.	**Suppliers' credibility & commitment affects brand factors positively.**	
H1.2.a	*Suppliers' credibility & commitment affects brand image positively.*	**.439****
H1.2.b	*Suppliers' credibility & commitment affects brand awareness positively.*	.249
H1.2.c	*Suppliers' credibility & commitment affects brand trust positively.*	**.586****
H1.2.d	*Suppliers' credibility & commitment affects brand communication positively.*	-.077

*Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 9. Results of Hypothesis Tests (H2)

Hypothesis		Pearson Correlation
H2.	**Suppliers' supply chain orientation affects suppliers' brand equity positively.**	
H2.1	*Suppliers' corporate norms affects brand equity positively.*	**.343***
H2.2	*Suppliers' credibility & commitment affects brand equity positively..*	.305

*Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 10. Results of Hypothesis Tests (H3)

Hypothesis		Pearson Correlation	Sig. (2-tailed)	Result
H3	**Suppliers' brand factors affect suppliers' brand equity positively.**			
H3.1	*Suppliers' brand awareness affects suppliers' brand equity positively.*	0.72	.680	**Rejected**
H3.2	*Suppliers' brand image affects suppliers' brand equity positively.*	.309	.071	**Rejected**
H3.3	*Suppliers' brand trust affects suppliers' equity positively.*	**.349***	.040	**Accepted**
H3.4	*Suppliers' brand communication affects suppliers' brand equity positively.*	-.068	,698	**Rejected**

*Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 11. Results of Hypothesis Tests (H4)

Hypothesis		Pearson Correlation	Sig. (2-tailed)	Result
H4	***Suppliers' brand equity affects supply chain performance positively.***			
H4.1	*Suppliers' brand equity affects supply chain's cost & service-based performance.*	**.526****	.001	**Accepted**
H4.2	*Suppliers' brand equity affects supply chain's time & operation-based performance.*	.260	.131	**Rejected**

*Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 12. Results of Hypothesis Tests (H5)

Hypothesis		Pearson Correlation	Sig. (2-tailed)	Result
H5	***Suppliers' brand factors affects supply chain performance positively.***			

H5.1	***Suppliers' brand awareness affects supply chain performance positively..***			
H5.1.a	*Suppliers' brand awareness affects supply chain's cost & service-based performance.*	-.024	.889	**Rejected**
H5.1.b	*Suppliers' brand awareness affects supply chain's time & operation-based performance.*	.270	.117	**Rejected**
H5.2	***Suppliers' brand image affects supply chain performance positively.***			
H5.2.a	*Suppliers' brand image affects supply chain's cost & service-based performance.*	**.396***	.018	**Accepted**
H5.2.b	*Suppliers' brand image affects supply chain's time & operation-based performance.*	**.059****	.000	**Accepted**
H5.3	***Suppliers' brand trust affects supply chain performance positively.***			
H5.3.a	*Suppliers' brand trust affects supply chain's cost & service-based performance.*	**.512****	.002	**Accepted**
H5.3.b	*Suppliers' brand trust affects supply chain's time & operation-based performance.*	**.607****	.000	**Accepted**
H5.4	***Suppliers' brand communication affects supply chain performance positively.***			
H5.4.a	*Suppliers' brand communication affects supply chain's cost & service-based performance.*	-.261	.130	**Rejected**
H5.4.b	*Suppliers' brand communication affects supply chain's time & operation-based performance.*	-.400	.400	**Rejected**

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2tailed)

CONCLUSION

This research examines how suppliers' supply chain orientation and brand equity affects overall supply chain performance in the context of manufacturing companies; while, contributing our understanding of brand in B2B service settings. For this purpose, a scale has been developed considering supply chain orientation, brand equity and supply chain performance. Online survey sent to Aegean Exporters' Association, ESBAS Aegean Free Zone and Manisa Organized Industrial Zone, and with 35 responses analysis has been made with using SPSS21.0. The findings provide evidence that when a supplier has corporate norms and credibility and commitment values, it positively affects supplier's brand image and brand trust. Moreover, it is seen that supplier's corporate norms affect supplier's overall brand equity as well. Second, it is validated that suppliers' brand trust has a positive impact on suppliers' brand equity. Third, it is seen that suppliers' brand equity impacts whole supply chain's cost & service-based performance. Finally, it is found that both suppliers' brand image and brand trust impact whole supply chain's both cost- & service-based and time- & operation-based performance.

Managerial Implications

This study provides a number of important implications for management. First, the study results reveal the importance of supplier's supply chain orientation within a supply chain if partners want to develop a high-performing supply chain. In addition, the study was able to show the importance of supplier's brand trust in band equity. Managers generally think that the only relationship between is the brand and customer. However, this study shows that brand trust is also affects firm's brand equity.

The study results further show that supplier's brand image and brand trust have distinctive roles in inducing better supply chain performance; meaning that if supply chain managers consider their supplier's brand image and brand trust during supplier selection process, supply chain as a whole can achieve higher supply chain performance.

Limitations and Suggestions for Future Research

There are some limitations of the study with regards to the time limit and the low return rate. Although great effort was spent to increase the number of questionnaires answered by the participants, only 35 managers answered the questionnaire. This can be considered as the main limitation of the study since a low response rate limits the generalizability of the results of the survey. When related studies concentrated on manufacturing companies and specifically supply chain managers are considered [22] - [23] - [50], it was observed that there is a similar pattern in such studies.

This study employed brand awareness, brand image and brand trust for brand equity dimensions. Future studies may be conducted for exploring for different brand equity characteristics. Investigating the antecedents of brand awareness, brand image and brand trust can also be suggested for providing an overview especially for logistics managers who want to improve their firms' brand. In the study, one participant is used however; collecting data from multiple participants within a company can be another future research idea. There are numerous exogenous or moderating variables that affect brand equity. In a future study, those variables can also be examined. By using different conceptualizations and dimensions of SCO, a different perspective can also be used. Thus, conducting a study with these dimensions would be informative to see if additional dimensions improve the exploratory power of the model. Also, same study can be applied again within different sample with high return rate. Moreover, this scale can be used for manufacturing firm and its suppliers simultaneously to see how partners in the same supply chain see each other and how firms' brand positioned partners' mind.

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NEW OPPORTUNITIES FOR 3PL COMPANIES IN SOCIAL MEDIA

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Abstract − *Using social media as a marketing tool has become one of the widely accepted strategic communication activities in the world. Global companies recognize the popularity, high number of users and great advantages that social media platforms offer. Due to its growing rates of e-commerce and internet usage, social media platforms present a good and effective way of communication for companies operating in Turkey. However, business-to-business (B2B) industry falls behind business-to-consumer (B2C) industry when usage of social media is considered, and thus previous studies recently emphasize the need for companies in B2B markets to utilize social media. Accordingly, main aim of the study is to provide a description regarding social media usages of 3PL companies in Turkey. Sample of the study includes 3PL companies operating in Turkey which are listed in Fortune 500-2016 company list, and has net sales margin higher than 500.000.000 TL. According to the results, Facebook, Twitter and Linkedin are the intensively used platforms among the selected 3PL companies. In terms of engagement rates, Facebook engagement rate results are higher than Twitter results except one company.*

Keywords − *Web 2.0, Social Media Marketing, Logistics, 3PL Companies, Integrated Marketing Communications*

1. INTRODUCTION

> *"Business is not about changing the people but about changing yourself and your reactions for them. Success comes when one learns to control and coordinate. So integrated marketing communication plan should not be considered an end goal but rather a continuous approach"* [1].

Integrated Marketing Communications (IMC) aims to manage processes for "*planning, executing, and monitoring the brand messages that create brand-customer relationships*" [2], and to provide benefits when companies implement IMC strategies in a correct manner. For instance, it will help company "*to reach right customers with the right messages at the right time and in the right place*" [3], thus it creates relevant, effective, sensitive, and less wasteful messages, and help companies to build strong brand relationships [2].

However, since the beginning of 21st century, the tools and strategies for IMC, and communication medium have changed [4]. The importance of interactive media is constantly increasing, and the most significant driver of this is the Internet [2]. Internet recently altered the life and habits of human beings in terms of finding information, watching soap operas, looking for partners, searching for entertainment, et cetera [5]. A more recent phenomenon is the development of business intelligence environment and Web 2.0.

Web 2.0 is a new system in which all users continuously modify the content through a colloborative and participative manner [6], thus one of the characteristics of Web 2.0 is "user-generated content" (UGC). This characteristic provides an interactive, participative and collaborative environment within websites and thus, individuals share information and communicate more easily than the previous verison Web 1.0 [7,8]. Interactivity, real-time user control and, social participation or sharing are some other characteristics of Web 2.0 [7]. These characteristics, in turn, enable companies and customers to acknowledge and trust each other, and build extremely valuable brand relationships [2].

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Furthermore, due to these features, it is possible to consider Web 2.0 as a tenet that aids the development of social media [6] applications such as Facebook and Twitter. Since the Internet, and Web 2.0 provide a cheap and interactive communication medium [2] by removing the barriers to the flow of information, it has an impact on consumer behaviour (i.e. information search, opinions, buying behaviour, post-purchase communication, etc.), and on the IMC strategies of organizations [4].

Earlier studies on social media try to define the phenomenon, and highlight the advantages and challenges for organizations regardless of the markets they operate in [6,4]. However, business-to-business (B2B) markets and business-to-consumer (B2C) markets have different features in terms of product nature or customer orientation (See Table 1). Moreover, although the number of studies regarding social media is high in B2C markets, the number is limited for B2B markets. Therefore, some studies recently emphasize the need for companies in business-to-business markets to utilize social media [9,10].

Table 18. Differences Between B2B and B2C Markets

	Characteristic	B2B	B2C
Product Nature	Development	Linear	Cyclical
	Driver	Technology	Fashion
Customer Orientation	Motivation	Organizational need	Individual wants/desires
	Selection	Objective criteria	Subjective criteria
	Decision	Left brain	Right brain
Macro-social	“two cultures”	Science	Art
	Cultural scope	Global/Universal	Culture Bound
Professional Approach	Analogies	Legal /Medical	Politician/Entertainer
	Focus	Sales & Application Cases	Consumer Characteristics

Source: Adapted from [11]

Furthermore, Turkey’s logistics industry holds the third biggest margin within gross domestic product [12]. The increasing trend of outsourcing logistics activities has been followed by Turkish industry, and the number of third party logistics providers (3PLs) has been growing accordingly [13]. 3PLs in Turkey are acting as the engine of logistics industry by working on different and new ways to improve their services [14]. However, although there are some studies regarding social media usage of 3PLs in Europe [15] and North America [16], to our knowledge there are no studies on social media usage of 3PLs in Turkey. Therefore, this study aims to shed a light on the issue.

2. THE NEW BUZZ WORD: “SOCIAL MEDIA”

“*A powerful force now drives the world towards a single converging commonality and that force is technology”* [17].

Our everyday life is passing through a transitional phase due to the current changes in technology [18], such as the Internet, Web 2.0 and social media, and these developments aid forming the modern life [19]. Web 2.0 could be regarded as ‘the social evolution in the use of web technologies’ [20] whose main value comes from network effects due to collaboration and interaction between users [21]. Thus, Web 2.0 created ‘the platform for the evolution of Social Media’ [6].

Social media platforms, by nature, are highly interactive. They are “a *group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content*” [6]. This means they enable individuals and communities to share, co-produce, examine and reshape user generated content through utilizing mobile and web-based technologies [22].

Some of the Web 2.0 social media applications are social networking sites, creativity work sharing sites, company or user-sponsored blogs, commerce communities [4]. [6] create a list, consisting *colleborative projects* which includes wikis (i.e.: wikipedia) and social bookmarking applications (i.e.: delicious), *blogs, content communities* (i.e.: for e-books-bookcrossing, for powerpoint slides-Slidesshare), *social networking sites* (i.e.: MySpace, Facebook), *virtual game world* (i.e.: World of Warcraft), *virtual social worlds* (i.e.: Second Life).
Due to its own characteristics, social media changed the nature of communication between organizations, communities and individuals substantially [22]. From an individual perspective, these platforms are tempting for consumers since it presents an environment which has characteristics such as participation, openness, conversation, community, and connectedness [23]. The reasons for organizations to engage in social media, on the other hand, are simple. Firstly, organizations' actual and potential customers are engaging and interacting in social media platforms [24]. This means organizations need to think future purchases, and their influence of their actual customers on their potential customers. Secondly, your rivals as an organization have already engaged in social media [24], thus you need to the same and even better in order to stay competitive.

Social media offers advantages in terms of cost and time [25], observing information regarding consumer behavior [26], and creating brand awareness and building brand image [27]. Although, social media presents advantages, it is not without challenges. Organisations have been challenged since the traditional one-way communication with a passive user has turned into a two-way communication with an active user [21]. This means that traditionally organizations has complete control over the information about themselves, they were the ones to create the messages for existing and potential customers [28,6,4]. However, social media has democratized communication [22] through customer co-creation of, for instance, product design, promotional and brand messages [29,30]. Therefore, organizations should find a way to have their part in social media because the absence in these platforms may damage the reputation [30]. The presence in these platforms, on the other hand, may generate reputation risk since they might create a "distorted reality" which is intended to be favourable for companies but, it may harm the reputation of company when it is revealed [28] Thus, social media is becoming even more essential tool for marketing communications which needs to be carefully managed.

As mentioned above, the differences between B2B and B2C industries are different from each other. These differences also show themselves in the form of marketing communication strategies. For instance, while consumer products could be characterized as 'iconic', meaning mostly imagery with an aim of revealing emotional responses, B2B products are more technology-driven and could be characterized as instrumental and pedagogic, meaning that they are created to communicate information for people who are searching for a product to satisfy a specific need [11]. Similarly, they have different characteristics in terms of social media usage. The type of content, their approach and voice, channels they prefer to use, and goals and metrics demonstrate differences [31]. For instance, the type of content for B2C includes promotional content, while B2B industry utilizes webinars, case studies, or reports. Moreover, the approach is more easy-going for B2C markets, whereas it is more serious in B2Bs. In terms of channels they use, there are also differences (See Table 2 and Figure 1).

However, according to previous literature B2B industry, in general, falls behind B2C in their use of Social Media [21]. Although, companies and marketing managers in B2B industry have increased their use of social media [32], academic studies on social media use of companies in B2B industry are limited [33,34,35,36,37].

Table 2. Differences of B2B and B2C Markets in their Preference of Social Media Platforms

B2C Content Marketing Report 2015		**B2B Content Marketing Report 2015**	
Facebook	94%	*LinkedIn*	94%
Twitter	84%	*Twitter*	88%
Youtube	76%	*Facebook*	84%
LinkedIn	71%	*Youtube*	72%

Google+	68%	*Google+*	64%
Pinterest	59%	*Slideshare*	41%
Instagram	49%	*Pinterest*	33%
Tumblr	29%	*Instagram*	24%

Source: [27]

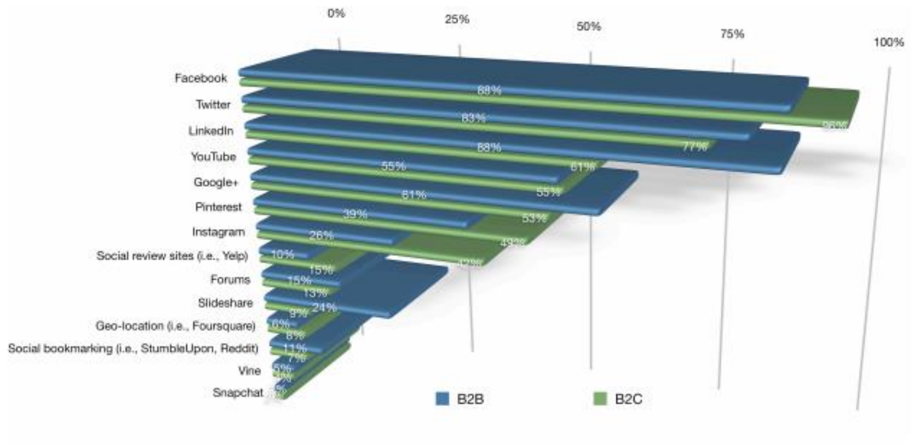


Figure 20. Social Media Platforms Used by B2B vs B2C

Source: [38]

Turkey presents a good market for social marketers. Turkish e-commerce is, for instance, one of the fastest growing internet economies in the world [39]. From a B2C perspective, the rate of Internet usage is 55,9 % in 2015 [40]. Regarding the motivation of using Internet, 80,9 % of the household use Internet for social media (to create profiles, send messages, share photos, etc.), 70,2 % use it for getting news, 66,3 % search for medical information, 59,4% search for information regarding goods and services. The users in Turkey also ranked at the top in terms of visiting social media platforms (See Figure 2).

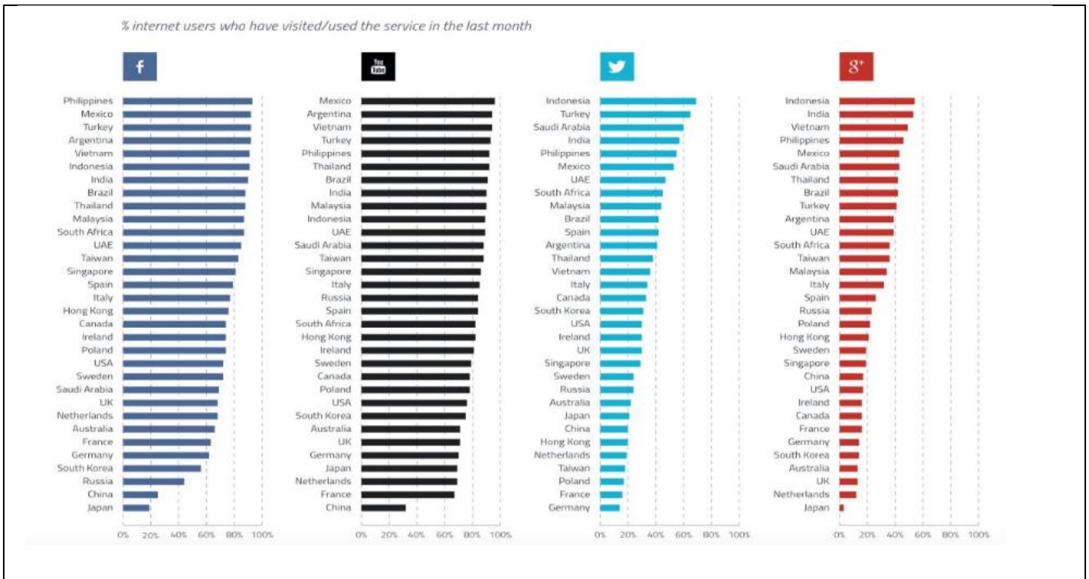


Figure 2. Visitors to the top Social Platforms by Country

Source: [41]

From a B2B perspective, for organizations that have more than 10 employees, the access rate for Internet is 93,7 % [42], and the rate of enterprises owning a web-site is 66 % in 206. In terms of online sales, 11,9 % of enterprises buy and/or sell through web-sites, online shops, mobile applications and/or Electronic Data Interchange (EDI) in 2015. The rate for social media usage is, 38,1 % for enterprises with 10 or more employees in 2016, which also supports previous literature stating that B2B industry falls behind B2C in their use of Social Media. Thus, this study aims to shed a light on the social media usages in B2B industry, by focusing on Third Party Logistics companies operating in Turkey.

3. LOGISTICS INDUSTRY IN TURKEY

Outsourcing of logistics activities has been dramatically increased and improved over the years. Traditionally, outsourcing was used for improving the efficiency of organizations, especially for trnsportation and warehousing activities but nowadays, it has becoming a strategic process including medium-to-long range planning of integrated logistics processes [43].The motivations behind outsourcing logistics activities include, but not limited to, focusing on core competencies, better solutions for transportation, cost reduction, improving service levels, and creating competitive advantage by improving the efficiency and effectiveness of logistics activities[44]. In general, outsourcing logistics helps increase productivity in short-term, and create strategic advantages in long-term through sharing both information and risks [45].

Growing interest in outsourcing logistics activities has led an increased usage of Third Party Logistics Providers (3PLs) [46]. One of the most significant reasons for employing 3PLs is their expertise and experience which otherwise would be hard for companies to acquire or develop in house [47,48]. Their expertise comes from working with various clients which enables them to benchmark, and to develop cost reductions and increase customer service [49].

Turkey's logistics industry hold the third biggest margin within gross domestic product (GDP) by 11,3 % between 1998-2014 [12] 3PL companies have been operating since 2000 and their growth rate is increasing since then [13]. Although the number of 3PL companies is not much, they are acting as the engine of logistics industry by working on different and new ways to improve their services [14].

However, despite the growth of social media, 3PL companies have been acting slowly in terms of social media engagement. A European Report highlighted the issue (See Table 3).

Table 3. European 3PL Use of Social Media Tools

Social Media Categories	Number of Companies Using (n=9)
Has a Facebook Page	2
Has a Blog	1
Has a LinkedIn account	5
Has a Twitter account	1
Post company videos on Youtube	2

Source: Adapted from [15]

Although, logistics industry is one of the most important industries contributing to GDP, to our knowledge, there are no studies regarding the social media usage of 3PL companies. Therefore, the aim is to explore the current state of 3PL companies in terms of their social media.

4. RESEARCH METHODOLOGY

Since there are no previous studies on the subject, this study is an exploratory study based on case study method. The case study focuses on understanding the dynamics within single settings with an aim to provide description, to test or generate theory [50]. Case studies may include single or multiple cases [51], and these cases can be individuals, groups, organizations, events, movements, or geographic units [52]. Case studies may combine various data collection methods such as interviews, questionnaires, and archives, and the evidence collected may be qualitative or quantitative, or both [50].

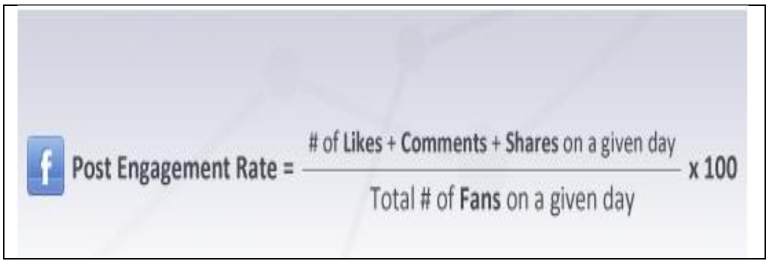
The present study employs cases in the form of organizations with an aim to provide a description regarding social media usages of 3PL companies in Turkey. In order to select 3PL companies operating in Turkey, Fortune 500-2016[1] company list has been used as a sampling frame. The list ranks companies according to net sales, and according to Fortune 500-2016 list of Turkey, there are six 3PL companies operating in Turkey with a net sales margin higher than 500.000.000 TL (See Table 4).

Table 4. 3PL Companies List

Rank	Company	Net Sales (TL)
101	NETLOG LOJİSTİK HİZMETLERİ A.Ş.	1,569,737,335
107	EKOL LOJİSTİK A.Ş.	1,512,011,386
115	BORUSAN LOJİSTİK DAĞ. DEPOLAMA TAŞIM. VE TİC. A.Ş.	1.411.008.151
244	MARS LOJİSTİK GRUP A.Ş.	649,771,437
249	OMSAN LOJİSTİK A.Ş.	638,761,218
286	HOROZ LOJİSTİK KARGO HİZMETLERİ VE TİC. A.Ş.	554.521.645

Since the aim of the study is to create a view of social media usages of these 3PL companies, a metric should be chosen to measure the performance of these companies regarding their social media usage. Previous studies offer various metrics like Return on Investment [24]. Another metric is Engagement which includes time-on-site, page views per visit, and bounce rates[2] [53]. [53] also mentions eyeballs as a metric which includes hits, and visit to a web-site. These engagement metrics and eyeballs may not be generating direct sales (yet), but they are the source of highly engaged visitors because if a visitor stays on your web-site longer, the relationship built would be deeper [53]. Therefore, as a metric, this study will provide information regarding daily time on site, daily page reviews per visitor, and bounce rate.

Besides, social media analytics companies have created some equation metrics for calculating engagement rate. For instance, Socialbakers[3] is one of the most popular social media analytics companies serving over 100 companies listed in Fortune 500 provides such an equation for Facebook and Twitter[4] (See Figure 3). Besides the information regarding daily time on site, daily page reviews per visitor, and bounce rates, engagement rates for aforementioned 3PL companies will also be presented.



[1] See the link: http://www.fortuneturkey.com/fortune500
[2] . "A bounce is when I visit a page of your site and then don't go to any additional pages; I bounce right off your site" (Zarrella, 2009, p. 209).
[3] See the link: https://www.socialbakers.com/company/about/meet-socialbakers
[4] See the link: https://www.socialbakers.com/blog/467-formulas-revealed-the-facebook-and-twitter-engagement-rate

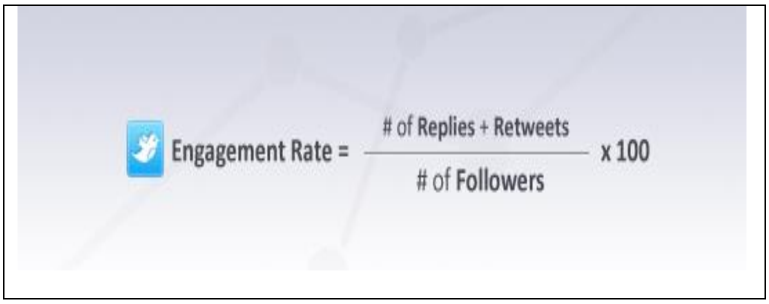


Figure 3. Engagement Rate Equations

5. FINDINGS AND DISCUSSION

Social media has lots of benefits such as cost reduction by decreasing staff time, increasing of probability of revenue generation, sharing of expertise and knowledge, and helping customers [54]. These advantages have been recognized from transportation and storage companies in Turkey, but their social media usage rates have been fluctuating, and the increasing trend has recently been observed (See Figure 4).

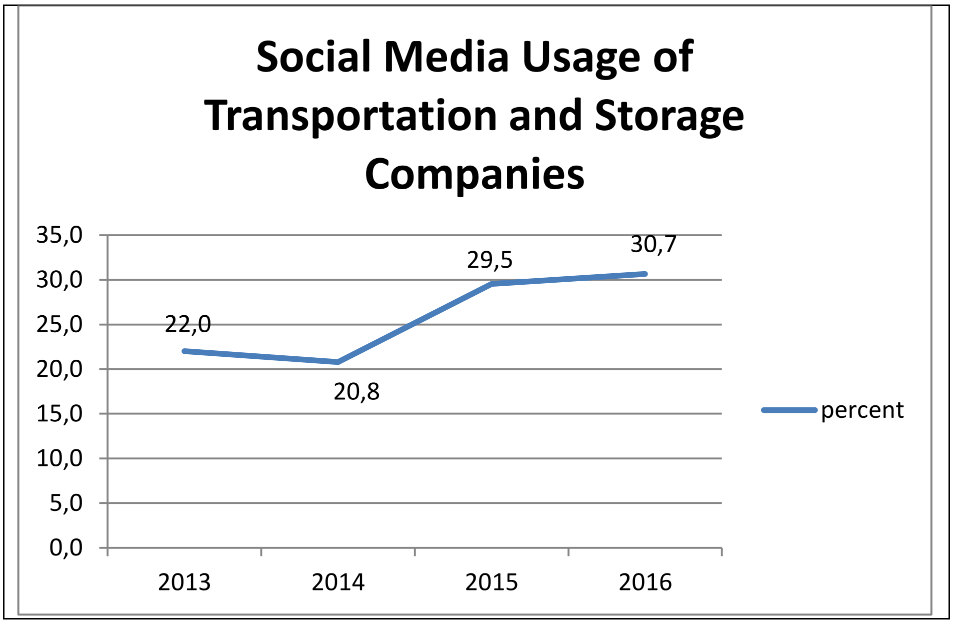


Figure 4. Social Media Usage of Transportation and Storage Companies
Source: Adapted from [42]

Before the social media usage analysis of given 3PL companies, their web sites traffic and statistics were examined via Alexa[1] web information company. Alexa is one of the most conversant web site information companies in the world. It provides information related to global and national ranking of particular web site in addition to daily time on site, bounce rate and daily page views per visitor. Alexa performances of aforementioned 3PL companies are presented in Table 5.

Table 5. Alexa Data of Selected 3PL Companies

Web Adress	Global Rank	Rank In Turkey	Daily Time On Site	Bounce Rate	Daily Pageviews Per Visitor
www.netlog.com.tr	1,580,447	67,371	1:35	51.70 %	2.30
www.ekol.com	326,926	7,574	4:40	34.10 %	3.50
www.borusanlojistik.com	1,398,336	44,137	1:53	48.10%	2.30

[1] See the link: http://www.alexa.com

www.marslogistics.com	1,754,240	55,873	2:01	49.20 %	2.40
www.omsan.com.tr	4,030,340	84,085	0:29	79.30 %	1.10
www.horoz.com.tr	428,133	7,750	4:46	21.70 %	3.40
Access Dat: 15.10.2016					

Table 5 illustrates that only two companies, Ekol Lojistik and Horoz Lojistik Kargo Hizmetleri are in the first of 500.000 web sites in the global rank and first of 10.000 web sites in the rank in Turkey. In accordance with this information, their daily time on site, page views per visitors and bounce rate are higher than other companies. Netlog Lojistik which is the most successful company according to net sales, has a weaker web site performance based on Alexa results.

When examining selected companies' usage of social media according to the number of followers, it can be seen that Facebook, Twitter and Linkedin are intensively used platforms among the 3PL companies (See Table 6). Youtube is used by five companies and Google+ and Instagram are used by four companies with relatively less followers than other platforms. Tumblr, Pinterest and Blogs are preferred almost never by companies in the sample.

Table 6. Social Media Usage of Selected 3PL Companies

FIRM	FACEBOOK (number of followers)	TWITTER (number of followers)	INSTAGRAM (number of followers)	LINKEDIN (number of followers)	GOOGLE+ (number of followers)	YOUTUBE (number of followers)
NETLOG	8.290	2.588	107	3.263	29	30
EKOL	132.131	6.066	2.586	23.038	18	306
BORUSAN	8.591	4.091	731	15.282	36	90
MARS	5.949	120	695	6.633	-	44
OMSAN	17.240	2.567	-	10.192	46	84
HOROZ	4.696	377	-	5.839	-	-
Access Date:15.10.2016						

In the step of engagement rate, only Facebook and Twitter social media platforms were calculated since they have relatively higher follower numbers and since they are used by every company in the list. Aforementioned formula was applied for six selected company in terms of their Facebook and Twitter engagements (See Table 7).

Table 7. Social Media Engagement Rates

FIRMS	FACEBOOK		TWITTER	
	Engagement Rate (%)[1]	Number of Posts	Engagement Rate (%)	Number of Posts
NETLOG	0,0693	7	0,0040	6
EKOL	0,0502	95	0,0693	123
BORUSAN	0,8662	55	0,0901	59
MARS	0,7689	91	1,0701	77
OMSAN	0,3828	29	0,0255	26
HOROZ	0,2529	36	0,1058	22
Data gathered is for the period of 15.04.2016 to 15.10.2016.				

According to the results, most successful 3PL companies according to the net sales have low and intermediate level of engagement rates. Numbers of posts are generally close in two different platform

[1] If the engagement rate is over 1, this means the social media account is successful. If the rate is between 0,5 and 0,99, the social media account is moderately successful, and if the rate is lower than 0,5, then the account is not successful [55].

and they have similar contents. Besides, Facebook engagement rate results higher than Twitter results except one company. According to the engagement rate results, Borusan Logistics is the most successful company in the Facebook platform and Mars Logistics is the most successful company in the Twitter platform. Moreover, it can be concluded that, first company according to sales (NetLog) have not given sufficient importance to the social media and can't move its success into this area

As an additional analysis, the company with highest Facebook engagement rate is selected for a content analysis of its posts. Similar to the engagement rate calculations, the activities in last six months have been observed and during this time, Borusan has 55 posts in total which is a low number, especially if you compare it with a company operating in B2C market. Further, these posts are analyzed in terms of their content. In general, it is possible to gather these posts in two headings, including internal company information, general industry information, and celebratory posts (See Table 8).

Table 8. Content Analysis of Borusan's Facebook Posts

Representative Posts	Content Type	Number Of Posts
World Energy Congress, where the future of Energy is discussed, has started. You may visit us as Borusan Logistics, Borusan EnBW Energy and Borusan Industrial Systems at our booth.	General Industry Information	3 /55 posts
In 9-13 October, Istanbul hosting World Energy Congress. Borusan EnBW and Borusan Industrial Systems will be in there like the leaders of the industry, international organizations, universities and energy industry associations.		
Announcement of 1 July 2016 Container Weight Document implementation		
New location of Halkalı Custom is 7 km away from Borusan Logistics' Çatalca Warehouse	Internal Company Information	37/55
We increase our productivity with Eta and Bukoli. Happy productivity week		
In last year Borusan logistics chartered 330 ships.		
Eid mubarek	Celebratory Posts	15/55
May 19 The Commemoration of Atatürk Youth and Sports Day		
Wish success to Ekol Logistics for quertal final in basketball.		

These headings demonstrate similarities with existing literature stating B2B marketers' need of focusing on more professional content [56]. However, as previous studies state content should also create a value for the customers, this means customers want to see what is in it for them [56]. For instance, they may provide customers with more visual or audio content in order to be more creative. In general, it is important for 3PL companies to be present in the social media platforms, however having an account is not enough. Therefore, they need to demonstrate the value for the customers through these platforms and posts.

6. LIMITATIONS AND FURTHER RESEARCH

The limitations of this study come from the engagement rate formula used. The number of followers is used as a denominator in the equation, this means as the number of followers increase, the engagement rate decreases which, in turn, may seen as negative for companies. Therefore, further studies may try to find other measurements such as return on investments. Despite the limitations, this equation creates an important inception point along with web traffic results.

Researchers further include more social platforms, or may create a cross-industry analysis for social media usage. Furthermore, a deeper content analysis could be conducted in order to analyze the meaning of companies' posts in each social media platform.

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FOSTERING INTERNAL CUSTOMER SATISFACTION AND INNOVATIVE BEHAVIOR BY MANAGING TALENT WASTE

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Abstract − *Principles of lean management has become more popular nowadays and the implementation area of Lean, spread from manufacturing environment to service sector. Elimination of wastes is one of the priority of lean thinking and it is essential for organizational improvements. Wastes in lean were firstly defined under seven categories as overproduction, over-processing, waiting, motion, inventory, defect, transportation for manufacturing environment. Additionally, the 8th waste of Lean was presented as "talent" in order to include the human factor. The aim of this study is to focus on talent waste by gathering some of well-known concepts including, over-qualification, underutilization of skills, over-education and skills mismatch under a single framework and present its relations with job satisfaction and innovative behavior of internal customers. This study can be seen as a primary attempt to explore this relation from lean perspective and propose a contextual model for the future studies.*

Keywords − *Talent Waste, Internal Customer, Job Satisfaction, Innovative Behavior*

1. INTRODUCTION

Even it can be traced back till the works of Deming and Taylor, the core of lean concept is based on Toyota manufacturing systems. "Lean" has evolved to the state of art in manufacturing environment (Dombrowski & Mielkea, 2013) however, principles of lean are also used commonly in service sectors including finance, healthcare, education, hospitality etc. (Maskell & Kennedy, 2007; Stanton, et al., 2014; Balzer, et al., 2015; Vlachos & Bogdanovic, 2013). Shah and Wards (2007) defined lean as "an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability." The term "lean" was first used by Jim Womack and his research team to describe the Toyota's business ideology, whose priority was focusing on customer needs while minimizing activities that do not add value to the system, in other words, wastes.

These wastes were categorized under eight topics including, overproduction, over-processing, waiting, motion, inventory, defect, transportation and finally talent waste. The first seven wastes are the well-known manufacturing wastes, however the 8th waste of Lean considers the human factor. This study can be seen as a primary attempt to present the relation between talent waste, internal customer satisfaction and innovative behavior by presenting a model. Wastes in lean management, the concept of talent waste and the interaction of talent waste with internal customer satisfaction and innovative behavior are presented respectively in the following sections.

2. WASTES IN LEAN MANAGEMENT

Elimination of wastes is one of the priority of lean management practices. Lean is also defined as an organizational performance management system which includes the collaboration of all employees from different stages to identify, minimize or eliminate activities that do not create value for the customers or stakeholders (Kavanagh & Krings, 2011). Hines and Rich (1997) stated that the process of elimination or at least reducing wastes is firstly based on identifying them on value stream and after that removing them from stream by using appropriate tools and techniques. To eliminate these wastes five main principles of lean are considered (Hines & Taylor, 2000; Hines & Rich, 1997): specifying value added and non-value added activities from customer perspective; identifying all the needed stages to design, order and produce the products through the value stream; making those actions that create value flow

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without wastes and creating a pull system according to customer expectations are followed by striving for perfection by continuously removing wastes.

Wastes in Lean Management were firstly defined by Taiichi Ohno, formerly the chief engineer at Toyota, and they are also called as *muda* (Womack & Jones, 1996). Taiichi Ohno (1978) classified wastes for manufacturing industry as: over-processing, overproduction, waiting, transportation, unnecessary motion, unnecessary inventory and defects. Over-processing, in other words inappropriate processing, refers to using the wrong set of tools, procedures or systems during the work, rather a simpler way (Hines & Taylor, 2000). It occurs, when the process is more complex than necessary or process/ product includes more features than needed (Brenson & Kulkarni, 2011). Main factors cause over-processing were stated as poor understanding of the customer's true requirements, the failure to communicate customer requirements to workers, or failing to design the products according to customer requirements (Kavanagh & Krings, 2011). Overproduction is one of the most common waste in manufacturing environment. Basically it refers to producing too much without customer demands. It's usually caused by poor information flow which results of an excess inventory (Hines & Taylor, 2000). The next waste is, waiting waste which refers to unused time or inactivity period of employees, machines, goods and resulting ineffective flows and long lead times (Hicks, 2007). Transportation waste is unnecessary or excessive movement of people, materials, goods, information etc. (Hines & Taylor, 2000) that does not add value to the process. The similar concept is unnecessary motion which contains only employee movements that does not add value (Benson & Kulkarni, 2011). As it was mentioned before unnecessary inventory is the cause of overproduction which refers to excessive storage and delay of information or products. It directly increases the costs therefore; it is important for organizations to eliminate inventory related wastes from working environment (Karlsson & Åhlström. 1996). Finally, defects or scraps may be the most common wastes of any kind of organizational environment including, manufacturing and service, and refers to damaged goods or non-compliant products (Benson & Kulkarni, 2011).

However, these well-known 7 wastes, explained above, defined and categorized exclusively for the manufacturing environment; were not found sufficient by Womack and Jones, 1996, for more general use; since the human factor is not included and human related wastes are disregarded. Therefore, in 1996, Womack and Jones introduced the 8^{th} waste, "talent", which refers to underutilizing talent, knowledge and skills. Womack and Jones (1996), define talent waste as underutilization of people's talent, knowledge, skills and abilities. Risks of talent waste were stated as frustrated and unfulfilled employees, high turnover rates, poor morale and lack of belief to change.

3. THE CONCEPT OF TALENT WASTE

The 8^{th} waste of Lean Management has been defined by several authors in different aspects (Hicks, 2007; Martin and Arokiam, 2007; Brenson and Kulkarni, 2011; Kavanagh and Krings, 2011), however there are some common terms in all definitions. Brenson and Kulkarni (2011) defined the 8^{th} waste of lean as "under-utilized talent" and explained it as improper utilization of talent and creativity loss. Moreover, Kavanagh and Krings (2011) named the 8th waste as "underutilizing people's abilities" and explained it as the failure to make use of employees' knowledge, skills and abilities. As an example using highly trained and capable professionals rather than using less trained person for performing easy tasks can be a failure. According to Hicks (2007), 8th waste of Lean Management relates to the underutilization of people and in particular their ideas. Furthermore, Martin and Arokiam (2007) defined the 8^{th} waste as "skill utilization" which emphasizes the missing out of the right set of skills performing the appropriate task.

As it can be understood from all definitions above, the 8^{th} waste of Lean Management is related to utilizing peoples' talents, knowledge, skills, background, abilities etc. Therefore, according to these explanations, it can be said that 8^{th} waste of lean includes the concepts of over-qualification, underutilization of skills, skill mismatches and over-education.

Wasting talent at the working environment is not a new concept in the literature and it has received considerable attention of researchers. More than two decades ago Alba-Ramirez (1993) focused on over-education which is identified as “information obtained from employees about the educational background they actually have and the schooling they report as necessary to perform their respective jobs.” Similarly, skill underutilization was remarked as “employment which underuses workers’ skills” Felstad & Green, 2013). Fine and Nevo (2008) had seen over qualification as a multidimensional term, and referred different kinds of situations of improper employment such as over-education, over-experience, and skill under-utilization, referred to the possession of a greater level of education, experience, or skill than is required for a given job. These explanations are also concurrent with this research’s focus area. Similarly, Christiansen, Sliter and Frost (2014), focused on person-job fit related with a match between persons’ skills, knowledge, abilities and the demands of the job. The term *talent waste* was used by Paolo and Mañé (2014) in their research. They focused on qualification and skill mismatches on PhD graduates. According to their review, qualification mismatch by itself is not strongly related with job satisfaction, however, underutilization of skills has more serious results, especially when convoyed by educational mismatch. Furthermore, Amador et al. (2012) investigated job-worker educational mismatches in Spanish labor market and stressed that job satisfaction is predicted by skill mismatches better than educational mismatches.

Despite these research area has received a considerable attention of several researches, the usage of lean perspective has not been used to analyze over-qualification, underutilization, over-education, skill mismatches, in other words talent waste. This paper intends to explore the relation between talent waste, internal customer satisfaction and innovative behavior.

4. INTERNAL CUSTOMER JOB SATISFACTION AND INNOVATIVE BEHAVIOR

Employee-job fit has become an important aspect for the executives to manage the abilities, competencies and skills to achieve an effective organization (Elegbe, 2016). As Berry (1981) identified the employees as an internal customer, their level of satisfaction in their jobs and their importance in satisfying external customers have been stressed by many authors (e.g. Ahmed and Rafiq, 2003). Job satisfaction is an attitudinal reaction and is related with the feeling of oneself about their jobs and different aspects of the job (Spector, 1997). According to Rafferty and Griffin (2009), there is a debate in the definition of job satisfaction about its being an emotional reaction and/or cognitive response. However, he stressed that it will continue to progress as insights grow from new methodologies. Several factors have been found to influence the satisfaction of internal customers such as job content, pay/compensation, working conditions, security, relation with co-workers, relation with supervisor, job enrichment, high involvement work system (Orpen, 1979; Matzler, K., Fuchs, M., & Schubert, A., 2004; Parvin, M. M., & Kabir, M. N. 2011; Harmon, et.al., 2003). One of the most important factors that causes dissatisfaction of employees is talent waste which comprises over-qualification, underutilization of skills, skill mismatches and over-education (Allen and van der Velden, 2001; Vieira, J. A. C., 2005; Allen, J., & De Weert, E., 2007; Mavromaras, K., Sloane, P., & Wei, Z., 2012) of internal customers. The literature review in Table 1 shows some important studies related to the investigation of the relationship of talent waste elements and internal customer job satisfaction.

Table 1. Literature Review

Author(s)	Focused Area	Main Findings
Johnson and Johnson (2000)	Perceived over qualification and dimensions job satisfaction	Perceived over qualification has a negative effect on job satisfaction. However, the relationships varied by dimension of perceived over qualification and dimension of job satisfaction

Allen and Velden (2001)	Relation between educational mismatches and skill mismatches	Skill mismatches are much better predictors of job satisfaction and on-the-job search than are educational mismatches
Vieira (2005)	Relation between skill mismatch and job satisfaction	Overall job satisfaction is adversely affected by perceived over-qualification. Same is valid for satisfaction as well. A worker would be willing to extent to take a wage cut in order to preclude over-qualification.
Fine and Nevo (2008)	Examining the concept of cognitive over-qualification	Cognitive overqualification was found to be associated with job dissatisfaction, but was only weakly related to measures of job and training performance.
Fleming and Kler (2008)	Over education and work place satisfaction	Although levels of satisfaction remain high, that across all measures of workplace satisfaction, overeducated workers are less satisfied compared to their non over-educated counterparts.
Amador, Nicolas and Vila (2012)	The consequences on job satisfaction of job–worker educational and skill mismatches	Skill mismatches emerge as a much better predictor of job satisfaction than educational mismatches as the effects of the latter are related to unobserved heterogeneity among workers. The current level of job satisfaction appears to be influenced by workers' previous job perceptions, suggesting a dynamic structure for job satisfaction.
Fleming and Kler (2014)	Female over education and job satisfaction	For females with dependent children at home, over-education has a detrimental effect on a minority of satisfaction measures, whereas for females without children at home, over-education has a detrimental effect on a majority of satisfaction measures.
Paolo and Mane (2014)	Consequences of qualification and skills mismatch on PhD graduates	Graduates who are both overqualified and over-skilled and also showed that being mismatched reduces job satisfaction, especially for those whose skills are underutilized.
Weymer, Maciel and Castor (2014)	Influence of over qualification and individual's learning at work about their satisfaction	Over qualification and exploration learning influence the satisfaction indeed, but the exploitation learning does not influence satisfaction.

Al-Yahya (2007) stressed that the problem with the many organizations may not be the lack of skills and capabilities, but the lack of appropriate management mechanisms and organizational design that support this. In this regard senior management should realize the importance of talent which has a direct effect on employee's motivation and satisfaction (Bhatti, 2011). Scott and Bruce (1994a, 1994b), and Nerkar, McGrath and MacMillan (1996) emphasized the importance of satisfied employees in behaving innovatively in the organizations. It is revealed that creativity and job satisfaction are interconnected as job satisfaction provides creativity and knowledge creation (Davis, 2009). A high job satisfaction will encourage employees to be more innovative (Shalley et al., 2000) in their jobs. Innovative behavior of employee is defined as an external expression of the inner creativity of internal customers and it is utilized to develop creative outputs, product or process, which are used to solve problems or making improvements (Janssen et al., 2004; Li & Hsu ,2016). Innovative behavior is influenced by both individual resources as problem-solving skills or motivation and also by organizational factors including leadership and work group relations (Yu et al.., 2013). According to Bakker and Demerouti (2008), internal customers who are engaged with their jobs, work with their full capacity and take actions before the problems occurred and this encourages their innovative behavior. Therefore, an inference as job satisfaction supports the innovative behavior of internal customers can be presented. These concepts are discussed and proposed in the research model in the following section.

5. DISCUSSIONS AND FURTHER STUDIES

Skill mismatch, over-qualification, underutilization of skills and over education and their relation with job satisfaction have been studied by several authors Johnson & Johnson, 2000; Allen & Velden, 2001; Vieira, 2005; Fleming & Kler, 2008; Paolo & Mane, 2014; Weymer, Maciel & Castor, 2014). However, none of these studies analyzed these concepts under lean philosophy. On the other hand, the 8th waste of Lean, *talent*, fulfills the need of gathering these concepts under a single framework. From this point of view, it can be said that the level of top management commitment directly affects the talent waste. In other words, in order to eliminate and avoid talent waste the support of top management is needed. Moreover, internal customers, who thinks that their talents and background are matched with the needs of their job, and they have enough responsibility, are expected to be more satisfied with their jobs (Orpen, 1979; Matzler, K., Fuchs, M., & Schubert, A., 2004; Parvin, M. M., & Kabir, M. N. 2011; Harmon, et.al., 2003). On the other hand, internal customers, who believe that their job can be done by a lower-skilled/educated employee or they could perform better if their work would be more challenging, have lower job satisfaction. These assumptions are expected to lead their innovative behavior (Jannsen Weste, 2004; Li & Hsu, 2016). The main contribution of this paper is to explore the relationship of talent waste with internal customer job satisfaction and innovative behavior within a contextual model, which is proposed in Figure 1.

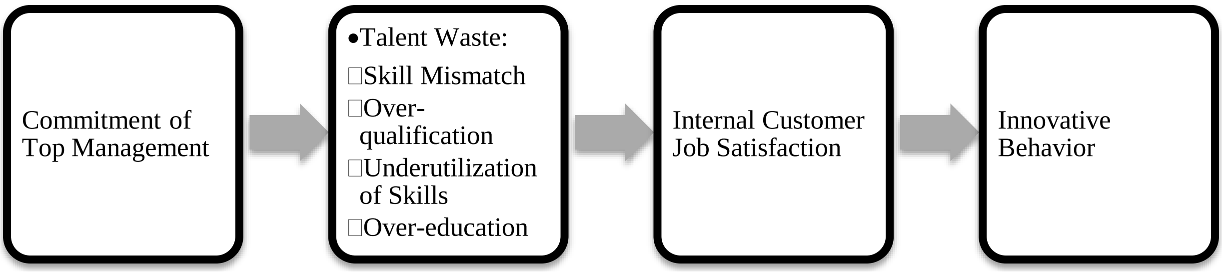

Figure 1. Proposed Model

For future studies, testing the contextual model by conducting a survey on white collar employees from different sectors would be planned by the authors. Moreover, broadening the research area from private to public sector, investigating the ways to eliminate talent waste and increase internal customer satisfaction and innovative behavior can be suggested as future implementation areas.

6. CONCLUSION

Wasting internal customers' talent is a severe problem for both employees and organizations. Increasing internal customer satisfaction by eliminating talent waste with the support of top management commitment is expected to encourage internal customers' innovative behavior. This study can be seen as a primary attempt to gather well known concepts like overqualification, underutilization of skills, over education and skill mismatches with the 8th waste of Lean Management and propose a model to present the relation between top management commitment, talent waste, internal customer satisfaction and innovative behavior. t is necessary for future research to test the proposed model by conducting a survey on white collar employees from different sectors.

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ATP CONVENTION EFFECTS ON FOOD SUPPLY CHAIN

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Abstract - Food is one of the pillars upon which society is built. Therefore, food safety and sanitation are very important for both societies and governments. The food must be properly protected during transport. Furthermore, transporters must have an appropriate structure that will provide temperature adoption to the transported products. Products, the breaking of the cold supply chain from production areas in the final consumer is extremely important. This is the damage to the national economy billion dollars.ATP (formally, the Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage) is a 1970 United Nations treaty *that establishes standards for the international* transport *of* perishable food *between the states that ratify the treaty. It has been updated through amendment a number of times and as of 2016 has 50 state parties, most of which are in Europe or Central Asia.We examine how they will affect the ATP convention on food supply chain in this study. In this context, a survey done by performing a statistical analysis of the results will be based on it.*

Keywords- ATP Convention, Food Supply Chain, Cold Chain Logistics, Food Logistics.

1. INTRODUCTION

Food products are strategically important product in terms of social and economic value. Nowadays, food sector has changed rapidly in the past decade. The number of actors in the supply chain and product diversity are increased. A supply chain is a system of organization, people, activities, information, and resources involved in moving a product or service from supplier to customer. Supply chain activities involve the transformation of natural resources, raw materials, and components into a finished product that is delivered to the end customer (Wikipedia,2016).

A food supply chain refers to the process that describe how food from a farm ends up on our tables. There are many various factors that influence food supply chain such as value chains, legislation, consumer choice, sustainability and collaboration. In fact, sustainability is one of the most important think on food supply chain. Sustainability is improving the quality of life not only for the current generation but also for the future generations (Bundtlandt,1987). The world's population is around 7.2 million but the number of arable land in the world is dwindling despite a growing population. Water resources which are clean and qualify for irrigation are disappearing. Therefore, a well-managed food supply chain must be considered such as energy consumption, carbon emission, water usage, food availability, ethical behavior and economic sustainability. There are some actors in a food supply chain as producers, processors, retailers and distributors, hospitality sector (hotels, restaurant, etc.) and consumers.

Evaluation of the wholesale market system in Turkey is shown in Figure 1 below. We see that this system of chain of many handling from producers to consumers. Shelf life of the product is affected by each of handling in the process. Therefore, each transaction in the chain is required very careful planning and management. In addition, seed, fertilizer and pesticides supplier also needs to be added to this chain because of seed and others are part of food safety.

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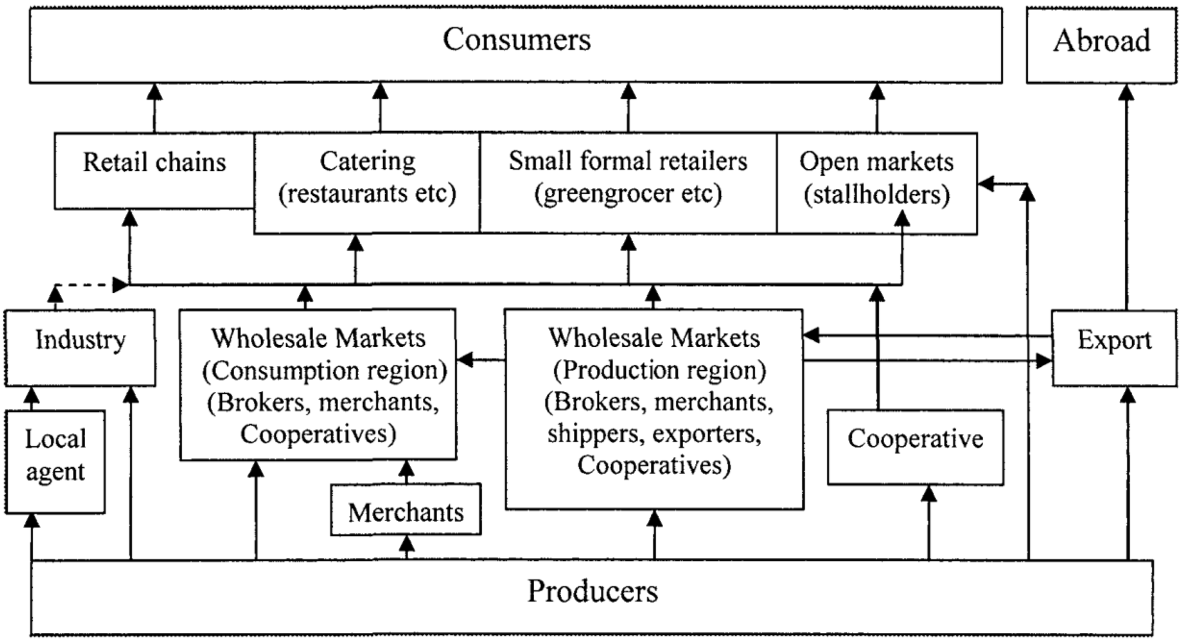
FIGURE 1. Turkish Fresh Fruits and Vegetables Supply Chains



Yilmaz & Yilmaz—Evaluation of the Wholesale Market System, 2008

On the other hand, food safety is another factor that plays a very important role in the success or failure of a food supply chain. Food products such as fresh vegetables and fruit, meat, milk have had short shelf life. Hence, closer monitoring of product integrity in the logistics system is the important issue.

Basically, a cold chain is a temperature-controlled supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities which maintain a given temperature range. From the supply chain management perspective, cold chain is a process and refers the system of policies, vehicles, equipment, procedures and technologies that work together to make sure that food products proffered to people are safe and effective. An effective logistics system and well-maintained cold chain are essential for safe and effective service delivery. In addition to, an effective food logistics systemsshould deliver food products not only on time but also freshly and safely which is an important concern for customers (Kuo and Chen,2009).

ATP (formally, the Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage) is a 1970 United Nations treaty that establishes standards for the international transport of perishable food between the states that ratify the treaty. It has been updated through amendment several times and as of 2016 has 50 state parties, most of which are in Europe or Central Asia. ATP convention includes technical and technological details in the cold supply chain of perishable goods. This agreement also aimed that the use of special vehicles and tools, determining which it will move per the mode of transport of food products, raising standards of quality storage in perishable foods, determination of the International Accepted Standard and to facilitate the process of the products from manufacturer to the final customer. It is generally being summed up as monitoring and the prevention of the supply chain breakage in this agreement.

In Turkey, ATP Convention was legalized in 2011. Shortly after, it was published in the Official Journal and entered force in 10 May 2012. However, requirements of the ATP Convention have not yet been fully fulfilled. Although international food transport companies have already to act by this convention, it is rare in domestic transport. For this reason, there are a great loss for the transport of domestic food products because of the refrigerated vehicles not using. This situation negatively affects the country’s economy and cause the customers to pay high amounts. Millions of pounds are wasted every year in our country due to product degradation. Products must reach customers with the right equipment in the right way. It is the most effective way to reduce these losses. Thus, we investigated why it should be passed as soon as possible the implementation of the ATP convention in the food industry.

In this study, a survey was done by some companies in the food sector. Questions were asked about the ATP Convention. Including the transporters and storage operators taken to the expectations and problems of the sector. Firstly, we will examine which studies have in the food industry in the world is done by doing literature review. Secondly, we will evaluate the survey results. And finally, we will present our conclusion and recommendations.

2. LITERATURE REVIEW

To understand the importance of food supply chain in academic literature, it is detected that journals are classified basically in three titles as “food supply chain”, “food logistics” and “cold chain logistics”. This research was done with using *Thomson Reuters Web of Science* academic database with these key words *“Food Supply Chain”*, “*Cold Chain Logistics”* and *“Food Logistics”* searching by “title”. With analysing the abstract and title analysis of journals published between 2006-2016, there are 25 researches were found but 11 of them were taken into account in this literature review research. It is shown below the classification of researches by chosen methods and key words.

Table.1: Dispertion of Researches Food Supply Chain

RESEARCHER	Case Study	Conceptual Study	Literature Review	Operation Research	Operation Management	CONTENTS
Montanari, 2008	*	*				Meet the cold chain management system requirements and to manage provide a tools which allows to choose the cheapest configuraiton.
Soysal, Ruwaard, Meuwissen, Vorst, 2012				*		It is reviewed quantitative studies in food logistics management in a structured way.
Tsolakis, Keramydas, Toka, Aidonis and Iakovou, 2012					*	Development and management of sustainable agrifood supply chain management provide a guiding systemic framework for researchers and practioners.
Bosona, Gebresenbent, 2013						The definition, driving forces, barriers in developing food traceabilitys’s and identified

		*				benefits, Technologies and preformences.
Soysal, Ruwaard, Vorst, 2013	*					A MOLP model for the generic beef Logistics network problem in this study. It has two competing goals. Minimizing total logistic cost and minimizing total CO2 emmissions from transportation operations.
Dabbene, Gay, Tortia, 2013					*	To analyse how traceability concepts, requirements and Technologies influence modern supply chain management and are handled by the ensuing optimisation principles.
Validi, Bhattacharya, Byrne, 2014	*					Sustainable distribution process and dairy market Logistics problems. With a model presented which adresses the multi objectives of carbon reduction and cost minmisation in the design stage of the milk distribution system.
Mohan, Gunjan, Jain, 2015		*				To provide a lietrature Review of perishable food supply chain qulaity and includes all the products/process(milk,meat,vegetable,grains and butter)
Defraaye, Nicolai, Kirkman, Moore, Niekerk, Verboven and Cronje, 2016	*					Interection of the cargo load with the container for the cold Logistics management. This Research shows that the way of convectively cooling container has a clear impact on.
Ali, Shukran, 2016		*				Literature of organizational behavior and strategic management into multi-level supply chain.

As it seen on the table about classification of Journals about “Food Supply Chain”, “Cold Supply Chain” and “Food Logistics” mostly Case and Conceptual Study method were used. There are so much Journals in academic databases. Because of food supply chain has long been researched the number of journals and the method used in researchers are various. When the researches are classified by journals published, the dispersion will be held at the table below:

Table.2: Dispersion of Journals Consist Food Supply Chain Researchers

Journal	Number of Researchers
Journal of the Operational Research Society	**1**
International Journal of Physcial Distribution&Logistics Management	**1**
International Transaction in Operational Research	**3**
International Journal of Production Economics	**5**
Journal of Network and Computer Applications	**2**
Journal of Operation Management	**6**
Computers&Operation Management	**1**
Journal of Industrial and Management Optimization	**2**
The Journal of Developing Areas	**1**
Biosystems Engineering	**5**
British Food Journal	**2**
Others	**4**

3. SURVEY RESULTS

The production of agricultural products, the production of food products, agricultural products logistics, food products logistics and consulting firms are responded to our survey. Consulting firms have the highest share with 31%. Each of the other participants have a share of about 17%. According to our survey results that we made between survey participants in the food supply chain, 12% of interviewers stated that they have ATP Conventions and its content (Figure 2). However, 9% of interviewer stated that they had heard of the ATP convention, but they do not know exactly the content.

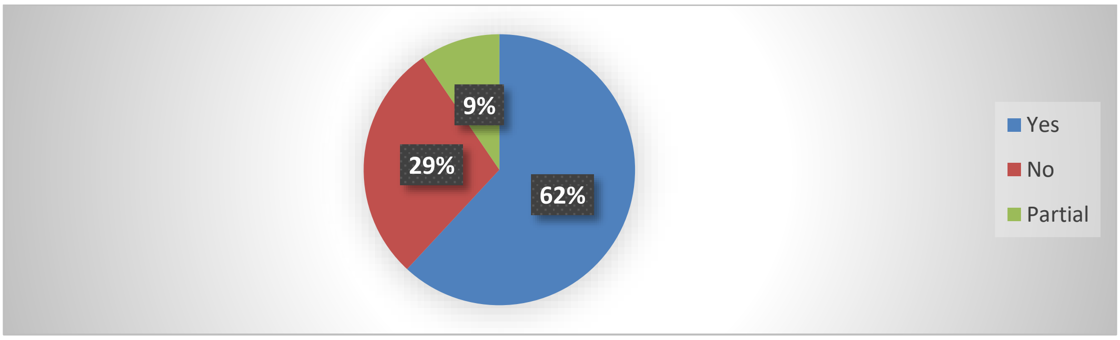


FIGURE 2. The Number of People Who Know What is the ATP Convention

According to the survey responses, ATP convention would create %12 cost balance in terms of food sector and supply chain. At the same time, 36% of respondents to our survey said that it would be increase the value of the food safety. Furthermore, interviewers said that just woke up on the rules will be disadvantaged against those who wake up in the long term will be 12%.

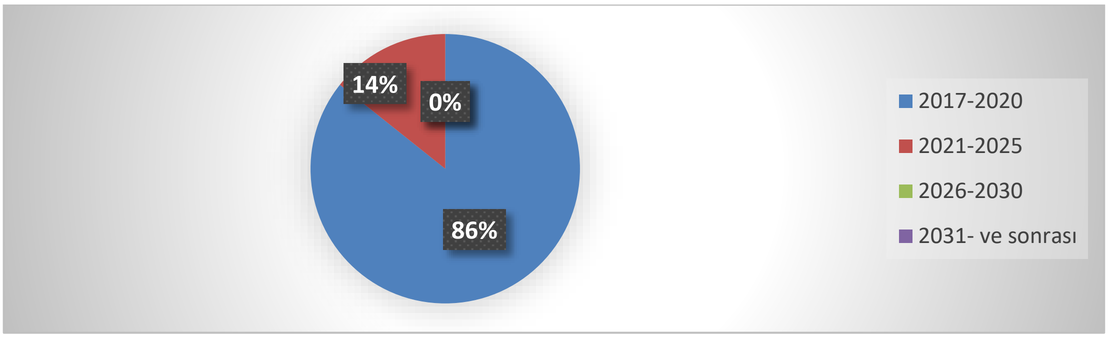


FIGURE 3. ATP Convention Should Be Adopted at What Period

We can look at the responses of the four periods mentioned in the above Figure 3. According to results interviewers have chosen to the 2017-2020 period. They stated that the need to put into practice as soon as possible in the domestic logistics applications.

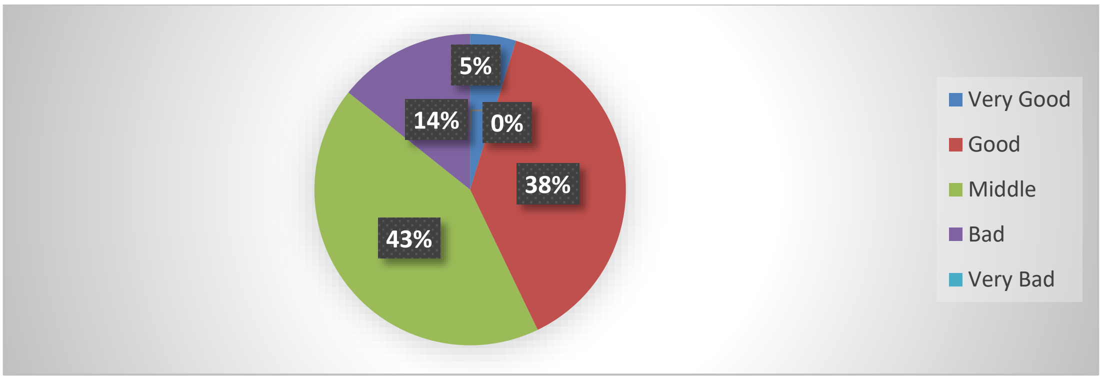


FIGURE 4. Transport Mode and Selection Level

We see responses that to selection transport mode and vehicle level on the Figure 4 by product type. 5% of the interviewers said that it was very good. On the other hand, the highest share is medium level with 43%.

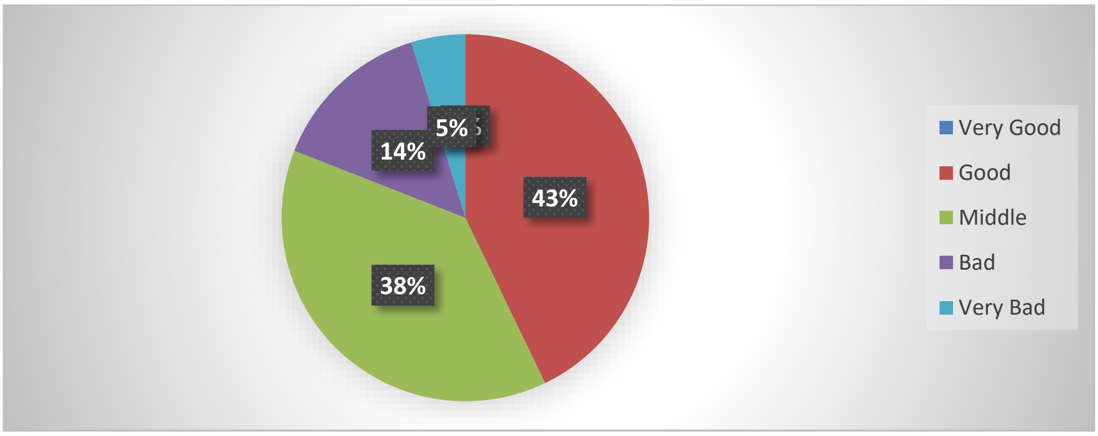


FIGURE 5. Quality Lvel of Equipment

We also asked that refrigerated, mechanically refrigerated and heated equipment for the production and use of quality levels are at what stage. 5% of people pointed out that is poor after-sales service level. However, 43% of interviewers said that thought it was good.

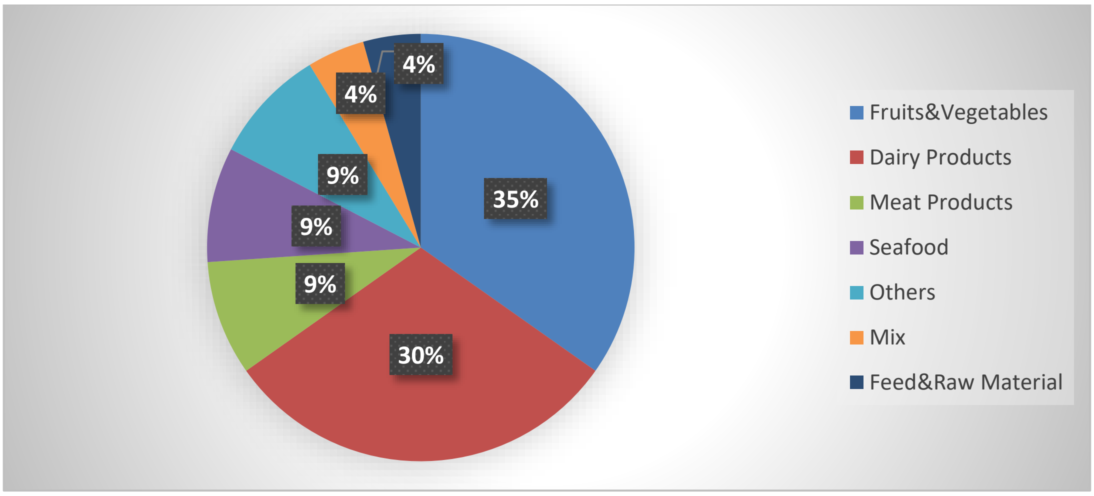


FIGURE 6. Which Products are Carried within the Scope of ATP

35% of respondents of our survey are carrying fresh fruits and vegetables and 30% are transpor dairy products. It carries only 4% mixed products. The Number of employees of these companies are between 1-10, 11-50 and 51-100. They also indicated that education on the subject Should be given to sector before the starting ATP Convention. This group mostly consists 95% of consulting firms and they said that for compnies Should be given counselling ATP.

4. CONCLUSIONS and SUGGESTIONS

Food is an essential part of our lives, which is why the way it is grown, processed and transported is worth understanding and improving. When we look to global food supply chain, we can buy the bet foods from all over the world. We live in a world of scarce resources so there are important things to be considered for the next generations of transportation of food products from farm to fork.

The food industry is highly diverse and comprises several important components. Each component adds distinctvalue to the whole food chain by improving sustainability and producing better products. The current challenge for the food industry is to accomplish economic success with a focus to improve energy savings and ensure social as well as environmental performance.

Temperature controlled products require specialized transportation equipment and storage facilities. Transfrigoroute which is international owner of the Convention has revealed the main rules for the international cold chain transport. It has also been determined principles for the supervision of perishable foods. However, sanctions to be applied are determined independently by the countries party to the convention. Therefore, these rules immediately should be reflected in national legislation.

From a logistics point of view, unbreaking of the cold supply chain of products are extremely important for to the final consumer from the production site. In this case, effective implementation of the ATP Convention will ensure unbreakage of the cold chain. With the enactment of the ATP Convention meat, milk, fish and perishable foods will prevent the unhealthy move and will be eliminated to a large extent of the economic losses caused by it.

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A STUDY ON THE APPLICABILITY OF REVERSE LOGISTICS IN FOOD ENTERPRISES

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ABSTRACT- Increase in competition and emphasis to customer satisfaction have obliged companies to choose and provide right items for consumption and production, such as right place, right time, right condition and right cost, also recycling of products and right product flow. This is only possible with the development of logistics activities. Increasing customer satisfaction, complying with the law, reducing costs, fulfilling the requirements of social responsibility are the most effective ways of providing a competitive advantage in marketplace. In logistic activities, one of the key processes is reverse logistics activities. Reverse logistics is important in terms of businesses, consumers and the natural environment. The implementation of reverse logistics activities a systematic way has become ecologically, economically and legally imperative. Reverse logistics activities are included in the mission of many companies. Accordingly, the importance of reverse logistics worldwide is expected to increase further day by day. In our study, the concept of reverse logistics which is a systematic way of recycling products and allowing the return to the starting point of the products and information is discussed. Reverse logistics activities of the food firms' operating in the manufacturing sector in Gaziantep Organized Industrial Zone are examined via survey method which measured the level of knowledge on this subject of business; thereby the industry's current situation has been displayed. As a result of the current situation, a variety of suggestions on reverse logistics have been put forward.

Keywords-Product Recovery, Recycling, Reverse Logistics.

Related Topıcs- Reverse Logistics, Supply Chain Management, Social Responsibility

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LITERATURE REVIEW

Reverse logistics has been one of the important part of the world economy (Morgan et al., 2016:293). The research on reverse logistics has developed over the years and authors have assigned various reverse logistics definitions. The first definition of reverse logistics was found to be done by Murphy and Poist (1989) by pointing out the reverse flow of goods (Agrawal et al., 2015:73). Tibben-Lembke and Rogers (2002:271) defined reverse logistics "as the movement of product or materials in the opposite direction for the purpose of creating or recapturing value, or for the purpose of proper disposal". All recovery actions in which a firm gains economic benefit directly or indirectly refer reverse logistics. This process is very both complicated, different and more expensive than forward distribution of a new product (Ramírez & Morales, 2014:954). It should be noted that reverse logistics is not a homogeneous subject but an umbrella term that covers a number of different operational cases (Bernon et al, 2011: 486).

Each company has to appoint the specific mix of reverse logistic activities for strategic decisions on reverse logistics. Through the growing importance of reverse logistics as a main factor to optimise resources by means of decreasing the negative influence on costs, it is important to understand how these activities affect the costs of reverse logistics, with an aim to find out results on organisational performance (Ramírez&Morales, 2014:954). There are many economic drives for companies to implement reverse logistics; cost savings by less use of virgin materials; reduced transportation and disposal costs; and revenue generated by the use of salvaged materials are within the main economic reasons (Chileshe, 2016: 137). Reverse logistics can also develop customer loyalty, because customers respond positively to environmentally responsible actions by the company, so goodwill formed by reverse logistics could be a source of competitiveness (Hsu et al., 2016: 92). On the other hand, a company has to implement reverse logistivs due to legislation. Legislation refers to any jurisdiction that makes it mandatory for companies to recover products produced by them or own accountability of products after their end-of-life. Nowadays , there has been an increase of environmental legislation such as recycling quotas, manufacturer take-back responsibility and packaging regulation that have increased the interest on reverse logistics activities (Ravi & Shankar, 2015:875).

Some spesific strategies as recommendations for companies to keep the reverse logistics as successful process are as follows: Customer satisfaction, eco-compatibility, strategic alliances, knowledge management, new technology implementation, value recovery (Antonyová et al., 2016:2). Specifically, reverse logistics create tangible and intangible value by helping firms (Hsu et al., 2016: 92);

1. Extract value from used/returned goods instead of wasting labor force, time, and to procure more raw materials,
2. Create additional value through increasing product life cycles,
3. Increase customer satisfaction and loyalty by caring for faulty goods and for merchandise repairs,
4. Get feedback to suggest improvements and enhance understanding of the real reasons for product

THE PURPOSE AND RADIUS OF THE RESEARCH

Reverse logistics, which is quite important for firms, consumers and environment, has crucial importance in the area of food production. Because, accurate reverse logistics practices can make a firm more competitive by reducing the cost of material diminishing the customer's risk when buying a product, diminishing the market response time, fulfilling social responsibilities and improving the environmentalist or greener image. In this study, literature on reverse logistics has been examined and academic articles dealing with reverse logistics applications have been classified in a systematic way. This work intends to explain how much the firms in food industry value reverse logistics activities besides their production activities. This study has focused on the reverse logistics activity of food production companies which are active in Gaziantep province. The purpose of the work is to state the current status of the industry by examining reverse logistics activities of the firms which operate in food industry in Gaziantep Industrial Zone and to measure the knowledge levels of the firms on the article reverse logistics.

METHOD AND RESEARCH

Survey was used as a tool to collect data in this research. The survey was applied between the months June-July 2016. It was done by visiting food production firms and applying face to face survey method. Through literature review the questions in the questionnaire (Dirik, 2012) were prepared with the intension of picking out the reverse logistics activities of the firms. The questionnaire of the research consists of 13 questions. The first 3 questions of the questionnaire are about the answering participants' specialties and other 10 questions are about firms and the industry. Questionnaire consists of multiple choice and yes/no questions. There are 92 food firms operating in Gaziantep Industrial Zone. Convenience sampling is used to collect data from these firms. 36 of them participated in the survey. Out of those, 32 of them have applicable qualities. The data of the survey was compiled and analyzed with SPSS 22.0 software.

Table 1. Participants' Demographics

	f	%
Participants' Positions in Firms		
Principal\Head	14	43,8
Vice Principal	4	12,5
Head of Departments	13	40,6
Others	1	3,1
Total	32	100,0
Industrial Experience of the Participants		
1-5 years	3	9,4
6-10 years	10	31,3
11-15 years	7	21,9
21 years and over	12	37,5
Total	32	100,0
Education Levels of Participants		
Elementary	1	3,1
High School	7	21,9
University	24	75,0
Total	32	100,0
The Markets the Firms are Active		
Domestic\Local Market	8	25,0
Both International and Domestic\Local	24	75,0
Total	32	100,0

When looked upon the people that joined the research, it is observed that most of them are principals, heads or heads of departments. This tells us that the answering participants are at managing levels and therefore the answers are more accurate. Answering participants were asked about their experience in the industry. %37,5 of the participants had the work experience of 21 years and over. This datum shows us that answering participants were experienced in the industry.

As seen in the table, %75 of the survey respondents had a university degree. High education level of the participants' made the responses more accurate in the light of intellectual. Besides, the ones with higher education levels had more interest in the research and answered questions in a more sensitive way. %75 of the participating firms are active in both international and domestic/local markets.

Upon asking about reverse logistics, first things that came to minds of the firms' managers were listed and shown below in Table 2.

Table 2. Perception Levels of the Answering Participants about Reverse Logistics

	f	%
Recycle	10	31,3
It is reverse flow of used products towards production process for re-use.	3	9,4
It is the collection of products with the intension of destructing them to minimize their damage on environment.	4	12,5
It is a way to evaluate recycled products to determine usable ones and by doing so to lower resource use and to increase profit level.	15	46,9
Total	32	100,0

While %46.9 of the answering firms conceive the term reverse logistics as "It is a way to evaluate recycled products to determine usable ones and by doing so to lower resource usage and to increase profit level" %31.3 of them conceive it as "recycle". This question was included in the survey to evaluate the knowledge levels of the firms about the conception of reverse logistics.

Table 3. How Reverse Logistics Activities were Executed

	%
With the help of reverse logistics professionals (recycle experts etc.)	62,5
On their own	37,5
Total	100,0

The firms were asked about how they executed reverse logistics activities. While %62 of the participants executed reverse logistics activities with help of experts, %37 of them executed reverse logistics activities on their own.

Table 4. The Valuation of Waste and Waste that Valuated with Recycling

Waste Valuation Rates			Waste that Valuated with Recycling		
	f	%		f	%
Yes	17	53,1	Glass bottles	2	11,8
			Plastic cover	11	64,7
No	15	46,9	Aluminum	1	5,9
			Organic Waste	2	11,8
Total	32	100,0	Paper	1	5,9
			Total	17	100,0

While %53 of the answering firms manage recycling of waste, %46 of them are not capable of valueing waste. %64 of the firms recycle plastic cover, %11 of them recycle glass bottles and %11 of them recycle organic waste. The reason electronic and textile waste are not present is that the survey was applied to food manufacturing firms.

Table 5.Reuse of the Recycled Supplies

	f	%
Sales at secondary markets	14	82,3
Outlet sales	1	5,9
As donations	2	11,8

While %82 of the answering firms stated that they, at the end of recycling process, put the recycled materials up for sale in secondary markets, %11 of them stated that they donated the materials. Donation of food waste makes valuation of waste in the right way possible and it makes the reduction in environmental damage of waste.

Table 6. How Products are Recollected

	f	%
By taking directly to its origin	8	61,5
By using external sources	5	38,5
Total	13	100,0

13 of the firms that participated in the research put products into recycling processes. %61 of these firms recollect products directly from their origins and, %38 of them use external sources to recollect products. Recycled products were mostly applied decomposition and product alignment.

The participating firms were asked about how products return in reverse logistics activities. They were asked to answer with frequencies such as “Always, mostly, sometimes, rarely and never”.

Table 7. How Products Return

How Products Return	Always	Mostly	Sometimes	Rarely	Never
	%	%	%	%	%
Returns at the end of material use.	6,3	15,6	12,5	6,3	
Warranty returns.		12,5	9,4	15,6	3,1
Commercial returns.		3,1		15,6	21,9
Returns due to defective production.	3,1	9,4	12,5	15,6	
Returns because products became waste.	3,1	3,1	15,6	9,4	9,4

In Table 7, the application frequencies of returns during firms’ reverse logistics process are given. Every possible way of return was evaluated within itself according to usage frequencies. As a result, “Returns at the end of material use” has the highest percentage with %15,6 in “Mostly” section; on the other hand, with %3,1 the statements “Commercial Returns” and “Returns because products became waste” have the least frequencies. If the statement “Never” was to be evaluated within itself, with %21,9 “Commercial returns” has the highest and with %3,1 the statement “Warranty returns” has the least frequencies.

Table 8. The Reasons for Applying Reverse Logistics

The Reasons for Applying Reverse Logistics	Agreement Degree
Reverse Logistics is mandatory according to laws.	3,07
Important for accomplishing social responsibilities.	3,76
Helps reduce the resources.	3,84
Reduces the amount of input (resources etc.).	3,84
Provides economical increments in value.	3,92
A profitable investment.	4,07
Provides firms advantages for competitions.	4,23
Gives environment-friendly look.	4,30

As seen above, Table 8 provides us with the knowledge why firms think they should apply reverse logistics. Values are sorted from low to high and as the values get higher they get close to “Most agreed” statement Therefore, according to this table, the statement “Gives environment-friendly look” has highest degree and considered as “Most agreed”; and the statement “Reverse Logistics is mandatory according to laws” has the least degree as a result it is considered “Least agreed”.

Table 9. Evaluating the Statements about Reverse Logistics

Some Statements about Reverse Logistics		
It brings in products that completed their life cycles to re-use.	3,71	1,22
It reduces process number in stock production.	3,81	1,06
Important for the economy of firm. It makes firms more active in environmental issues	3,81	1,17
It provides customer satisfaction.	3,90	0,89
It increases the value of products.	3,93	1,04
It has strategic importance.	3,96	0,74
It focuses on maximum profit.	3,96	0,76
It makes firms gain environmentalist look.	4,15	0,91
It multiplies proficiency.	4,18	0,78
It provides valuation of the waste.	4,25	0,62
It helps reduce the expenses.	4,31	0,64
It prevents waste damage environment.	4,50	0,56

As seen in Table 9, the statement “It prevents waste damage environment” by having the highest average is closest to the statement “Most agreed”. “It provides the valuation of waste” and “It helps reduce the expenses” are other statement with high averages. The general opinion of the firms on this statement is towards the statement “Most agreed”. Out of all statements about reverse logistics, the least agreed statement inclined that firms go with is the statement “It brings in products that completed their life cycles for re-use”. The reason for this is that in food industry products which have completed their life cycles are almost impossible to bring in for re-use. Firms consider that reverse logistics plays an important role in preventing waste from damaging environment, valuating waste, reducing expenses and in profit making. Therefore, reverse logistics, reduces environmental damage and provides firm a better financial context.

CONCLUSION

As firms care about customer satisfaction and having an environmentalist look with manufacturing less damaging products for people and environment, reverse logistics enacts competition to a strategic level. To compete in this way, especially in non-government firms, reverse logistics has become compulsory. With reverse logistics activities, elements used in food industry such as organic food, plastic cover, glass bottle and paper will be recycled and by doing so damage on environment and expenses of firms will be reduced, hence firms will profit out of this process. Companies especially operating in the food sector by recycling organic waste and selling them to feed mills will help firms profit economically and help them reduce damage given to environment by their products.

Gaziantep, with its large capacity of industry and trade contributes to state economy at significant levels. Most of the food manufacturing firms operating in Gaziantep Industrial Zone, operate on both domestic/local markets and on international markets; and most of these firms have the experience of 21 years and over. Furthermore, most of the answering participants are university graduates, educated and experienced. However, most of these firms were identified not applying reverse logistics. Application of reverse logistics will provide firms advantages in social and economic aspects and help them acquire a positive image in the mind of the consumers where customer satisfaction is at utmost importance. The research has concluded that firms suffer from the lack of knowledge on reverse logistics. This lack of knowledge will be resolved by raising consciousness of firms about reverse logistics and making necessary arrangements to support “reverse flow” in production processes of firms. Although with the new laws recycling became mandatory in Turkey, for the lack of material returns, firms cannot acquire enough waste to put them through recycling and profit from this hard and expensive process thus reverse logistics activities cannot be operated economically. It is a faulty situation that firms consider reverse logistics activities only as a profitable purpose. Reverse logistics activities reduce environmental damage and it is one of the most effective ways to leave upcoming generations a clean world. For these reasons, firms should be trained about reverse logistics and awareness should be raised.

There was no work conducted about Gaziantep's reverse logistics activities and operation of distribution channels, the contribution of this work to the literature is the information it provides for this subject matter.

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AN INTEGRATED MODEL FOR BLENDING AND INTERMODAL TRANSPORTATION IN THE WHEAT DISTRIBUTION NETWORK

Bilge Bilgen [1]

Abstract − *The supply chain considered here derived from current operations of a major organization that manages the wheat supply chain from the time a grower delivers to a storage facility until the time that product is delivered to an end use customer. A logistics network is a set of storage sites, loading ports and destination ports (customers) to manage the blending of original grains, and the distribution of original and/or blended grains to the customers. Rail and/or road transportation is used between storage sites and loading ports. Marine transportation is used to reach customers in various locations in the world. The problem is to assign appropriate type and number of vessels to each customer order, while determining the quantities to be transported from upcountry storage sites to ports; blended, and loaded at ports; and transported from ports to customers.*

Keywords − *agricultural supply chain, intermodal transportation, mixed integer linear programming, wheat distribution.*

INTRODUCTION

A wheat industry is a large supply chain containing sectors of wheat growing, blending and storage of grains, and shipping to the customers. The supply chain considered here derived from current operations of a major organization that manages the wheat supply chain from the time a grower delivers to a storage facility until the time that product is delivered to an end use customer. A logistics network is a set of storage sites, loading ports and destination ports (customers) to manage the blending of original grains, and the distribution of original and/or blended grains to the customers. Rail and/or road transportation is used between storage sites and loading ports. Marine transportation is used to reach customers in various locations in the world. The problem addressed in this paper is to minimize the blending, loading, and distribution costs for satisfying demand for wheat products. This problem is an extension of the problem considered in Bilgen and Ozkarahan [2].

In recent years, there has been a growing interest on the operations research (OR) applications in agri-food supply chain literature. Comprehensive reviews on application of OR, and Management Science (MS) on agri-food industry have been provided by [1, 4-6, 8-12]. For recent reviews on ship routing and scheduling, and maritime inventory routing, we refer to [3-7]. The contribution of this paper is an optimization model for a combined blending and multi-mode transportation planning problem in a wheat supply chain together with an industrial case study that shows its practical usage.

PROBLEM DEFINITION

This paper attempts to optimize a wheat blending and multi-product, multi-period, multi-echelon distribution planning problem with consideration of multi-mode transportation. The distribution system considered here derived from current operations of a major organization that manages the wheat supply chain from the time a grower delivers to a storage facility until the time that grain is delivered to an end use customer. The company seeks that cost minimization is achieved through an integrated supply chain plan that takes domestic transport, marine transport, as well as blending, loading decisions into consideration. Figure 1 shows the general structure of the system we analyze in this paper.

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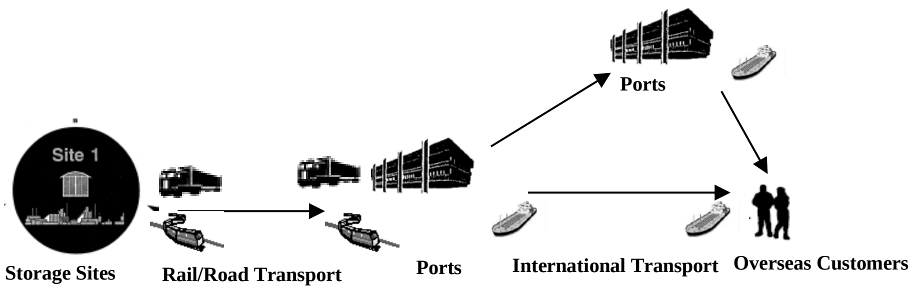

Figure 1. Wheat Supply Chain Network

The supply chain network considered in the model consists of multiple upcountry storage sites, loading ports, and customers. The planning horizon, in keeping with the midterm nature of the model, ranges from 1 month to 3 months. Different transportation modes are used between sites. Each storage site has limited out-loading capacity for each transportation mode. Grains stored in storage sites are then transported to loading ports by rail and/or road transport. Possible transports links are defined between sites including the carriers. Road and rail transportation are contracted out with long term contracts. Contracted freight rate per route, per transportation mode, and carrier is given. Some of the original grains are directly supplied to the loading ports. The others come from storage sites by rail and/or road transportation. Ports also have limited in-loading capacity for each transportation mode. When necessary, original grains are blended at loading ports, prior to ou-loading, to produce new grain types required by customers. Blending is defined as mixing two or more original grains to form another grain type. Blending incurs blending charges. Blending costs differ from port to port. Grains are then loaded on bulk vessel types of various capacity levels for delivery to customers located overseas. It is assumed that a vessel can pick up grains from at most two loading ports (1 or 2 loading ports) in a voyage. Ports have draft constraints, which is represented in the model as the maximum tonnage that can be safely carried in and out of a loading port, and carried in a destination port for a vessel class. A vessel is discharged in a single destination port, where the customer is located. Each vessel is hired for delivering one shipment of grains to one customer, and is not allowed to discharge cargo at loading ports. There is no restriction related with the number of grain types can be carried on each vessel. It is assumed there are an unlimited number of vessels of each type available. Marine transport routes and their corresponding voyage costs by vessel type are given. Customers are allowed to demand both original grains as well as blended grains. It is assumed that customer’s demand for a grain and the shipment of that grain must take place in the same period.

INTEGRATED DISTRIBUTION PLANNING MODEL

In this section, a MILP model is developed to solve the wheat blending and distribution planning problem in an integrated way. The model developed in this section aims to address the question of how much original grains to be transported from the storage sites to the ports by transport mode, by route, by carrier, by grain type and by period; how much to load from the port(s); how many vessels of each type used by route and by period; how much original grains used to make the blended grains by port and by period; how much to be blended by port, by grain type and by period; how much to store by site, by grain type, and by period. The objective function seeks to minimize the total cost, including the land transportation, loading, blending, and marine transportation costs. In the following the notation and the integrated mathematical formulation of the decision problem is given as a MILP model.

Indices

J	set of original grains $\{1,2,\ldots,J\}$
I	set of blended grains $\{1,2,\ldots,I\}$
S	set of storage sites $\{1,2,\ldots,S\}$
M	set of transportation modes $\{RL,RD\}$

C	set of carriers $\{1,2,\ldots,C\}$
P	set of ports $\{1,2,\ldots,P\}$
L	set of customers $\{1,2,\ldots,L\}$ (set of destination ports)
V	set of vessel types $\{1,2,\ldots,V\}$
T	set of time periods $\{1,2,\ldots,T\}$

Parameters

D_{ilt}	demand for grain i ($i \in \{I, J\}$), by customer l, in period t,
$SSupply_{js}$	the amount of original grain j supplied to storage site s,
$Supply_{jk}$	the amount of original grain j supplied to port k,
$OutCap_{sm}$	out loading capacity at storage site s, by using transportation m,
$InCap_{km}$	in loading capacity at port k, by using transportation mode m,
$ComCap_s$	combined out loading capacity for storage site s,
$ComCap_k$	combined in loading capacity for port k,
$CCap_{mc}$	carrier capacity for transportation mode m and carrier c,
$MinBlnd_{ij}$	minimum ratio of original grain j in blended grain i,
$MaxBlnd_{ij}$	maximum ratio of original grain j in blended grain i,
$LCap_k$	maximum loading capacity at port k,
$BCap_k$	maximum blending capacity at port k,
$FCap_v$	maximum vessel capacity for vessel type v,
$DCap_{kv}$	draft capacity for vessel type v at port k,
$DCap_{lv}$	draft capacity for vessel type v at destination port l,
$FCost_{skmc}$	transportation cost for route from storage site s to port k, by using transportation mode m, and carrier c,
$TCost_{kqlv}$	fixed transportation cost on route k-q-l for vessel type v,
$LCost_k$	unit loading cost at port k,
$BCost_k$	unit blending cost at port k.

Variables

z_{jskmct} the amount of grain j transported from storage site s to port k by using transportation mode m carrier c during time period t, $j \in J, s \in S, k \in P, m \in M, c \in C, t \in T$,

x^{p}_{ikqlvt} the amount of grain i (original and/or blended) loaded at port p *(either k or q)* on vessel type v on route k-q-l during time period t, $i \in \{I, J\}, \{k, q\} \in P, v \in V, l \in L, t \in T$,

n_{kqlvt} the number of vessels of type v used on route k-q-l during time period t, $\{k, q\} \in P, l \in L, v \in V, t \in T$,

w_{ijkt} the amount of original grain j used to make blended grain i at port k during time period t, $i \in I, j \in J, k \in P, t \in T$,

b_{ikt} the amount of grain i blended at port k during time period t, $i \in I, k \in P, t \in T$,

SI_{jst} quantity of remaining stock of original grain j at storage site s at the end of period t, $j \in J, s \in S, t \in T$.

I_{jkt} quantity of remaining stock of original grain j at port k at the end of period t, $j \in J, k \in P, t \in T$.

IB_{ikt} quantitity of remaning stock of blended grain i, at port k at the end of period t, $j \in J, k \in P, t \in T$.

Minimize

$$\sum_j\sum_s\sum_k\sum_m\sum_c\sum_t FCost_{skmc} z_{jskmct} + \sum_i\sum_k\sum_t BCost_k b_{ikt} + \sum_{p\in\{k,q\}}\sum_i\sum_k\sum_q\sum_l\sum_v\sum_t LCost_p x^p_{ikqlvt} + \sum_k\sum_q\sum_l\sum_v\sum_t TCost_{kqlv} n_{kqlvt}$$

(1)

, (2)

(3)

$$\sum_j\sum_k\sum_c z_{jskmct} \le OutCap_{sm} \qquad \forall s,m,t$$

(4)

$$\sum_j\sum_s\sum_c z_{jskmct} \le InLoad_{km} \qquad \forall k,m,t$$

(5)

$$\sum_j\sum_k\sum_m\sum_c z_{jskmct} \le ComCap_s, \qquad \forall s,t$$

(6)

$$\sum_j\sum_s\sum_m\sum_c z_{jskmct} \le ComCap_k, \qquad \forall k,t$$

(7)

$$\sum_j z_{jskmct} < FCap_{mct}, \qquad \forall s,k,m,c,t$$

(8)

$$\sum_j w_{ijkt} = b_{ikt}, \qquad \forall i,k,t$$

(9)

$$w_{ijkt} - MaxBlnd_{ij} b_{ikt} \le 0, \qquad \forall i,j,k,t$$

(10)

$$w_{ijkt} - MinBlnd_{ij} b_{ikt} \ge 0, \qquad \forall i,j,k,t$$

(11)

$$\sum_i b_{ikt} \le BCap_k \qquad \forall k,t$$

(12)

$$Supply_{jk} = I_{jk0}, \qquad \forall j,k$$

(13)

$$\sum_q\sum_l\sum_v x^k_{ikqlvt} + \sum_q\sum_l\sum_v x^k_{iqklvt} + \sum_{i\in I} w_{ijkt} - I_{j,k,t-1} + I_{j,k,t} - \sum_s\sum_m\sum_c z_{jskmct} = 0, \qquad \forall i,j\in J, \forall k,t$$

(14)

$$IB_{i,k,0} = 0, \qquad \forall i,k$$

$$SI_{js0} = SSupply_{js}$$ 15)

$$, \quad \forall i\in I,k,t \quad \sum_k\sum_m\sum_c z_{jskmct} - SI_{jst-1} + SI_{jst} = 0 \qquad \forall j,s,t$$ (16)

$$\sum_{i\in\{I,J\}}\sum_{q}\sum_{l}\sum_{v}x_{ikqlvt}^{k}+\sum_{i\in\{I,J\}}\sum_{q}\sum_{l}\sum_{v}x_{iqklvt}^{k}\leq LCap_{k}\quad,\quad\forall k,t$$

(17)

$$\sum_{i\in\{I,J\}}x_{ikqlvt}^{k}-DCap_{kv}n_{kqlvt}\leq 0\quad,\quad\forall k,\forall q,\forall l,\forall v,\forall t$$

(18)

$$\sum_{i\in\{I,J\}}x_{ikqlvt}^{k}+\sum_{i\in\{I,J\}}x_{ikqlvt}^{q}-DCap_{qv}n_{kqlvt}\leq 0\quad,\quad\forall k,\forall q,\forall l,\forall v,\forall t$$

(19)

$$\sum_{p\in\{k,q\}}\sum_{i\in\{I,J\}}\sum_{k}\sum_{q}x_{ikqlvt}^{p}-\sum_{k}\sum_{q}DCap_{lv}n_{kqlvt}\leq 0\quad,\quad\forall l,v,t$$

(20)

$$\sum_{i\in\{I,J\}}\sum_{p\in\{k,q\}}x_{ikqlvt}^{p}-FCap_{v}n_{kqlvt}\leq 0\quad,\quad\forall k,\forall q,\forall l,\forall v,\forall t$$

(21)

$$\sum_{p\in\{k,q\}}\sum_{k}\sum_{q}\sum_{v}x_{ikqlvt}^{p}=D_{ilt}\quad,\quad\forall i,l,t$$

(22)

CONCLUSION

The supply chain considered here derived from current operations of a major organization that manages the wheat supply chain from the time a grower delivers to a storage facility until the time that product is delivered to an end use customer. A logistics network is a set of storage sites, loading ports and destination ports (customers) to manage the blending of original grains, and the distribution of original and/or blended grains to the customers. Rail and/or road transportation is used between storage sites and loading ports. Marine transportation is used to reach customers in various locations in the world. The problem addressed in this paper is to minimize the blending, loading, and distribution costs for satisfying demand for wheat products. The problem is to assign appropriate type and number of vessels to each customer order, while determining the quantities to be transported from upcountry storage sites to ports; blended, and loaded at ports; and transported from ports to customers. The company seeks that cost minimization is achieved through an integrated supply chain plan that takes domestic land transport, marine transport, as well as blending, loading decisions into consideration.

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A NEW SUPPLY CHAIN MODEL IN AGRICULTURAL PRODUCTION AND RETAILING

Öznur Özdemir-Akyıldırım[1]

Abstract − Today one of the main problems in agricultural sector isthe low profit margins obtained by the farmers despite the high prices faced by the end consumers. This is especially a severe problem in our country. Many small farmers are getting out of business due to not being able to cover their costs with their revenues. To alleviate this problem and sustain agricultural production,`new business models where farmers can get a higher share from the total revenue are needed. Given these, this study presents a new supply chain model which eliminates intermediaries such as wholesalers and middlemen. The model may provide both higher and secured earnings to small farmers and better products to end consumers. The model has been inspired by a project implemented in Mid-Anatolia. This project brings lands of small farmers together and leases them to a large-scale agriculture company. Motivated by this project,this article models a supply chain structure where a big agricultural producer leases lands of small farmers and provide constant returns to them while she is selling the crops in her own markets. The article compares the benefits of this supply chain model with those of traditional supply chains.

Keywords − agricultural supply chains, agricultural production, supply chain management, supply chain contracting,

INTRODUCTION

Today one of the major problems of the world is supplying sufficient and healthy food to the rapidly growing world population. Considering the rapid destruction of farming areas, climate changes, prevalent use of pesticides and moving away from natural food, it may become even more difficult to provide healthy and cheap food to human beings in the future. On the face of these problems, many countries and organizations have started to put more emphasis on food supply chains. For instance, the European Commission set up a new High Level Forum for a Better Functioning Food Supply Chain. The Forum conducts meetings with main stakeholders including national authorities, representatives of the sector and non-governmental organizations and reports on the principles to achieve good practices in food supply chains [1].

Sustainable food production which is defined as “a method of production using processes and systems that are non-polluting, conserve non-renewable energy and natural resources, are economically efficient, are safe for workers, communities and consumers, and do not compromise the needs of future generations” in [2] is the goal of most countries today. In this context, one important issue is the food prices faced by the end consumers. Especially for fruits and vegetables, the end consumers generally pay high prices in the markets while the farmers cannot get a high share from this revenue. In other words, there exist a high margin between the prices faced by the end consumers in markets or bazaars and the prices paid to the farmers. One of the main reasons for this is the supply chain structure for agricultural products. Small farmers who do not have bargaining power and access to markets generally sell their products to intermediaries at prices set by the intermediaries. Moreover, due to budget limitations and small size of their lands, such farmers generally cannot make sufficient investments to increase their yield or to decrease the cost of cultivation. Especially in Anatolia, due to the frequent partition of land with inheritance, farmers with very small lands are prevalent. These farmers cannot undertake expensive investments to ensure sustainable production. Sometimes, they may even stop cultivating their land with worry of making loss.

One possible way of overcoming these problems is establishing cooperatives to bring the farmers together and consolidate their lands. However, cooperatives are generally not preferred in Turkey due to the administrative difficulties and commonly experienced conflicts between the members. An

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innovative alternative has been used in a village of Yozgat, in Mid-Anatolia. Villagers with small lands come together and combined their land under a cooperative established by the local government.The local government then leased these lands to a company for a certain period of time, who can apply modern cultivation technologies and increase the yield from the land. Inspired by this example, this paper aims to discuss the benefits of such an innovative supply chain structure over the traditional supply chain structures in agriculture.

LITERATURE

Our study relates to two main streams: contract farming and agricultural supply chains. Contract farming is defined as "agricultural production carried out according to an agreement between a buyer and farmers, which establishes conditions for the production and marketing of a farm product or products. Typically, the farmer agrees to provide agreed quantities of a specific agricultural product." by Food and Agriculture Organization of the United Nations [3]. In contract farming, the farmer commits to supply predetermined quantities of a specific agricultural product which should meet the quality requirements of the buyer and be provided at the required time. The buyer, on the other hand, agrees to buy the product and, may support cultivation through providing some inputs, technical advice, etc. In such a contract, farmers have a guaranteed market and can enjoy certain prices and demand and investment help while the buyer company benefit from guaranteed supply that meet its standards regarding quality, quantity and timing of delivery. According to Nicolas Minot who analyzes contract farming in developing countries, it can be viewed as a form of vertical integration, in between spot markets and vertical integration [4]. In the literature contract farming has been mostly studied in agricultural economics; studies in operations management or supply chain management field are very scant. In one of the few studies, [8] focuses on vertical coordination in agri-supply chains and examines the drivers for such type of structures. The authors conclude that technological, regulatory and socio-economic factors may lead to such changes in traditional food supply chains.

In agricultural economics, studies on contract farming are more prevalent. In an empirical study, which compares the vertical coordination, namely contract farming, with vertical integration in terms of farm performance, it has been found that vertically integrated farms has significantly higher yields and revenue [5]. In fact, contract farming seems to be a solution for the access of small farmers to the markets; however due to the relatively lower bargaining power of farm owners compared to the purchasing companies which are generally large-scale companies, contract farming does not seem to help to increase the revenues of small farmers.

Studies on agricultural supply chains are also very rare in operations management literature. [6] develops mathematical models to analyze the strategic decisions of small farmers in joining agricultural cooperatives and deciding on how much to produce and how many farms should take place in the cooperative. [7] uses dynamic modeling to optimize agricultural chains focusing on the product quality and appearance dimensions. [9] focuses on the link between fruit quality and consumer behavior and analyzes how the supply chain players can benefit from using the consumer response to improve supply chain performance.

In the face of the above review of the existing literature, there seems to be a gap on the investigation of agricultural supply chains from an operations and supply chain management perspective. This study aims to respond to this need by focusing on a new supply chain structure which can provide substantial benefits to smallholder farms. Particularly, we investigate how small farm owners can increase their yield by uniting their lands.

MODELS

In traditional agricultural chains, small farmers, who cultivate their land independently and do not have immediate access to markets, generally sell their products to wholesalers called as intermediaries. Since, in this transaction the farmer is the party with relatively lower bargaining power , the farmers generally cannot have an impact on pricing and have to accept the price offered by the intermediary. Generally, this price is under the real value of the products and considering the high costs made during the growth of the crop, it may not even cover the costs of the farmer. In the and many farmers stop cultivation due to such uncertainties. The unit cost of cultivation is higher in small lands because advance technological investments are not possible or affordable in such farms. In this sense,cooperative can be a solution to solve the problems of small farmers and ensure higher yield and revenue by providing them with technology and easy access to markets; however; due to administrative difficulties and the need for managerial expertise, cooperative structure may not be long-lived or preferred by the small farmers who are generally not well-educated villagers. An innovative supply-chain structure applied in a village of Mid-Anatolia may be a solution to these problems. In this structure, villagers with small lands combine their lands and rent it to a company established by the local government. The renting company, afterwards, lease the land which is substantially large after the consolidation, to a large-scale agriculture company which also have retail markets. Single farmer system and the new system which we will call as the consolidated land system, from now on, are depicted in Figures 1 and 2.

The farmers both obtain a rent and also enjoy working as a paid employee in the consolidated land chain. There are several benefits of such a system to both small farmers and the society in general. First of all, the farmers enjoy secured earnings in the form of salaries and the rent under the new system. In a village where there are not many employment opportunities, getting employed to cultivate their own land is important. The farmers also learn modern cultivation techniques which they cannot reach individually. The society also benefits. First of all, the crop yield increases with the investments made and techniques applied by the contractor company. Moreover, easier access to the markets are enabled thanks to the connections of the contractor company. This prevents double marginalization seen in traditional supply chains. While the farmers can sell their products at higher prices, the consumers also pay lower prices.

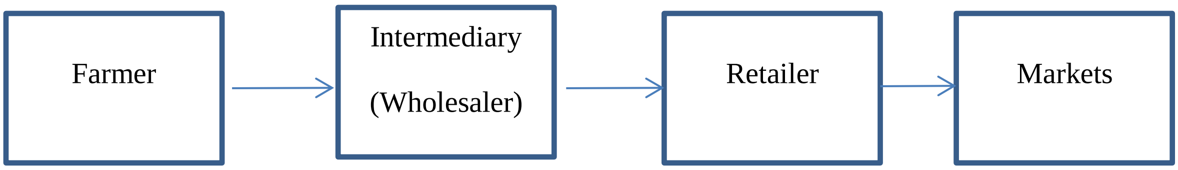

Figure 1. Traditional Agricultural Supply Chain

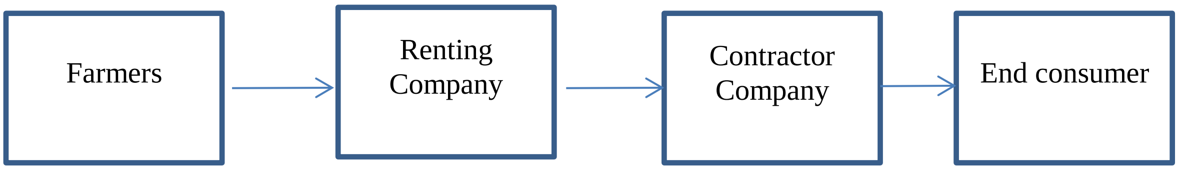

Figure 2. Consolidated Land Supply Chain

Motivated by this example, in this study we focus on the investment decisions of farmers in the single farmer system and the consolidated land system. In farming investments in the cultivated area may take different forms. It may include equipment improvements, better pest control techniques or improved use of technology. Generally, such improvements contribute to the yield rate and enable farmers to harvest more from the same amount of plantation.

In the single farmer chain, we consider a single farmer with a small land. We assume that the farmer is a price-taker and seeks to maximize his profits by deciding on the investment amount, which determines the yield rate, y. The yield rate is modeled as a concave increasing function of the investment amount, I where $y = y^b + \sqrt{I}$. Of course, there exist a cost of investment, c^I. The farmer plants a constant amount, q, determined by the size of his land incurs a production cost, c, per unit plantation. The selling price for the farmer's products, p is lower than the selling price observed in the consolidated land system, $\hat{p}$. Finally, we assume that there exists a constraint on the total amount of money that can be invested by the small farmer, B, since budget limitations is a serious problem for small farms. In the consolidated land system, the contractor company also maximizes her profits by deciding on the investment amount. The contribution of investments to the yield rate and the investment cost is assumed the same as in the single farmer model. The production cost, $\hat{c}$, is higher than that of the single farmer model. There are several reasons for this choice. First of all, one major component of variable production costs is labor. The contractor company has to employ workers while generally the farmer and his family work in small farms. Hence, the labor cost portion of the production cost should be higher in the consolidated land model. Moreover, we already discussed that in the consolidated land, more modern and advanced cultivation techniques are employed. These also add to the variable production cost. Finally, we make a simplifying assumption that the sizes of the lands consolidated are same and represent the consolidation by multiplying the plantation amount by N which shows the number of lands brought together. Here,we should note that the results will not change if the land sizes were assumed different.

Given all these, the models for the single farmer supply chain and the consolidated land chain are given below.

Single farmer model

$$\max_{I} q\,y(I)\,p - cq - I c^{I} \qquad (1)$$

$$s.t. \quad I c^{I} \leq B \qquad (2)$$

Consolidated land model

$$\max_{\hat{I}} Nq\,y(\hat{I})\,\hat{p} - Nq\hat{c} - \hat{I}c^{I} - Nr \qquad (3)$$

In objective function, we consider the rent paid to the land owners as well. Rent paid to each owner is shown with r. Note that both objective function (1) and (3) are concave functions of I, hence we can find the optimal solution by first order conditions. As a result, optimal $I = \min(\frac{q^2 p^2}{4(c^I)^2}, B)$ in the single farmer model and optimal $\hat{I} = \frac{Nq^2 \hat{p}^2}{4(c^I)^2}$ in the consolidated land model. Since $p < \hat{p}$ and $N > 0$, $\hat{I} > I$. That is the optimal investment amount preferred by the contractor company is higher than the one preferred by the small farmer. The contractor is willing to invest more because her expected revenues are higher and she enjoys the economies of scale. This implies that the consolidated land model also provides a higher yield rate. Enjoying the benefits from the increased bargaining power in selling her products and larger funds for investment, the contractor company can help to augment the crop yield.

In order to examine whether it is worth participating in the leasing contract for the small farmer, we should compare the rent and the wages obtained by the farmer from the contractor company with his profit from objective function (1).

CONCLUSIONS AND FUTURE RESEARCH

In this study, we discuss a new supply chain model applied in agriculture sector. In contrast to the traditional system, in the new chain, small farmers consolidate their lands and rent it to a big company. Since the access of the contractor company is easier and her bargaining power is higher, she can enjoy higher selling prices. Moreover, she can provide larger funds for investment. However, we assume that the variable production cost of the contractor company should be higher than that of the small farmer since she has to employ workers. Considering all these in the models, we observe that the investment amount, and as a result, the yield rate occurs higher in the consolidated land system. This implies that the consolidated land system is more beneficial for the society and the region.

Due to the space limitations this study addresses only the investment decisions of the supply chain players and assumes that demand and selling price are exogenous. However, models where demand is stochastic and selling price is endogenous can also be considered in future studies. Moreover, the decisions of the small farmers and the contractor company can be considered in game theory setting where interaction between these two players is possible. Even the decisions of other supply chain players such as the decisions of intermediary and retailer can be included in the model to see whether which player is better off under which model.

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COOPERATION IN TEXTILE SUBCONTRACTING

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Abstract**−***Home-textile is the most common business line in Denizli, Turkey. However, most companies are not integrated, i.e. not all the production processes are performed in their organizations. As a result of this, regional concentration (clustering) is still keeping its importance in the area. To compete with the competitors, companies need to cut down the transportation costs which account for the biggest proportion in the total logistics costs. To do this, companies in the cluster should cooperate. In this paper, we introduce a case study involving four home textile companies. The most considerable side of this study is that the subcontractors can be used jointly and their fabric production capacity can be split among the companies in the coalition in order to meet their demands. Coalition costs are allocated using different cost allocation methods and the results are compared.*

Keywords− *Regional clustering, game theory, horizontal cooperation, vehicle routing problem.*

INTRODUCTION

The most important source of livelihood in Denizli is home-textile that includes everything from bed linen to towels. Even though there are various small, medium or large sized enterprises, most of them are not integrated companies, i.e. a majority of factories can do only some parts of production processes. For this reason, regional concentration (clustering) is still keeping its importance in Denizli.

Firms cluster together within a region because each company benefits from being placed closely to other similar or related firms. Companies in a cluster have common competitive strengths and needs. For instance, common strength of textile companies in Denizli is to increase their capacity easily using other companies' (subcontractors') capacity in peak season. On the other hand, transportation operation is too high among companies when they outsource the processes that are not expert in. The aim of companies that are in a cluster is to build on the unique strengths of their regions i.e. to decrease the transportation costs which have the biggest fraction of total costs.

One way to reduce transportation cost is cooperation among the companies. The cooperation can be vertical, i.e. different branches of business can cooperate (e.g. between a dye house and a weaving facility), or it can be horizontal, i.e. companies in the same business line can cooperate (e.g. between two weaving facilities). The focus of this paper is horizontal cooperation among the weaving facilities. In the literature, case studies about horizontal cooperation are applied several specific industries, such as grocery distribution [6], distribution in rural areas [10], furniture industry [1,2], freight carriers [12], forest transportation [9] and railway transportation [15]. To the best of our knowledge, this study is the first collaboration work in the home textile sector.

The paper is organized as follows: Literature review is given in section 2. A case study is described and individual and coalitional cost calculations are explained in section 3. Concluding remarks are provided in the section 4.

LITERATURE REVIEW

Horizontal cooperation offers some opportunities to companies; as a result, collaboration has grown and is attracting the interest of companies and researchers. One of the benefits of horizontal cooperation is creating a synergy among the companies. The synergy is relational rents which are defined by [8] as a supernormal profit jointly generated in an exchange relationship that cannot be generated by either firm in isolation and can only be created through the joint idiosyncratic contributions of the specific alliance

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partners. Companies create the synergy by three ways: (1) pooling their resources and concentrating their core business, (2) sharing the specific strengths and capabilities of members in the coalition and (3) trading different or complementary resources to achieve mutual gains [4]. [7] introduced a new approach to exploit synergy in transportation which is called insinking procedure. This method proposed pull approach, i.e. the service provider is the initiator of the logistics activities. The main advantage of the approach is that the logistics service provider can proactively select a group of shippers with a strong synergy potential. In that study, the synergy is allocated fairly among the participants by Shapley Value.

Horizontal cooperation provides companies to learn from one another and combine their knowledge and skills. Therefore, they can focus on their core business by increasing their ability to control costs and using labor force more efficiently. By increasing specialization, the ability to meet customer requirements improves. Collaboration provides not only cost savings and productivity but also reduce environmental impact caused by transportation (e.g. cut down CO_2 emissions can be seen in [3]).

There are several case studies worked on horizontal cooperation within specific industries [6,1,12,9]. However, to the best of our knowledge, there exists no application on horizontal cooperation in the home textile sector.

CASE STUDY

In this study, we focus on towel and bathrobe production. There are 4 companies which produce towels and bathrobes in Denizli, Turkey. Their market share is the same and power of negotiation is assumed to be same. These firms are selected based on their close business relationships which are also willing to cooperate.

In Denizli, most of textile companies focus on their core business, for example some companies do only ”sizing and weaving process” or some companies are only responsible for “dyeing process”. To produce a towel or a bathrobe, all production processes are necessary. If a company does not include a process in itself, it has to be outsourced to a company which is an expert about that process.

Each of the four companies has different subcontractors to get the fabrics weaved. The majority of the total cost of these companies is transportation cost. We predict that their transportation cost and indirectly total cost will decrease if these companies merge. In most of the studies in the literature, the vehicles of the companies that are planned to cooperate are used jointly. However, in our situation this collaboration method is not suitable. Because each company wants to keep customer information a secret or worried about the special design of its products. So the common use of the vehicles is not suitable cooperation method for this method. Instead, a different type of cooperation is possible among these companies. As mentioned before, each company has different subcontractors. Let’s assume there are two companies, *A* and *B* and some of the subcontractors of company *A* are close to company B. Also assume that some of the subcontractors of company *B* are close to company *A*. If company *A* uses the company *B*’s subcontractor, which is near to company *A*, instead of using its own farther subcontractor, the vehicles of company *A* travels less distance. The same situation is acceptable for company *B*. Therefore, total travelled distance and total transportation costs decrease.

In this work, companies use the subcontractors jointly and they still keep the same vehicle fleet in contrast to other studies in the literature which focus on the joint use of the vehicles. Companies want to compare the costs for two situations; first one is the individual costs that is before merging and second one is the allocated cost of coalition.

Individual Cost Calculation

We consider four companies, *A-B-C-D*. The numbers of subcontractors of the companies are 8, 11, 12 and 10 respectively. The daily fabric requirements (demands of the companies) are known and the numbers of vehicles and cost of each type of vehicle is given in the Table 1 below. Companies use their own vehicle fleets that are heterogeneous, i.e. capacity of each vehicle differs from one another. The cost of each driver is not variable, i.e. drivers get their salaries monthly and the salary is almost same for all companies in the coalition. In the study, the transportation cost consists of fuel consumption cost (/ km). The distances between companies are known. Each company records the information about their vehicles such as where and when they go and what the distance is between the company and the place that the vehicle goes. The distance information is obtained from companies. Also, the addresses of the companies are known and "Google Maps" is used for obtaining distance matrix. Each subcontractor's daily production capacity is known that is equal to the demand of the company. Semi-finished goods can be transported at any time of working hours. The objective is to minimize transportation cost.

For non-cooperative situation, the problem type is "single depot heterogeneous fleet vehicle routing problem" (SDHFVRP). Four SDHFVRP are solved and the individual transportation costs are obtained. The model proposed by [11] can be applied to this work with small changes.
The model is solved using LINGO software.

The results before merging are shown in Table 1.

Table 1. Individual cost of each company

Company	# of subcontractors	# of vehicles	Veh₺cle	Total transportation cost
A	8	3	1,2	49,88 TL
B	11	3	1,2,3	17,82 TL
C	12	3	1,2,3	33,81 TL
D	10	3	1,2,3	30,34 TL

Coalitional Cost Calculation

In the coalition case, the problem converts to a "multi depot heterogeneous fleet vehicle routing problem" (MDHFVRP). There is more than one company (depot) that carries their own fabrics from the subcontractors back to the company. In total, 2^N-1 (2^4-1=15) coalitions can be established, including 4 one-player coalitions and 11 multi-player coalitions. 4 one-player coalitions are solved by SDHFVRP which were explained in the previous section. The remaining 11 multi-player coalitions are solved as MDHFVRP.

The multi depot vehicle routing problem is NP-hard [5,14]. Therefore, it is usually solved by a heuristic. The MDHFVRP can be solved as a clustering problem in the sense that the output is a set of vehicle routes clustered by depot. In our problem, firstly two-player-coalition (e.g. company *A* and *B* use their subcontractors jointly) problems will be solved, and then three-player-coalition problems (e.g. company *A*, *B* and *C* use their subcontractors jointly) will be solved and finally the model of grand coalition (company *A*, *B*, C and *D* use their subcontractors jointly) will be solved. For the two-three and four-player-coalition models, we have to solve the MDHFVRP. The problem can be solved in two stages: firstly, subcontractors must be allocated (assigned) to the companies (like depots); then routes must be built that link subcontractors assigned to the same company (depot). Using "cluster first, route second" method, MDHFVRP will be solved. After obtaining the subcontractor clusters for each company in the coalition, vehicle routing problem is solved as a single depot vehicle routing problem.

The pseudo-code of cluster first, route second algorithm

set the distance of subcontractor *i* to company *j*
find the minimum distance for the subcontractor *i*
assign subcontractor *i* to the closest company
check whether the demand of company *j* is met by assigned subcontractors
if the demand is met,
    solve the "single depot heterogeneous fleet vehicle routing problem (SDHFVRP)" for each company.
else
    while the demand is met
        select the subcontractor among candidate subcontractors according to subcontractor selection criteria
        check the selected subcontractor meets the demand of company *j*
    end
    solve the "single depot heterogeneous fleet vehicle routing problem (SDHFVRP) for each company.

By this way, individual and coalitional costs are obtained. To decide whether joining the coalition, we need to know the shared cost of each company. So the grand coalition cost must be allocated fairly among the companies.

Cost Allocation Methods

To allocate the coalitional cost, different cost allocation methods are selected: Shapley Value, The Nucleolus and Weighted Relative Savings Method. The Nucleolus and Weighted Relative Savings Method is an LP model. These models are solved by LINGO software.

The average saving is found as 33%. To the best of our knowledge, this study is the first collaboration work in the home textile sector. As opposed to previous studies from other sectors (e.g. forest transportation [9], freight carriers [12], etc.), the basis of cooperation is using the subcontractors jointly with keeping the same vehicle fleet. Therefore, each company collect own fabrics by own vehicles in order to protects customer information or special designs. Establishing a coalition is found to be quite sensible. Because coalition cost (88,413 TL) is lower than the sum of the individual costs (49,88+17,82+33,81+30,34= 131,85 TL). Among the three methods, the most suitable cost allocation method is found to be "the weighted relative savings method".

CONCLUSIONS

In this study, companies in the same business line merge and the coalition cost arising from their horizontal cooperation is allocated among companies according to cooperative game theory. After cooperation, companies obtain a significant cost savings around 30%.

There are some impediments to implement cooperation despite of the significant cost reduction. For instance, partner selection is vital for the success or failure of the cooperation. Teaming with the right partners is essential to increase speed, promote innovation and gain market share. However, analyzing a potential partner's strategic and organizational capabilities requires knowledge about its physical assets, as well as about intangible assets and organizational capabilities [4], which makes finding right partners difficult. For successful cooperation, fair allocation of the coalition cost is as important as selection of right partners and the cooperation's long-term success is provided by the fair cost allocation.

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LEAN LOGISTIC NETWORK DESIGN AND ANALYSIS WITH ANYLOGIC

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Abstract *− Lean logistics is one of the new study areas of both logistics and lean thinking philosophy. The objective of lean logistics is to deliver what is needed to where it is needed and when it is needed. Milk run is a lean logistics technique used to reach lean logistics targets which are decrease cost and/or increase efficiency of transportation. Milk run, in its original term, refers to a path in which a truck delivers product to/from suppliers and from/to retailers. This paper presents a case study using simulation analysis on a logistic system that incorporates milk-run operation. The company in study delivers product from a single supplier to multiple retailers or from multiple suppliers to a single retailer. The main goal of this research is to provide a method to model a lean supplier network for the company and to restructure its supply chain system. The proposed model is simulated using Anylogic simulation software. The results obtained from the case study showed that the proposed model improves the performance of the supply chain on the key performance measures.*

Keywords − Lean logistics, Milk run, Anylogic, Retail logistics and supply chains, Best practices in logistics and supply chains

INTRODUCTION

Logistic and transportation sectors create a platform for national development, and help build strong base for other sectors to operate efficiently [1]. The logistics network consists of facilities including vendors, manufacturing centers, and distribution centers; within this network customers, raw materials and finished products flow between the facilities. One of the key issues of network design is to determine which warehouses should service which customers that produce the most effective distribution channel in terms of cost and performance. In this context, improving a business through application of lean in its supply chain can produce significant savings. Lean thinking describes an approach that aims to deliver more with better use of resources, which is achieved through identification and elimination of waste [2]. Lean origins from manufacturing industry, but today its applications can be seen in all types of industries and businesses. One of the most significant outcomes of fully applied lean processes is achieving a system in which products are pulled by customers as opposed to pulled through the production line [3].

Organizations must constantly strive towards improving their business to gain a competitive advantage. A company's supply chain plays an important role in achieving this advantage. Lean logistics is a proven method that helps organizations improve their supply chain operations. Lean logistics, which requires lean thinking, aims to identify and eliminate waste from the supply chain. Improved customer service, reduced environmental impact are some of the benefits organizations gain by incorporating lean thinking into their supply chain [4]. To stay competitive in the market, it is important for these supply chains to enhance their operational efficiency, responsiveness, resilience, and reliability. Different analysis techniques are used for this purpose, including analytical and simulation models. However, due to the high complexity of supply chains, it is difficult to develop accurate analytical models to study the behavior of the supply chain. In this case, simulation is the most appropriate method to use because of its ability to provide a detailed and dynamic view of the supply chain [5].

Transportation and inventory are the main drivers of the logistics costs. The latter has received great attention in industry, but many times transportation costs outpace inventory costs. Furthermore, the external logistics normally has greater opportunity for cost reductions than internal logistics costs, but the main focus in industry has been on to improve internal logistics costs. This research explores the impact of Milk run logistics strategy, a lean logistics technique, on reducing transportation costs. In the

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system under study, trucks deliver products from one supplier to many customers. A simulation model that incorporates milk-run operation is developed to study the impact on cost of distributing items. Reduction in total logistics costs is expected by reducing the distance traveled as well as improving the flow of material and information through the system. The literature on implementation of Milk run logistics is limited [6]. Lin and Cha (2010) studied the integration of inventory and transportation in the distribution system, and used milk run to optimize this integration [7]. Rachman et al. (2009) implemented milk run to minimize vehicle routing costs in an automotive manufacturing company with a significantly large production capacity in Indonesia [8]. Toyota is one of the few examples in industry utilizing milk run strategy on a regular basis. The company uses milk run from suppliers to support its JIT manufacturing system [6].

MODELING AND SIMULATION

Wherever applicable mathematical modeling of transportation processes are used to quantify system parameters to make system-related decisions. However, some problems such as dynamic non-deterministic types are difficult to solve using mathematical techniques due to their nature. In a dynamic non deterministic problem, the modeler may not be able to expose all operational parameters of the system using mathematical techniques, the parameters may vary over time or the system behavior may be dependent on the previous time periods. In such cases, simulation can be an appropriate tool to model and study the problem on hand [9].

Simulation has been widely used a decision making tool not only due to its ability to provide a platform to study problems difficult to solve by mathematical modeling but also for many attractive features it provides to the decision maker. With simulation models what-if scenarios and sensitivity analysis can be performed quickly, easily, and furthermore without interrupting the real system. With animation feature it can become a power communication tool especially among technical and non-technical audiences. Nevertheless, simulation as a problem solving method has its challenges. Building good simulation models requires expertise, and while testing alternative scenarios with an existing model is quick, constructing a new model is time consuming. Furthermore, simulation involves stochastic inputs, thus generates outputs that are stochastic as well. Therefore, solutions derived by using simulation models does not always provide an optimal solution.

In recent years, agent based simulation modeling has gained popularity due to advancement in computer systems and simulation software. Agent based modeling involves defining system components as interacting active objects which captures individual behavior as well as interaction among the objects. Agent based modeling has been a very popular approach for modeling varying conditions in logistics system. AnyLogic, an agent based modeling simulation software, allows different complementary modeling approaches for applications including logistics and supply chain [10].

MILK RUN CONCEPT

Supply chains are usually quite long when counted backwards from the point of purchase. The best model and the most effective supply chain in the world is Toyota's parts distribution system. This system still determines the global standards on how to run a lean supply system via milk run that chose products and cross area with lean distribution centers. The name of milk run is attributed to the milk distribution process employed in the West in the early 1900s. In this distribution, the milkman follows a specific route, and makes stops at customer houses on his route to deliver bottles filled with milk and at the same time collect empty bottles [11]. We can say in general that milk run is a system in which a truck delivers the same or different loads from one or more points to various points and simultaneously collects empty container during this delivery. For instance, if we use three separate trucks that are sent to three separate manufacturing facilitates from a single supply destination to pick up parts as shown in Figure 1, and that each factory is 100 *km* away from the supply destination, then the trucks need to cover 600 *km* in total .

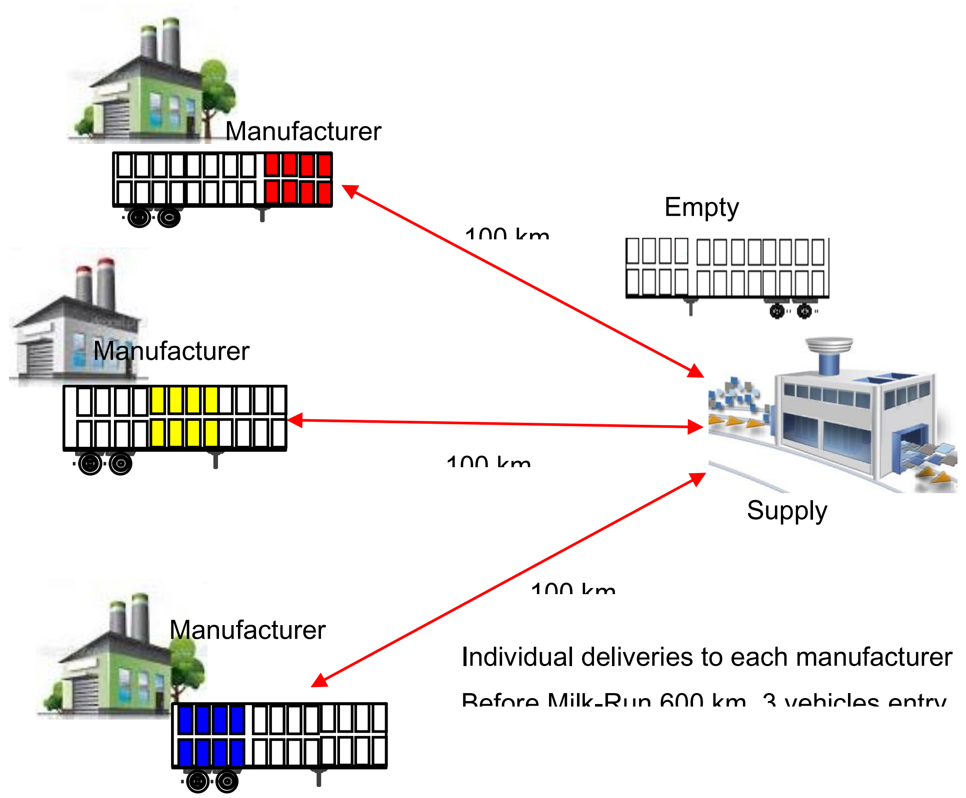

Figure 1. Before Milk run System

If the distance between the manufacturing facilities is 10 km, and if we have only one vehicle go to every manufacturing facility one by one, then the total distance traveled would be 220 *km* instead of 600 *km* as shown in Figure 2.

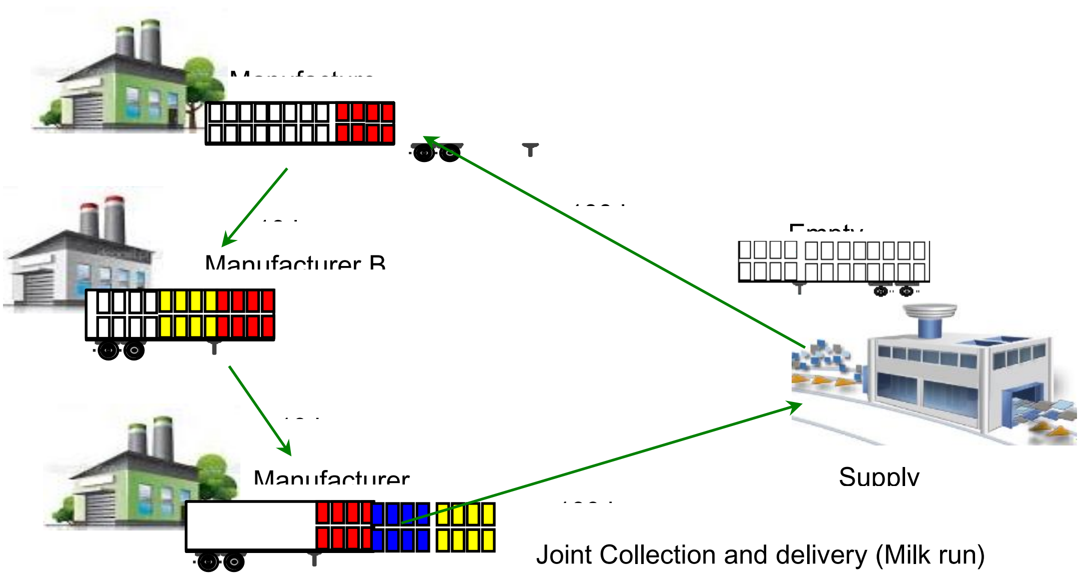

Figure 2. After Milk run System

There are certain conditions that would require an expedition process similar to the one shown in Figure 1 such as high inventory costs, high private transportation costs, uncertainty of shipment times, transportation with different vehicles and small vehicles, ramp congestions, long waiting lines for trucks, etc. However, if the system is not suffering from these symptoms, change over to milk run will lower the distance traveled and provide balancing and regularity for delivering.

Milk run approach works primarily with local suppliers, but a local milk run can include a remote supplier who maintains a local warehouse. Clusters of remote suppliers can also be served by milk runs with cross-docks or consolidation centers providing an interface t long-haul transportation by truc or intermodal railroad [12]. Milk runs should not involve more than four or five suppliers, who are usually chosen based on geographical proximity. If many are close to one another, then destination within the plant can also be used as a grouping criterion. Milk run routes can be planned using online mapping services, but should take into consideration factors like border crossings, traffic and weather conditions, and road work in progress requires a more dynamic analysis [13].

PROBLEM BACKGROUND

The work presented in this paper is based on a case study carried out at Çanakcılar Company Group in Turkey. Çanakcılar Company Group, established in Zonguldak, is one of Turkey's leading manufacturing companies with their 60.000m^2 main factory spread over 100,000m^2. They produce vitrified ceramic medical equipment along with bathroom furniture, office furniture, bathtub, lavatory and kitchen faucets, built-in reservoir and toilet cover for national as well as international markets. The Group is among the leaders of its sector. Besides their main factory, Çanakcılar Corporate Group also has other production plants, including second generation "Çaydeğirmeni Production Plants" established in 2006 in an indoor area of 36.000m^2 located in an open area of 80.000m^2.

The delivery line that is modeled in this study starts at the main factory and makes delivery to retailers. Çanakcılar Company Group's main concerns with this delivery line were rare faction of the ramps, cost and lead times. Based on system experts in the company, the vehicles ought to run in full capacity in order to consign quantities requested. Therefore, the vehicles are loaded full capacity, and then begin delivery. The Company does daily shipments to fifty mobile retailers, which are shown in Figure 3. Total 11 vehicles are used to do the daily deliveries.

Figure 3. Distribution of Factories and Retailers

Customers: The firm has 600 retailers, but just 50 of them place a moving order. A moving order is a fixed quantity order that is placed for every day until a predetermined order end date. Daily moving orders of these 50 customers are shown in Table 1. The firm gives priority to these 50 retailers' shipments. Other retailers' orders are variable and order periods are unpredictable.

Dispatching System: In the current system, shipments are done on a daily basis. Ten-wheeler trucks with a capacity of 9 pallets each are used for delivery. There is a single-vehicle-routing for each retailer. Ramp congestion is possible and when happens oversteps the limit and sometimes causes a delay to release a product, which leads to system delays.

Vehicles: The current system uses 11 18-wheeler trucks in cyclical expedition application. Their capacities are 24 pallets for each.

The proposed model, which incorporates milk run, combines delivery stops and generates a cyclic voyage for the delivery vehicle.The simulation model determines delivery routes based on the retail locations as well as the size of the order to deliver to each retailer. The goods are delivered to customers once in 1 to 3 days. With the goal of reducing distance traveled and balancing the deliveries among each route, the model then calculates the number of vehicles to complete the deliveries, their departure and arrival times for all retailers and actual shipment times as well.

Table 1. Daily Order Quantities

Retailer	*Pallets*	Retailer	*Pallets*	Retailer	*Pallets*	Retailer	*Pallets*	Retailer	*Pallets*
1	6	**11**	2	**21**	1	**31**	4	**41**	1
2	2	**12**	6	**22**	1	**32**	5	**42**	3
3	2	**13**	1	**23**	5	**33**	9	**43**	4
4	4	**14**	2	**24**	10	**34**	2	**44**	2
5	2	**15**	7	**25**	12	**35**	2	**45**	3
6	2	**16**	3	**26**	2	**36**	5	**46**	6
7	2	**17**	2	**27**	2	**37**	3	**47**	3
8	2	**18**	2	**28**	10	**38**	3	**48**	2
9	2	**19**	2	**29**	3	**39**	3	**49**	5
10	2	**20**	2	**30**	9	**40**	2	**50**	4
Total number of pallets/day = 181									

SIMULATION MODELING OF THE CASE COMPANY

This section provides a general view of ANYLOGIC program [10] that we developed and used to show the differences between the current and the proposed system that incorporates milk run. Figures 3, 4 and 5 are screenshots from the simulation model that demonstrates the gathering of the statistical data on deliveries and delays which we used to assess the performance of the proposed model .

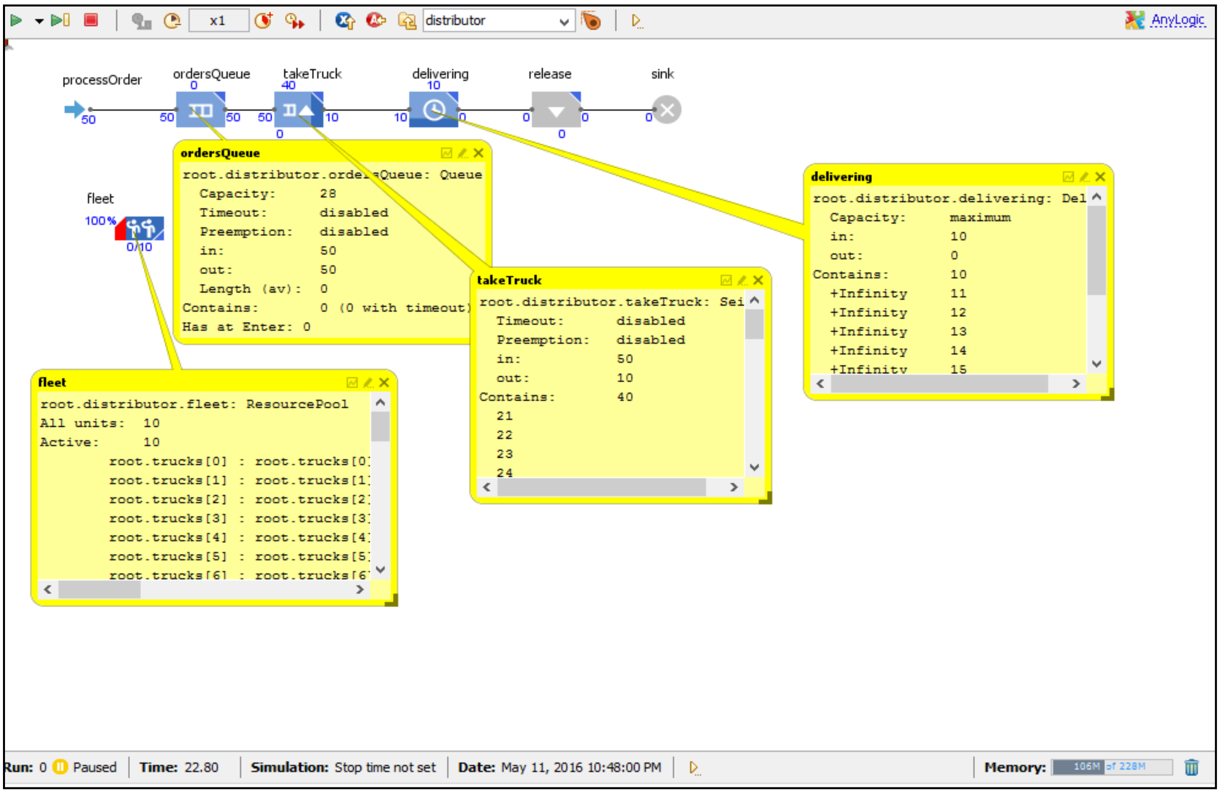

Figure 4. Twenty-second System Output of the Model in Current System

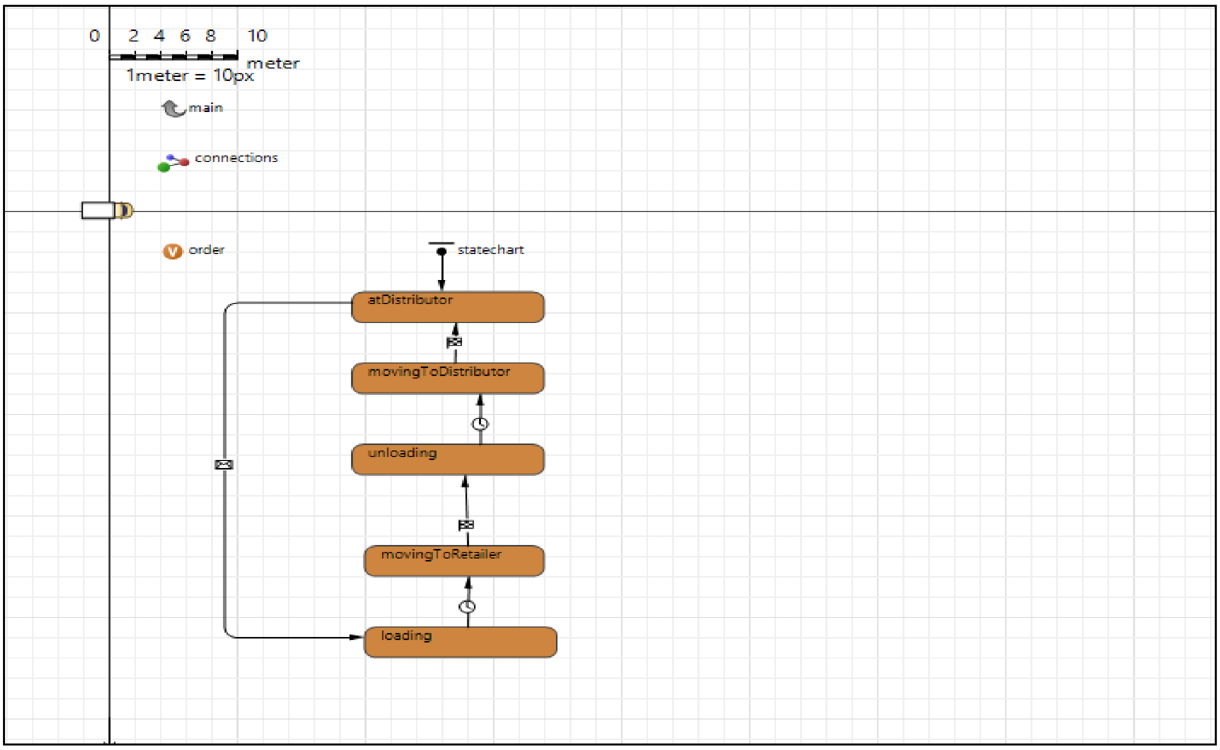

Figure 5. Order and Vehicle Routing in the Model

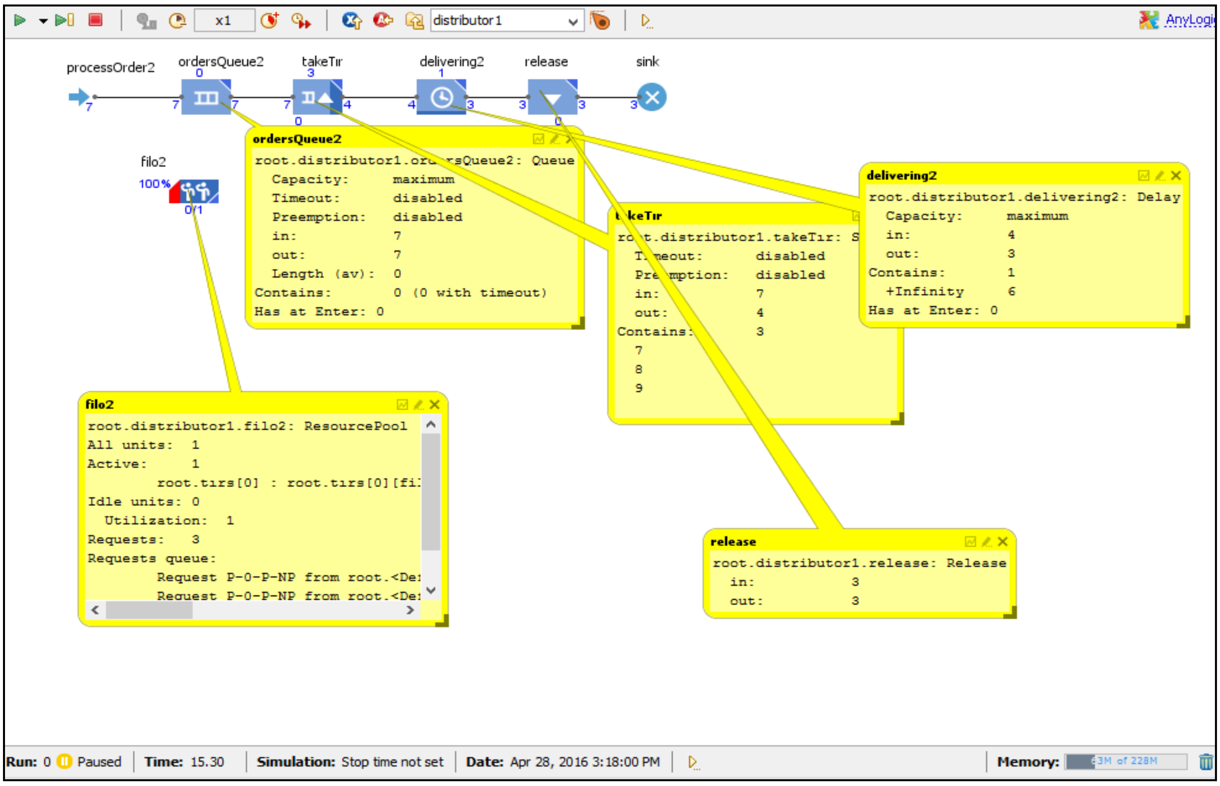

Figure 6. The Next 15 Hours Statistical Information for Route 3

ANALYSIS

Cost analysis: In this section, the current and the proposed system with milk run are compared based on the total transportation cost. Table 2 lists the distance between the main factory and each of the 50 retailer facility.

Table 2. Distances among retailers and the factory

Before Milk Run*(Distance in km)*									
Retailer	*Distance*	**Retailer**	*Distance*	**Retailer**	*Distance*	**Retailer**	*Distance*	**Retailer**	*Distance*
1	650	**11**	375	**21**	375	**31**	175	**41**	400
2	250	**12**	825	**22**	225	**32**	175	**42**	375
3	250	**13**	400	**23**	175	**33**	175	**43**	400
4	1525	**14**	375	**24**	1250	**34**	50	**44**	175
5	300	**15**	400	**25**	1500	**35**	175	**45**	175
6	250	**16**	225	**26**	175	**36**	50	**46**	50
7	250	**17**	375	**27**	175	**37**	300	**47**	175
8	350	**18**	375	**28**	50	**38**	225	**48**	50
9	300	**19**	375	**29**	50	**39**	375	**49**	50
10	225	**20**	225	**30**	50	**40**	825	**50**	1025
Total Distance = 17,725 ***km***									

Before Milk Run:

The total distance between the factory and the retailersis 17,225 kilometers (*km*). This is one-way distance, thus, the total tip taken is 17,725*2=35,450 *km*. The average cost per klometer for an 18-

wheeler truck is 1.2 Turkish Liras (*tl*). The total cost of transportation to the company is then 35,450 *km* x 1.2 *tl*/*km* = 42,540 *tl*. Vehicle costing (purchases, sales, etc.) are not included in the calculation of transport costs, and are calculated as separate cost items.

After Milk run:

'Route (retailer stops)' column in Table 3 shows the proposed delivery routes with all theirs stops obtained from the simulation model. 'Total number of pallets per route' column shows the number of pallets to be delivered on that particular route, and finally the 'Total Distance' column displays the total distance traveled to complete that route.

Table 3. Routes and Total Distances after Milk run

Trucks	Route (retailer stops)	Total Number of Pallets per Route	Total Distance
1-9-10	0-5-35-8-11-14-17-21-20-2-3-7-22-10-0	24	1150
2	0-25-24-0	22	2800
3	0-49-23-40-39-50-41-34-0	22	775
4	0-29-32-42-28-0	21	375
5	0-27-30-31-33-0	24	2475
6	0-1-15-4-12-0	23	3350
7	0-48-46-47-44-45-36-0	21	475
Total number of pallets/day = 181; Total Distance = 12,375 *km*			

Due to combining retail stops, the number of pallets to deliver per route in the proposed system is higher than the number of pallets delivered per route in the current system. The proposed model that incorporates milk run, therefore, employs larger vehicles, which are articulated lorries. The average cost per kilometer for an articulated lorry is 1.7 *tl*. The total cost of transportation for the proposed system is 12,375*km* x 1.7*tl*/*km*=21,037.5 Turkish Liras.

Cost Comparison:

With the proposed system the company is able to deliver the same number of pallets to all its 50 retailers by travelling shorter distances. The reduced travel distance results in a 51% reduction in transportation costs for the company, from 42,540 Turkish Liras to 21,037.5 Turkish Liras.

Milk Run SWOT Analysis:

While milk run brings improvements to the system it comes with its rewards as well as challenges. Table 4 shows the SWOT analysis of milk run strategy.

RESULTS

Milk run is an effective lean logistics method when implemented in comparatively small region. It is able to remove transportation waste without introducing too much waiting time. Through the simulated case study we were able to show that milk run is able to reduce travel distances. As a result of the cyclical time system, distribution costs were reduced and the customers could be reached on time. The proposed method also reduces cost for storage. With all these cost reductions, the company gains opportunity to improve its business in other dimensions. Simply to put in all improvements in numerical terms, we have brought milk-run cyclical time system to the company that previously stocked 18-wheels trucks.

The proposed system almost eliminates the stock holding costs, and reduces the transportation costs from 42,000 levels to 21,000 Turkish Liras for each shipment.

Table 4. Milk Run SWOT Analysis

Strengths:	**Weaknesses:**
• To perform the delivery process in much cheaper way • To reduce the intensity ramps • To reduce inventory holding costs	• Shipment of products in excess of the capacity of the vehicle • Disruptions in the cycle as a result of the delay of the articulated lorries • Trouble finding transporters due to unwillingness to work because there is more to unloading
Opportunities:	**Threats:**
• Reduce travel distance and transportation cost • Respond to new dealers as a result of the reduction in vehicle density.	• Reduced customer satisfaction due to possible delays. • Difficulty in finding transport vehicles to fulfill sudden orders.

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LEADERSHIP AS A STRATEGIC MANAGEMENT TOOL IN MARITIME BUSINESS: A CONCEPTUAL EVALUATION

Hatice AKPINAR[1],

Abstract−Literature shows that leadership is the one of the most popular management subjects that has been searched for many years. The researchers linked and related the leadership with the performance, productivity and effectiveness increase in organizations, organizational commitment rise of employees', gaining competitive advantage and many positive contribution to the way of handling problems which all could be a proof that leadership could be used as an important strategic management tool that shapes the organizations and strengthen the organizations' position in the globally uncertain environment. Also leadership styles and applications are subject to change according to the industry of the organizations, the situations that are faced by the organizations and managers/employees/people that are worked for the organizations. Maritime Business itself has a very unique, global, uncertain environment which could easily affected by any event in the world. Strategic management is a very good instrument to Maritime Business to handle all these uncertainties. The aim of the study is to evaluate the leadership under conceptual review as an important strategic management tool in Maritime Business. The contribution of the study is to make a solid base to understand the importance of leadership in developing Maritime Business Strategies.

Keywords−Leadership, Maritime Business, Organizational Effectiveness, Strategic Management

INTRODUCTION

Organizations would like to succeed internal integration and external adaptation [10] in changing world where they would like to be cost effective and productive in their businesses [4].

Within the organization, leaders are the director of the organizational structures. Leaders are the decision makers who act as a moderator in order to apply organizational mission and vision [33]. Leadership styles and behaviors and organizational effectiveness are the most important variables for achievement of organizational success and required organizational performance [7]. Previous studies and researches showed that leadership is constituent for the organizations for achieving organizational goals, reaching targeted performance and effectiveness, enabling the organizational commitment via good communicational abilities which also induce increased job satisfaction of the employees, increasing the business value, gaining competitive advantage, accomplishing the mission, vision and the objectives of the organization, many positive contribution on the way of handling problems or even failure of the organization [1] [13] [19] [18] [36][31][23].

Understanding global trends and facts are crucial for the organizational effectiveness and combining these realities with the targets of the organizations requires successful strategic planning. It could be hard to achieve such a complicated process without proper understanding of the political, social and environmental changes in business world [39]. Maritime business has very sensitive environment which would be faced with all of these mega trends [20]. Also in the light of previous researches there is a strong relationship between personal and cultural values of employees, leadership and organizational culture while accomplishing organizational effectiveness and performance [7] [41].

Leadership styles and applications are subject to change according to the industry of the organization, the situation that is faced by the organization and managers/employees/people that are worked for the organization. Maritime business itself has a very unique, non linear environment which is sensitive as affected by any change in the world, cyclical, dynamic, unpredictable which of all create high complex

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system. As other players of transportation, maritime business facing increased pressure to develop efficient systems with the increased customer oriented solutions via cost reducing applications.

The political developments in the world, new trade agreements between countries, production levels, increasing competition, export and import changes in economic conjuncture in the world have strong influence on maritime business [20]. Maritime industry perform pioneer role in countries' economic wealth and improvements which derived from trade, enables movement of goods long distances and overseas [17].

As stated maritime business is responsible from the carriage of all kinds of goods such as raw materials, semi finished goods, petroleum and petroleum products and so on from origin to destination according to shippers and buyers requirements. Maritime business is a very international business that causes a sensitive and even fragile structure that makes the sector affected any event in the world, any technological changes, political or economic development. Leaders in the maritime business organizations should be able to handle with all these developments and uncertainties of the sector [21].

The relevant literature has largely ignored the investigation of leadership as a strategic management tool in maritime business which is the main trigger for this study. The theoretical basis of this paper is found in the contents of leadership (styles and theories), and its importance as strategic management tool in the shipping industry frame. The affect of leadership to organizational performance and effectiveness and many other important phases had already searched and proved many other studies in the literature which is the motivation of this study. Moreover the aim of the study is to evaluate the leadership under conceptual review as an important strategic management tool in Maritime Business. The contribution of the study is to make a solid base to understand the importance of leadership in developing Maritime Business Strategies.

LITERATURE REVIEW

Strategic Management in Maritime Business

According to [11] all of the organizations operate under the "*Theory of Business*" which is a group of presumptions includes questions belongs company such as in what business the company is or who the customers of the organization are and so on. And in this frame, strategy could be turned as performance of the organization. Through this view organizations could be able to reach required outcomes in an uncertain business environment [11].

Strategic management could be developed by forecasting the future, making effective decision making, proper resource planning and so on. The harmony of the pieces within organization is strategically driven with responsive planning, organizational culture and convenient leading [29]. Strategy could be seen as a path of applications that could show the way to the organization as a vital while managing their survival.

Organizations could reach desired outcomes through ensuring strong shared values and beliefs of employees regarding organizational objectives, proper quality of their services and products, effective allocation of resources and sufficient planning and organizing all required processes [39]. The major duty of top management is to enable unique ambience in the organization which was driven by the core professional skills that could called as leadership.

Personal and cultural values are affected the managers leadership styles. Cultural values have a significant influence over the leadership process. Leadership performs a basic role in management and achievement of national and international objectives [7].

The definition of culture varies in the literature but the following definitions broadly describe the term. According to [9] culture is "*unofficial or unspoken rules, values, attitudes, and beliefs and customs of an organization*". Other definition of the culture according to [15] is "*generally conceived of as having a largely implicit, tacit core of shared values, beliefs, convictions, basic assumptions, etc., and manifests itself in artifacts like formal and informal dress, buildings, rituals and behavior, and verbal expressions like statements and explanations*" [2].

Organizational culture has an substantial influence in overall performance of the organization which could be defined as common values, beliefs and assumptions within the organization. These values could direct the behaviors and attitudes of the employees [14].

Maritime business confront lots of risky situations while carrying out their performance such as operational risk on board and in the office, insurance risks of ships, currency risks, interest risks, volatility of freight risk, increased competition and so on. However managing the risk is more important than a risk itself [20]. Leaders affect the impact of the risky situations through their leading skills while they are handling the risky situation [2].

Strategy management is very important for maritime business like other industries. With proper strategies, shipping firms could handle risky situations, could succeed in internal environment integration and external environment adaptation, easy handling of all managerial process, increased customer satisfaction, enable competitive advantage and make proper decision making [21] decrease the crew costs, operating costs, taxes, managerial costs, insurance costs etc. Also in strategic management of maritime business timing decisions (cycle management) are vital to achieve efficient management; whether to go long or short in the market cycle. In/out and long/short evaluations are the most risky decisions of the shipping firms that must be handled with very professional view [20].

Importance of Leadership

Leader could be defined as a person who has an ability to affect employees with a managerial authority. Leadership is the way of leaders' duty by which leaders impress the organization to reach organizational targets [25].

Leadership style is a way to manage the employees and organization. It is the philosophy or bundle of rules in which the leader capitalizes according to workforce [22]. Leadership is not a procedure or a tradition but it is a kind of inspiration.

Organizational leadership is appear in different variations of styles and behaviors [24] which is a path of operating in the organization. Effective leadership style could be exist in which leader should incrementally shows organizational progress, transforms resources for the organizational use for required objectives [22].

Preceding leadership theories in the 1920s and 1930s concentrated on the leader (leadership trait theories) and the way of interaction between leader and the leaders' group. Next generation of leadership theories from the late 1940s to the mid-1960s focused on preferred behavioral styles that leaders demonstrated. Contingency leadership theories deal with situational analysis such as Fiedler, Hersey-Blanchard, and path-goal theories. And contemporary leadership theories consist of leader–member exchange theory, transformational-transactional leadership, charismatic visionary leadership, and team leadership [25] and so on.

Industry of the organization has a huge impact on leadership which could be categorized as - production-oriented, employee-oriented, changed centered according to functional, managerial and operational requirements of the organization and industry [27].

There is no magic formula or a worldwide recipe that works for all industries for successful leadership. Leadership style and behaviors are not about good/bad, right/wrong, leadership depends on the task, organization's cultural and environmental structure, employees and other determinants that shapes the whole processes. But flexible leadership could be seen a very effective way of leading nearly all circumstances [39].

Today's global and uncertain environment causes challenging conditions for maritime leaders in order to lead the organization efficiently. This century offers opportunities and threats in such as fast changing world [25]. As stated leadership is very important element to reach organizational objects due to positive influence on organizational effectiveness via effective organizational operations as a whole with the increase of commitment, loyalty, job motivation and job performance of members [16].

Leadership as Strategic Management Tool

Human resources management and communication within the organization have very unique contribution to the effective organization when organizations need highly motivated and skilled employees who are not easily replaced. The literature shows related proof that "*human capital*" has a stressed influence on organizations [39]. People is seen as a unique source and reaching organizational targets bonded substantially on them [3] which could be easily said "*people make the difference*" in organizations [20].

Influential leaders play governing and directory duty in personal interactions within the organization in order to enhance social interactive relations. As a governor, leader should stresses community harmony and finds a common ground for organizational culture [37]. As a mentor, leader could affects the degree of work commitment, creates and manages the mission and vision according to objectives and goals of the organization, smoothly plans the future of the organization with integral integration and external adaptation in the light of strategic targets [26] [40]

Strategic leaders are very much important as a conductor in realizing and adapting the new opportunities which add additional organizational value [13]. In maritime business, different cases have seen that many organizations were failed as a result of adaptation problems [20]. The harmony of the leadership style with the organizational strategies is vital to survive in a highly competitive business environment [12]. As stated, efficient organizations depends upon leaders abilities, the resource allocation belongs organization and proper strategic mix [7].

As seen in Figure 1.1, [29] showed the importance of leadership as strategic tool by indicating its position in-between strategic management process.

Figure 21. Leadership as a Strategic Management Tool

Source: [29]

Strategic management is directed by effective leadership, proper decision making and sufficient organizational rules. The very first duty of the leaders is moving organization ahead to the planned future. The role of leadership in the organization could be said as very strategic for reaching the required targets [29].

As its nature, maritime business has a volatile and uncertain environment which requires very careful strategic management. With proper targets and objectives, leaders could change the threat to opportunity for the organization. Proper strategic planning for maritime business has three elements as explained by [20]:

- *Right timing is everything*
- *Cut the losses*
- *Squeeze the margins out of the business*

Conclusion and Discussion

In this framework, the aim of this study is to declare the importance of leadership as a strategic management tool while handling uncertainties. The theoretical basis of this paper is found in the contents

of lead rship (styles and theories) and its importance as strategic management tool in the shipping industry frame. In the light of the literature review the conceptual base has been studied to stress the strategic position of leadership in the organization as a solid base.

In today's global and highly competitive business environment, organizations confront different customer needs, try to constitute high organizational harmony and shared organizational culture, must apply proper resource allocation, needs to find ways of cost efficient solutions. Leadership has a key role to adapt changing environment of the organization and usually supposed that diversified combination of leadership behaviors and styles has a diversified combination of consequences [4].

According to previous researches, enabling continuous and satisfied work of employees are seen as an important result of their commitment to their organizations. High commitment shows adaption of organizational culture [1]. In order to deal with all these uncertainties leaders should have global vision, inspiration, strong communication with employees in order to increase organizational commitment, charismatic view that creates employees follow and approve organizational culture, catching the new trends and technologies, strengthen the organizational brand, enables customer loyalty with high satisfaction levels. Most of the organizations experienced obsolescence due to unsuccessful technological and environmental adaptation [20].

Leadership is a leading way of the managers by affecting the employees to perform the objectives of the organization. Leaders do this in their own way via their skills and abilities. Leadership styles could be directed by the national, personal and organizational culture, industry and the structure of the organization, the situations and the problems faced by organization and so on. In the current study the relationship between leadership and organizational effectiveness and the importance of leadership as a strategic management tool while handling uncertainties has been searched.

Strategic management could draw a path for survival of maritime organization such as identifying and prioritizing the opportunities, help to solve organizational problems, enables organizations to control their businesses, provide better understanding of current and potential customers' wants, help leaders to make proper decisions, guide the organization when allocating the resources, could assure new ways for cost minimization, relative strengths and weakness of competitors, keep organization to adapt new changes etc. [21] [24].

Main objectives of maritime organizations are to predominate and do their best than their competitors, developing customer loyalty with satisfied services, to make better decisions for each level of organizational processes, focus to create long term relationships with its current and potential customers [20].

From the literature the below mentioned variables have been deduced as outcomes for further studies as introduce leadership could be used as a strategic tool for maritime organizations in order to achieve better and targeted results.

- Be aware of situation that show up before make the decision. Sharing all information could create to finding new ways to serve the customers.

- A maritime organization should consider know how as necessary to perform a required strategy and should choose the best trade off between risk and return while managing the operations [20].
- All leaders in the organization could also work together in order to achieve organizational commitment, cooperation, and coordination. The decisions of each leader in different levels and different subunits should be in a harmony [39].
- Personal and national culture of the leader affact the organization. Also organizational culture shapes the leader's behavior and style. There is a mutual interaction [7].
- Leaders should see the whole picture of the industry and ready to make in/out decisions with long and short term startegies [20].
- Organizational culture and leadership are very crucial place for managing the employee commitment, increasing the organizational effectiveness and performance, creating comptetitive advantage for a survival of the organization [41].
- Leader could see the interrelation of the each part in the organization in order to create organization wide solutions for better management, identify potential trade offs among the performance determinants [39].
- Leaders should find ways to solve problems with creativity and personal relationship in order to improve "*experince building*" and every action should called as learning instead of failure. Gainig experience should seen as a vital for long term success [20]
- Leaders should learn to behave flexibly and improve their abilities to deal with change
- Maritime organizations should deal with more than one shipping segment in order to spread risk. Success of the shipping organizations could depend on desire to take risk but be ready of a probability of making wrong decisions [20]
- Leaders should recognize and use "*human capital*" as an important factor in reaching required organizational objectives.

Limitations and Future Research Directions

In the light of above approaches and outcomes the importance of leadership for long-term survival of the organization could be seen as vital which is the main trigger for this study. Leadership style and behaviors shape the organization and enable so many positive improvements from strategic planning to controlling and rectification of failures which are discussed as the main approaches in this paper. In this paper, several theoretical perspectives that hold promise for understanding the importance of leadership as a strategic management tool and above mentioned outcomes are offered.

The research has some limitations and further research into this area should be extended. This study is designed on a conceptual review in order to provide a solid base to the field and understand the main views and perceptions of leadership as a strategic management tool. The limitations and suggestions for further studies should be the following in the path of this study, some qualitative and quantities researches could be conducted as a case study or focus group, survey or as an interview in order to check the practical view to collect data and explore reasons to understand the leadership styles of the companies and its effects according to the maritime organizations. Also some benchmarking studies regarding organizational performance or effectiveness could be conducted in order to see the effects of leadership on maritime organizations.

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STRATEGIC COMPETITIVENESS OF MARITIME COMPANIES IN VOLATILE SHIPPING MARKET CONDITIONS: "KEEPING TRADE OR TRADITION?"

Ayse Asli Basak[1], Erdal Nebol[2]

Abstract - In international trade and logistics sector, competitive priorities are placed at important level on the success of a firm. A firm's position on its competitive priorities is determined by its four long-term structural decisions: facility, capacity, technology and vertical integration. However, maritime sector is quite different. Maritime transportation is the oldest economic mode of transportation and is still a viable part of the total transportation system. Competition among shipping carriers is limited as long as there are sufficient commodities to transport by using this method. The maritime transportation competes with many diverse economic factors such as commodity rates, petroleum prices and existing of other transportation types such as railroads and pipelines. In this study, qualitative methodology has been used and latest condition of shipping market including bulk, container and tanker segments has been descriptively reviewed within combination of different market reports and ship owners/managers' comments. Traders need a transportation service by chartering a vessel while performing the carriage step. This paper is aimed to reflect how shipper's and receiver's conduct decision-making process of chartering a vessel as per specifications of the vessels such as type, tonnage, flag, gearing condition, seaworthiness status and fuel consumption. Competition in maritime transport cannot be only described with supply and demand of shipping market, particularly the diverse fleets of different owners will become more important as the technologic developments increase. Evaluating the volatility of current shipping market will provide a new perspective to ship owners, managers and operators so that they can survive by changing the traditional mentality to trade benefit conjecture.

Keywords – Competitiveness, shipping market, maritime transportation, volatility

INTRODUCTION

In international trade and logistics sector competitive priorities are placed at important level on the success of a firm. According to Li (2014), a firm's position on its competitive priorities is determined by its four long-term structural decisions: facility, capacity, technology and vertical integration [1]. However, maritime sector is quite different. Maritime transportation is the oldest economic mode of transportation and is still a viable part of the total transportation system. Competition among shipping carriers is limited as long as there are sufficient commodities to transport by using this method. The maritime transportation competes with railroads and pipelines for the movement of low value and bulky commodities such as petroleum products or coals in general. In particular, competition of the firms is affected from many different and external economic factors. Traders need a transportation service by chartering a vessel while performing the carriage step. At a glance of shipper's and receiver's side, specifications of the vessels such as type, tonnage, flag, gearing condition, seaworthiness status and fuel consumption keep important role on decision-making process of chartering a vessel. Therefore, competition in maritime transport cannot be only described with supply and demand of shipping market, particularly the diverse fleets of different owners will become more important as the technologic developments increase.

Ship owners nowadays also face some new strict requirements which affect their competitiveness in shipping market directly as the technologic developments increase. For instance, a ship owner must comply with special Ballast Water Management rules if their vessel calls United States ports and invest into this system at least one million dollars. However, as per latest shipping notice from United States Coast Guard, they provided an extension letter up to five years so that IMO side also has not been ratified [2]. The market is getting worse; however stricter environmental requirements are continued. Therefore, for the further year's substantial investment is required to meet these requirements, and that may be a

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challenge on financial side of 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 [3].

Competitiveness between ship owners can be also affected by how much the running cost values are incurred. For instance, in current market labour expenses on Chinese cargo ships are cheaper than European based crew which totally affects the running cost expenses of both ship owners. Since salaries of crew and the other crewing expenses keep almost 50% of overall costs, ship owners prefer to occupy crewing expenses at the lowest level [4]. As the crewing expanses become lower, running cost values are also get lower and charter rate expectation of the ship owners may become less. This contradiction causes a return to market as a big competition in the low shipping market. As like in this example, Chinese ship owners become more competitive to fix their vessels for carrying cargoes by expecting less profits than European ship owners. Therefore, the need to competition in shipping market arises in very low and high freight markets more than stable and non-volatile market cycles.

The needs of customers in maritime transportation will only be met if business has control of the factors that affect the quality of their service. These may be human, administrative or technical factors and can only be controlled if tasks, equipment and procedures are used in the same way every time. These methods can be documented and used to assess the operation of the maritime companies. Quality audits and reviews can therefore lead to suggestions for improvements in the way work is carried out to the benefit of the company's clients and thus to the business itself while in a fixture operation with charterers. Companies which prefer to demonstrate their commitment to quality assurance with registering vessels by an internationally recognized authority will surely be more competitive for a corporate cargo charterer, seller or buyer. Foremost among shipping businesses to embrace the concept of quality assurance strategy were ship management companies and face highly competitive field lend themselves to the documented process. The concept of quality is a moving target. What may be of acceptable quality today may not be so in the future as customers' perceptions change and although most businesses benefit from introducing quality initiatives, there can be problems associated with their implementation such as cost of inspections, training and material, time required by both management and staff to make the system work, different viewpoints on short term costs and long term results and changes in culture. Therefore, an organisation must be absolutely committed to the concept of quality management if its introduction is to be success. Overall aim of the research is to maintain a current and detailed review for maritime companies and provide them some kind of strategies in the competitive global maritime industry via taking the ship owners' and managers' decision making process into consideration.

METHODOLOGY

This study is aimed to describe shipping market factors and their latest status in global trade within descriptive methodology that is also included in qualitative techniques. As preliminary method of the research, face to face interviews have been carried out within eight different general manager and CEOs of Turkish ship owning and management companies which are trading different sizes and types of vessels in worldwide shipping. The interviews took place in different kind of sectoral meetings and events. As the secondary method of the research, the literature review has been collected from different types of shipping market reports and summarized to be presented to the attention of ship owners or managers in the market. What a maritime company to do in volatile market conditions and what is to be regarded while considering increasing their value in competitive shipping market were descriptively explained in this research. Results have been added a different view to the study and their approach to competitive shipping will provide a new perception style in order to make clear how to become successful in global trade market.

FINDINGS

Participants of the study have a diverse background within an itinerary of 4 family-based ship owners, 1 pure ship-owner which has not family-based relation and 3 professional technical/commercial managements without ownership of the vessels. The fleet breakdown of the participants as follows (Table 1):

Table 1: Fleet breakdown of the participant ship owners/managers

Type of ships in the fleet	Number of ships in the fleet
Bulk carrier vessel	35
General cargo vessel	2
Product tanker vessel	1
Chemical tanker vessel	7
LPG/LNG tanker vessel	1
Heavy lift vessel	2
Ro-Ro vessel	3

The total deadweight tonnage of their fleet has been summed as 511,350 DWT within the average tonnage is calculated as 10,026 DWT between a range of minimum 500 DWT up to 57,000 DWT. Totally 15 of their ships are Turkish flagged and the other 36 ships are foreign-flagged such as Marshall Islands, Malta, Panama and Antigua and Barbuda. The minimum time charter rates which are described as total earnings of vessels from a charter ranged between 1500 USD and 7000 USD depending on the year. One of the family-based ship owners trading bulk carriers stated that the worst year in the market was 2016 while a technical management director of general cargo fleet stated that 2009 was the worst. In this difference, the tonnage and ship type diversity are becoming visible. Mostly the ship-owners which have tonnages between 30,000-60,000 DWT have the least time charter earnings due to the over-supply of such tonnages in global shipping market. This situation causes that managers/owners of those tonnages must be more competitive to charter their vessels by establishing good negotiation networks. For dry bulk owners/managers, the small tonnages between 3,000-10,000 DWT have not higher time charter rates than the other tonnages, however the daily running costs of small vessels are less than the larger tonnages. The difference is incurred in the total earning side. It is also seen that tanker owners did not face the worst market yet despite the global financial crisis occurred in 2008.

On the other hand of the maximum time charter rates in dry bulk sector, owners mentioned that they had the highest rates of all years in 2008 just before the global financial crisis. On the tanker owners' side, especially chemical tanker owners stated that 2016 has a good time charter earnings ratio than the other previous years. Also, decreasing of product oil prices have affected the demand for stocking the oil products as well as the chemicals. At this point to clear out the market rates, their current daily running cost values are also asked to owners/managers in order to make estimation regarding their net earnings per a year. For dry bulk carrier owners/managers the daily costs stand at 4,500-5,000 USD level per day when the chemical tanker daily cost rates have minimum 5,500 USD and tend to increase more with new requirements on the safety and quality management. While considering the time charter rates of tankers are higher than the dry bulk fixtures, the earning range difference also increase for both types.

As additional, owners/managers said that they did some investments to purchase technical equipment in order to comply with International Maritime Organization (IMO)'s new regulations. Particularly, a tanker management director said that they invested 200,000 USD per a vessel so that the new regulations for ballast water management entered into force as of September 2016. Dry bulk ship owners/managers also had investments about 15,000 USD to navigational systems and 1200 USD to some kind of safety compliance issues within the last 5 years. On the ship prices' side, dry bulk owners/managers said that their ships have less value in current market rather than the invested year. For instance, one of the family based dry bulk ship owner stated that their fleet had an average investment price 35 million USD per a vessel taken as the banking loans, however current prices have fallen into 9 million USD due to facing the deepest level in dry bulk freight market. For the tanker market owners' side it is quite different. The tanker vessel prices are higher than the dry bulk vessels however, return on investment of tanker vessels are more by far than the dry bulk vessels. As per the tanker managers' statements, it becomes more feasible to invest in tanker vessels despite it requires a very high qualified management style due to the safety risks of vessels. For Turkish ship owners' side, it may become essential to invest in tanker or LPG/LNG sectors instead of dry bulk vessels according to the opinions received from the managers.

Most of the managers attended into our interview stated that they do not have any external or internal support for business development and market research activities. Only two of the managers indicated that they have their own and internal business development departments at their companies when one of them externally gets support from a professional shipping market research company like Clarksons, IHS Maritime and etc. Additionally, 3 of the managers who are also bulk carrier owners stated that they used foreign banks' loans to finance their ships while 4 of the managers who are mostly tanker managers/owners stated that they used Turkish national banks to provide the credits for ships.

On the other hand, perception of owners/managers to success in the maritime sector was also asked. Their comments will surely provide a different view for existing managers in the market. They have different kind of opinions and issues to take into consideration while catching up the success. Their comments are quoted as below:

> "We accept sustainability as the success in this sector. The basic success is also to increase financial standards within a stable continuity and we see ourselves as successful despite the bad market."

Family based dry bulk ship owner

> "It is very important to calculate actual running costs of vessels and return on investment during dry-dockings and repairs.

Dry bulk technical/commercial management

> "The first thing to become a successful ship owner is to have a strategy to employ high qualified personnel. The strategies must not put on 'Save the day' basis without considering to comply with international regulations, otherwise, failure is inevitable."

Family based product tanker owner

> "The success is to stand on your feet and to conduct payments in time within these market conditions. Additionally, to continue with new developments are also very important. As our company succeeds this continuous growth, we can be acceptable as successful."

Family based dry bulk ship owner

> "A firm is successful unless any claim, maritime incident or personnel accident occur and also if earns profit with charters."

Family based chemical tanker owner

The common thought in the explanations of the success of the owners/managers is to get financial profit within a zero accident policy on the ship management side. At this point, technical management directors were found more aware for development activities in order to get more financial profit and to be a real competitor in the market. One of the dry bulk technical management director summarized this view as below:

> "If a maritime company does not develop its fleet and minimize the age of the fleet, the firm will surely go back in the industry without improvement. Turkish ship owners usually are in a mood of saving the day either on economical side or as mentality. They do not make plans for long term to develop their companies and therefore whole Turkish maritime sector suffers from this under-developed mentality."

Dry bulk technical management director

During the interview the general impression was that most of the Turkish ship owners did not conduct in time ship investments by catching up the popularity flow in the shipping market. Particularly some of the ship owners invested just before the global financial crisis are affected from the current deep freight rates more than the others. Therefore, marketing analysis and digging the current market rates within research keep highly important role before conducting investment in ships. Owners'/managers' opinion to sell and purchase activities by using advantage of deepest and highest ship prices are also quite different than the other countries. A family based dry bulk ship owners below statement explains this situation:

> "As Turkish ship owners 'including us', we are not able to attend in selling of ships activities or we do not like to sell our own vessels due to a typical losing feeling. However, when we look at Greek ship owners, they are very good at indicating the best timing to sell or purchase vessels as well as to invest in which type of vessels. Ass Turkish ship owners, we must improve ourselves to become open-minded to such activities by completing well-based shipping market research."

Family based dry bulk ship owner

The common thought of not getting adopted in timely investment and selling/purchasing activities of ship owners is stated that Turkish ship owners have inadequate perception on forecasting the future market and do not have discernment to estimate direction of global market, especially after 2008. According to owners/managers, nature of the shipping market has been in a change since 2008 and the market is becoming more competitive for ship owners, day by day. This is also can be called as the "*New Normal*" of shipping market and the system is getting changed when compared with past years. The mind-set of owners/managers to this new normal and merging activities are stated as below:

> "Merging activities are not for Turkish ship owners who have a strict traditional mind-set structure. They prefer waiting for the shipping market to increase instead of getting merged and earning much more profit!".

Family based dry bulk ship owner

> "Not with merging the whole management, merging on the supply services' side or merging on working with the same charterers on fixtures of voyages might be more useful and competitive. I do not expect that Turkish ship-owners will merge soon due to the fact that their mind-set to corporate management still remains at the Neolithic age. The real situations are hided from the owner and especially superintendents' behaviour to working with the technical supplier firms on commission basis causes unethical working conditions in the firms. Therefore, the biggest problem of Turkish ship owners is the trust problem."

Dry bulk technical management director

> "When the terms and conditions are well agreed and all the conditions are equally shared out, becoming merged will provide a great synergy to be competitive in the market. However, tricky behaviours must be fully disregarded in the relations while merging companies. Everything must be open and clear."

Product tanker ship owner

> "If you had asked about my opinions when we had only 2 vessels in our fleet, yes, I can say that we are open to merging idea. However, now we have total 10 vessels and our own professional management team and that is why it will not be so useful for us to merge with other ship owners. In contrast, for small fleets, it might be profitable."

Family based bulk carrier ship owner

> "Companies might be more determined to stand against the cargo owners or traders by merging on commercial side in order to establish a minimum standard on freight rates."

Family based chemical tanker owner

Similar points have been indicated as that traditional structure of Turkish ship owners still remains the same except in big competitor companies. In the following section evaluation of current market condition will be harmonized with the comments of owners/managers.

DISCUSSION: SHIPPING MARKET

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 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 [5]. 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 [6]. Therefore, it keeps an important role for maritime companies to establish a strategy for investing, chartering and operating their ships.

In previous literature, noted that political and economic factors can not be disregarded in international shipping [7]. He drew an inference that owners behaviours tend to continue to operate their fleet in order to reach utilization of tonnage most efficiently despite the volatile and uncertain market conditions. In his research, many different quantitative models have been indicated. Main topics of the models when used for analysing company's policy are asserted as structure of existing fleet, cash flow projections and company's management performance. According to this model, a shipping company's stable operations can only be maintained with a modern fleet and profitable charter contracts. At this point, sale and purchase activities of ships place at important level. Alizadeh H.A. and Nomikos N.K. (2006) investigated performance of trading strategies by combining technical trading rules and fundamental analysis on sale and purchase activities of dry bulk ships. They conducted time series analysis between ship prices and average time charter rates of ships by data between of 1976-2004. As per the analysis, they found that trading strategies based on earning are significant when sale and purchase strategies are considered as second-hand market for ships. According to Alizadeh, future behaviour of ship prices in their analysis can be used for in-time investment of shipping [8].

On the other hand of the real market, it is seen that especially in crude and product tanker segments, market does not reflect that a strong demand is available. Conditions change. As much as new refineries are opened and new regulations come into force, oil trade activities have been becoming within in a positive effect to rise up the market. However, demand side can not be explained only with the amount of how much transportation activities are being held in the market. That means price movements and regional imbalances may cause arbitrage between commodity prices. For instance, a quick change in regional activity such as port congestion may affect the demand of crude oil. Investors usually order new tanker vessels within the foresight of existing market will go upwards [9,10]. Therefore, all segments of shipping market have specific upward and downward rates as in below figure (Figure 1):

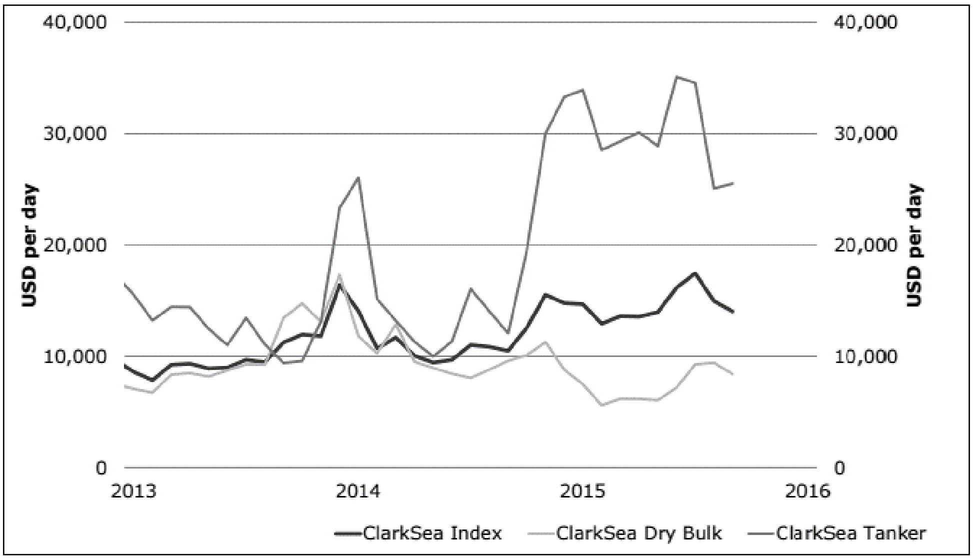

Figure 1. Variations between segments [9,10]

When the freight rates of all tanker, bulk and container segments are calculated as average by years, it is seen that latest six years have faced the lowest level of the market. Between the period of 2000-2008, time charter average rates were higher than the years after 2008 global crisis. It has been observed that freight rate environment is in an improvement however, its relatively low average level creates a big competition for ship owners which are trying to survive in the market.

Tanker Market

Baltic Exchange which is world's only known independent source of dry and wet maritime freight market collects data from different types of ships and different routes in order to benchmark the physical contracts and shipping freight derivatives including economic indicators [11]. In tanker market reporting the freight rates are divided into two different sub indicators as called clean and dirty tanker indices in Baltic Exchange. Clean tanker ships are defined as carrying refined products without havy residual components, on the other hand, dirty tanker ships mostly include the carriage of crude oil, vacuum gas oil, heavy fuel oil and other unrefined products which constitute dirty substances. In details, clean and dirty difference becomes aground within the importance of cleaning operation on board a tanker vessel. Cargo residues must be not affecting the clarity of next cargo and not cause any combustion due to contamination with next cargo to be carried in the same tank. Therefore, a clean tanker can be suddenly become dirty as a dirty tanker requires a higher effort to complete the cleaning process which means there are not any specific limits on explaining how much a tanker can be called as dirty or clean in the market [12]. Due to the fact that Baltic Exchange sells all the collected data to ship managers with a charge, below tanker index is taken from Capital Link which shows similar data as Baltic Exchange and is fully free of charge (Figure 2).

At a glance of previous tanker market (Figure 2), it is seen that global crisis in 2008 affected this market in a downward trend. However, between period of 2012 and 2014, it has slight increases which rise up the highest level by the end of 2014. Due to the global politics change and fast fall of crude oil prices have caused a deep point trend in tanker market. Despite this entire slight downward trend is still continued within the first quarter of 2016, freight rates of tanker ships are still higher than the operational expenses. Therefore, tanker market can be called as a more stable market rather than the bulk carrier market.

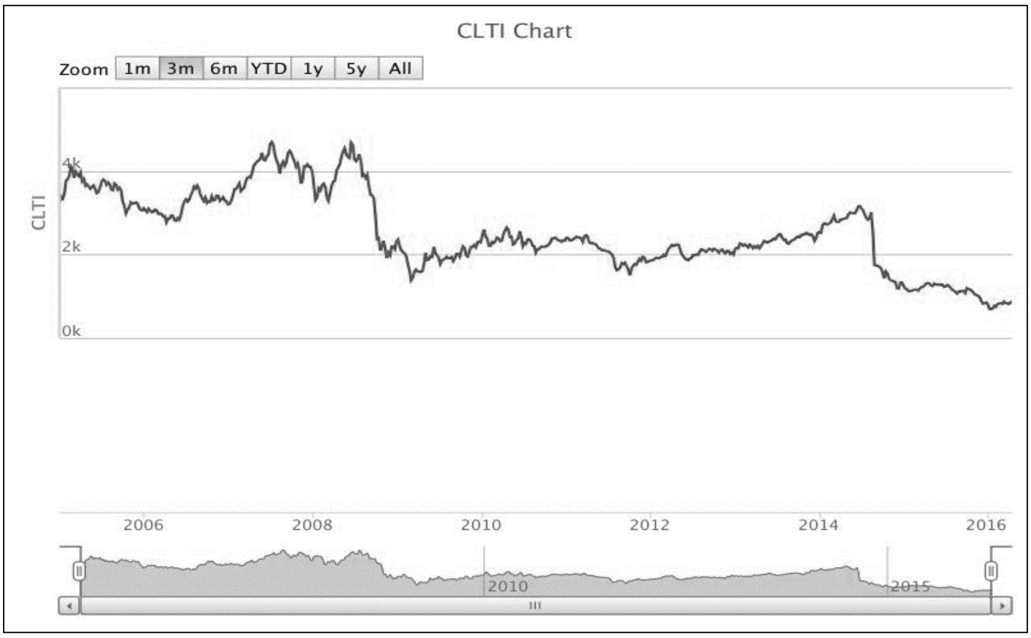

Figure 2. Last 10 years' average dirty and clean tanker indices [13]

The Crude Tanker market is characterised by having very few potential scrapping candidates and a fairly large order-book [10]. While demand for Crude Tankers has been robust in 2015, this is not a reflection of fundamental end user demand. It might be reinforced by longer travelling distances and temporary factors such as floating storage and port congestion in tanker terminals. Low crude oil prices which will be detailed indicated in section 2.3.9 and surplus volumes have also boosted transport requirements. In the short term, Crude Tanker demand may strengthen, for seasonal reasons and due to weather-related disruptions prone to occur during the winter in the Northern Hemisphere, but in the medium term, it remains highly vulnerable. True, refinery consolidation could create longer travelling distances and reduce fleet productivity if more Asian imports are sourced long haul from the Atlantic Basin rather than short-haul from the Middle East. But for seaborne crude ol volumes, the ongoing rebalancing of the Chinese economy is a major cause for concern, not to mention the expansion of the

ESPO (Eastern Siberia-Pacific Ocean) pipeline – which moves Russian crude oil to China – by 2020. Besides that, geopolitical tensions seem to be building up, not only in the Middle East, but also in the South China Sea and elsewhere. Overall, the outlook for Crude Tanker demand may turn out to be lower than investors currently seem to expect. Freight rates and second-hand values may suffer if demand is insufficient to employ the fleet, because there are virtually no scrapping candidates left to counterbalance a potential decline in demand [10,13].

As different from crude oil and product market, LPG and LNG market are quite different to make estimations. There are big contracts between big players in the market as well as big ship owners who indicate the competitiveness of the market. When it is looked into last ten years' development of gas carrier market, it is seen that there is a deepest level in the middle of 2008 due to global financial crisis. However, as opposite to crude and product tanker market, gas market has become in a very upward trend until 2012. After a stable market between 2012 and 2014, it has been in a downward trend again for the last two years. This can be explained within the effect of decreasing crude oil prices due to invention of shale oil in United States [14]. The current LPG market, in particular the Very Large Gas Carrier (VLGC) market, showed exceptional strength during the first three quarters of 2015 despite double-digit fleet growth. Demand for LPG Tankers was supported by a combination of strong end-user demand and temporary disruptions to the vessels' availability (Figure 3).

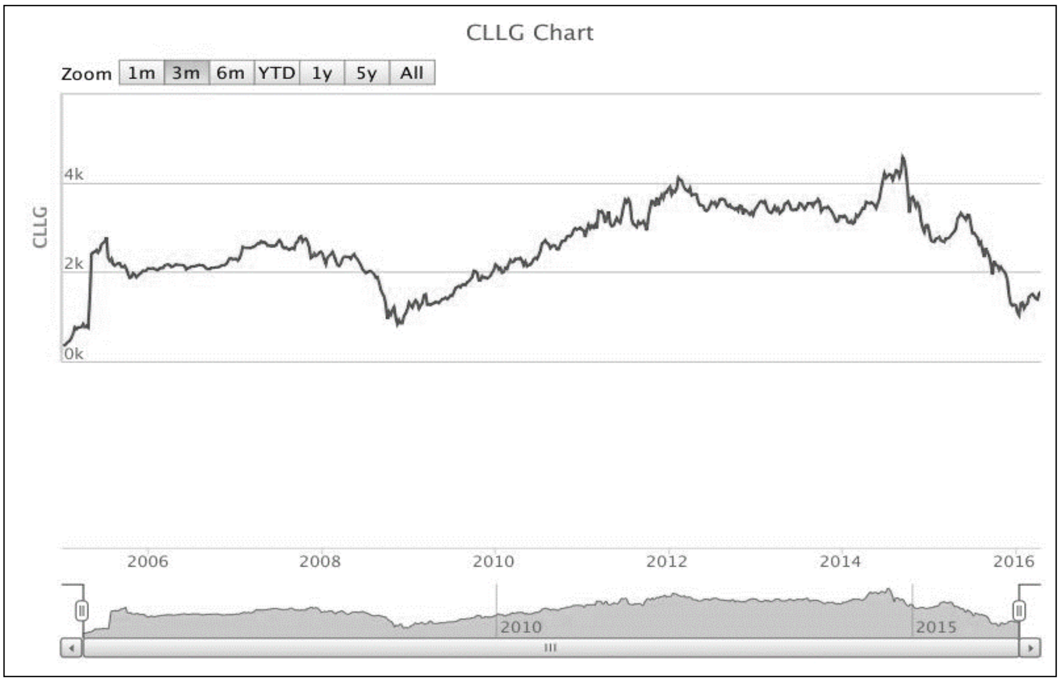

Figure 3. Last 10 years' average gas tanker indices [13]

The expansion of both the petrochemical industry in Asia and export facilities in the US continued to benefit distance-adjusted demand. In the short term, freight rates may remain fairly robust, but it seems unlikely that sufficient demand will materialise in time to meet the large influx of new LPG Tankers indicated by the order book, and consequently demand could fall below the expected fleet expansion at some point. Furthermore, the rebalancing of the Chinese economy along with the impending expansion of the Panama Canal, which could shorten average travelling distances, is a cause for concern. LPG demand from the residential sector, however, could soften the blow from temporary blips in petrochemical LPG demand. The long-term outlook is, on the one hand, supported by the residential sector, but on the other hand, is significantly threatened by the expansion of the sharing economy as well as a move towards a more circular economy. Freight rates and asset prices may suffer accodingly. In the short to medium term, second-hand prices may be hit hardest, as they raised more than new-building prices did during the upswing. In some cases, second-hand prices even exceed new-building prices.

On the side of Turkish ship owners or managers, it is seen that gas carrier management is not so competitive due to the fact that big key players are currently placing the most ratio in the market. For Middle Eastern LNG/LPG shipments, national and government controlled shipping companies have the most transportation traffic of the market due to long time shipment contracts. Within consideration of Turkish petroleum and natural gas resources as well as the production rates have almost been meeting the consumers' side, Turkish ship owners tend not to invest in more sophisticated ships like LNG/LPG tankers. Only a several of tanker managements which have also international partnerships have small type gas carriers trading in global shipping market. That means there is a huge lack of competition for Turkish ship owners in gas carrier market and further developments might be necessary instead of investing other types of vessels having decreasing market.

Dry Bulk Market

Dry bulk market has more volatile structure rather than the other segments like tanker or container. Coal, iron ore, cement, grains and other commodity rates are even affected by any small change in World trade which also cause an indirect effect in freight transportation rates. Therefore, as described in tanker market, Baltic Exchange generated an indice to measure and control freight rates of bulk carrier shipping that is called as The Baltic Dry Index (BDI). BDI is described as an assessment of the average price to ship raw materials on different kind of shipping routes which is about 50 and classified by ship size. It shows the prices paid to ship raw materials in global trade market and places an important component of determination of input costs. Therefore, the index is considered as a leading indicator of economic activity since it involves events taking place at the earlier stages of global commodity chains. High BDI index is the indicator of tight shipping supply due to high demand and is likely to create inflationary pressures along the supply chain. On the other hand, a sudden and sharp decline of the BDI forecasts a recession since producers have substantially decreased their demand leaving shippers to substantially reduce their rates in an attempt to attract cargo [6]. BDI includes average of different bulk market rates. There are different tonnages of bulk carrier vessels as per nominated in voyages at different trade routes. For instance, supra-max freight rates are calculated as per arithmetical average of routes between European continent and Mediterranean to Far East, Pacific Ocean Range, and Far East to European continent, United States Gulf to Baltic Sea and Baltic to United States Gulf [15]. As the example of size and specification difference, a Cape-size, Very Large Ore Carrier (VLOC) and Pana-max vessels are non-geared vessels and do not have a crane or lifting gear to load or discharge her cargo by own [16].

Since BDI explains a general condition in the market, specific sub-indices have been also generated as per different ship sizes as in above table. These indices can be sorted as Baltic Cape-size Index (BCI), Baltic Pana-max Index (BPI), Baltic Supra-max Index (BSI) and Baltic Handy-size Index (BHI). Sub-indices are generally independent from another one however, in the overall value of BDI, some relations can be existed. For example, a Pana-max vessel's trade routes and cargoes are almost the similar for all ship owners; in contrast in supra-max and handy-size, many different types of cargoes can be seen especially between trades of emerging countries. On the other hand, in the latest BDI report it is seen that cape-size trend BCI is much more tending to increase instead of Supra-max vessels and BSI [15]. Therefore, it is essential to look into the components of BDI and also its development in latest ten years in order to make correct estimations for fixtures.

The below graph underlines the BDI has been very volatile in recent years (Figure 3). Particularly it has been as a bubble between 2005 and 2009. The main driver of this surge was linked to commodity prices, particularly oil. The index then plummeted back to historical levels and has remained weak in spite of a recovery in global trade. A factor is that many ships were ordered during the "bubble years" and have entered the market, providing capacity growth above demand growth. In recent years the BDI remains low, underlining a situation of excess capacity in the shipping industry. According to Danish Ship Finance (2015), the Dry Bulk market has recovered slightly since reaching a historical low back in 2015, but freight rates remain low and the oversupply is still significant. The depressed market conditions have led ship-owners to postpone or cancel orders and demolish vessels, which has kept fleet growth in check, limiting it to 2% during the first nine months of 2015. By year-end of 2016, fleet growth is expected to end up around 4%. The rebalancing of the Chinese economy has, however, reduced growth in Dry Bulk demand to a modest 1%. This is the lowest demand growth seen since 1999, aside from the post-financial crisis figure of 2009. The short-term outlook is clouded by an order-book-to-

fleet ratio of 17% and the ongoing rebalancing of the Chinese economy. In the short term, the rebalancing effort is expected to lower Dry Bulk demand further, since the heavy investments in construction and infrastructure have lost steam. Freight rates and second-hand values are expected to remain at low levels for the next two to three years. The medium- to long-term outlook is shrouded in uncertainty, since the long-term demand outlook for fossil fuels is being threatened by the astonishing technological progress being made within solar, wind and energy efficiency and the improved ability to store the energy for later use. Fossil fuels will remain a major source of energy for at least a few decades, but a more efficient use of energy and the potential for new technologies to decarbonise the energy supply will reduce the medium- to long-term demand outlook for coal. The long-term outlook for steel and other building materials seems relatively promising in light of the expected urbanisation process, not just in China but in most emerging countries. In short, Dry Bulk vessels may experience a reduction in transport volumes in the short term before volumes stabilise at a lower level [9]:

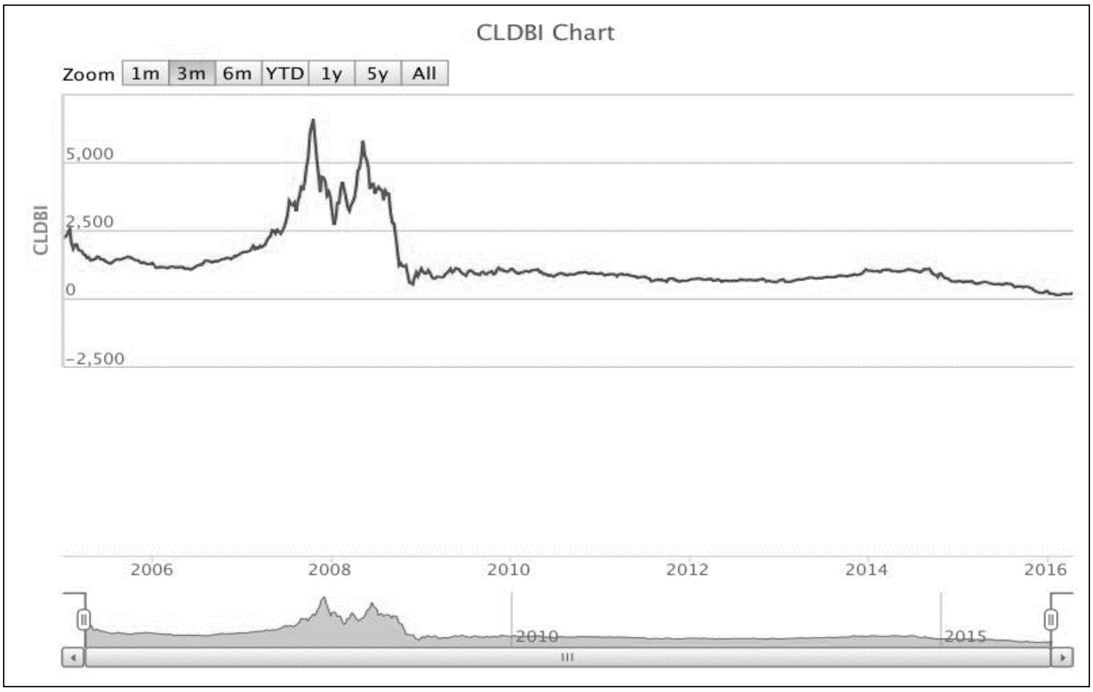

Figure 4. Last 10 years' average bulk-dry indices [13]

The rapid fall of bulk carrier market is affected from Chinese less growth rate than expected estimations. Despite the many attempts by steel mills around the world to fend off Chinese steel from their home market, China's steel export volumes did not fall significantly in January and February. Export dropped by just 1.6% to 17.85 million tonnes. New data for March showed exports of 10 million tonnes. In 2015, China flooded the world market as 112 million tons were exported, bringing down scrap steel prices in the wake of it. The three key items to watch out for in 2016 are Chinese imports of coal and iron ore, as well as how much dry bulk tonnage is going to be demolished. Nothing else really matters to an extent that can either improve or damage the fundamentals of the dry bulk shipping market (BIMCO, 2016). However, this is a theory between supply and demand rates. As the BDI value increases, ship owners will purchase new vessels so that they can develop their fleet by extra eaning in the market. While the supply side increases, this will cause a decline in BDI as well as freight rates and also cause ship owners to go bankruptcy due to low earning rates. This cycle must not be overseen by the ship owners and freight market rates must be well assessed. Especially for Turkish ship owners, this alert must not be disregarded.

Container Market

With the revolution in cargo handling, the design of general cargo ships has had to adapt and conform to new methods. Consequently, the cargo spaces of modern multi-purpose vessels tend to be as square as is possible, so as to assist the stowage of containers and palletised cargo, whilst on the weather decks, *modern designs allow for stowage of containers, often two or more tiers high, bearing in mind vessel stability, visibility from the bridge and deck strengths. As the container vessel technology has been developed, container market also has become relatively more stabilized structure than bulk carrier spot market, particularly not more than tanker market. Container market rate is calculated as per Ningbo Containerised Freight Index (NCFI) which is a sub-calculation index of Baltic Exchange. The index covers weekly movement of 20 feet, 40 feet and High Cube containers. The index is a composite of the three box types and covers Ningbo to East Mediterranean (Piraeus & Istanbul), West Mediterranean (Barcelona, Valencia, Genoa), Europe (Hamburg & Rotterdam) and the Middle East (Dammam & Dubai). It is based on transactional data from business conducted by a panel of 11 Ningbo based freight forwarders on Ningbo Exchange's e-trading platform and factors in various surcharges including bunkers, port congestion, peak season and Suez Canal fees. Index calculation NCFI is created by the application of a classical price index model. The sample data are calculated into the indices by using abnormal data of 3 Sigma Criteria. Abnormal data refers to the individual outlier data which would affect the calculation results in the process of index preparation. Secondly, calculations of each type of container's average price of each port are conducted via the index calculation model. It is calculated between of the indexes for container of each port by the each type of container's average price and the basis average price of each port. The last value is calculated of each route which is weighted for the volume on its representative trade [17].*

At a glance of container freight market rates it is seen that the container industry is struggling to employ the growing number of large vessels that are being delivered. Managing capacity by the individual companies in the industry is at the centre of the recovery. As demand is not expected to grow at a pace needed to match the capacity of new ships entering the fleet, extensive idling of the modern and efficient ships in the fleet and continued demolition of the inefficient ships will improve the market both in the short and mid-term. For the longer term management of capacity, a low level of contracting for new-buildings must be maintained. 2016 is off to a good start on all these parameters [18]. Below figure show the last ten years' freight development index of container shipping (Figure 5):

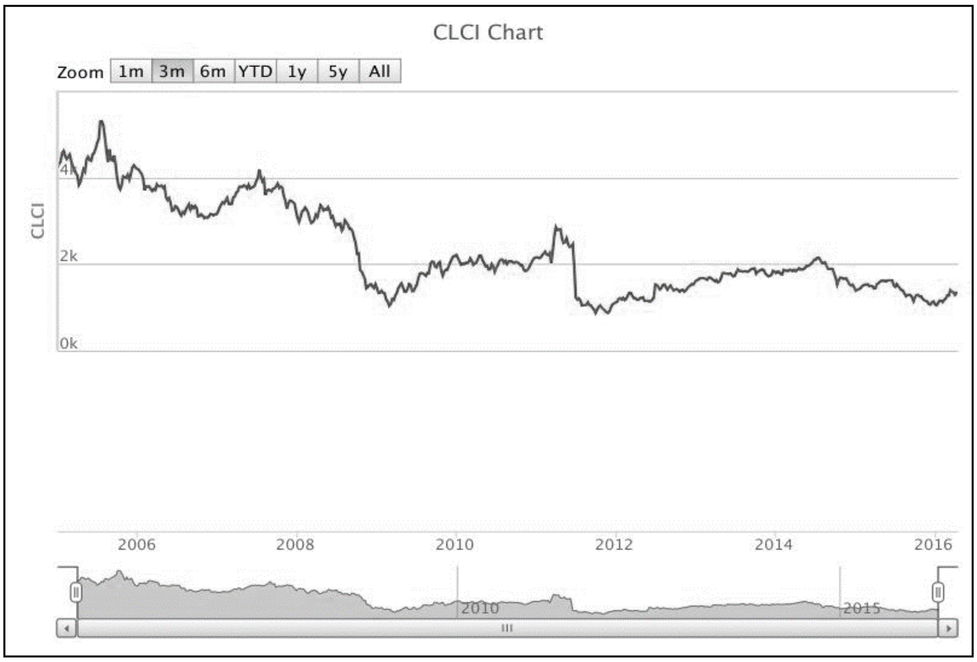

Figure 5. Last 10 years' average container freight indices (Capital Link, 2016)

There is little to indicate that demand will be able to employ the Post-Pana-max fleet within the foreseeable future. Looking further ahead, technological innovations could disrupt the market. The manufacturing industry is being reshaped by the introduction of advanced robotics and 3D printers. For large-scale and low-cost production, we are increasingly seeing examples of large-scale automation and robots replacing workers. For smaller-scale and higher-value production, 3D printers *offer local on-site production. If these trends mature within the lifetime of the vessels currently trading, the long-term outlook for the Post-Pana-max vessels could be very challenging. Trade patterns and travel distances could begin to be affected even within the next five to ten years, and by 2030, Container trade patterns could have shifted such that the majority of trades are regional and relatively few are long-haul overseas trades. Such a development would put significan pressure on the very young fleet of super large Post-Pana-max vessels. In April 2016 report of Zachariassen weekly market report that Container liner markets are in the process of further consolidation. A new alliance called Ocean Alliance, is to be formed between CMA CGM, COSCO, China Shipping, OOCL and Evergreen, in order to be able to keep up with 2M, consisting of the market leaders MSC and Maersk. In addition, Hapag-Lloyd has revealed progressed talks with UASC for closer cooperation which might lead to a merger in the end. In the sale and purchase area, MOL is said to have disposed of two 6.350 TEU vessels built in Japan to buyers from Southeast Asia [19]. The latest merging activity in container transportation was also held by Japanese biggest container companies as a surprising merging. Nippon Yusen Kaisha (NYK) Line, Mitsui OSK Lines (MOL) and K Line companies became in a joint venture and indicated that they will operate the world's sixth biggest container fleet with about 7% of global capacity by coming together [20]. That means the competitive is in an increase in container market and consolidating the power of ship owners is very important decision-making to minimize the financial risks in decreasing and hard market conditions. Consolidation will create a new competition structure for all types of shipping market and may be an effective solution for other ship owners which manage tanker and bulk carrier vessels, too.*

CONCLUSION

Shipping market is expected to become more and more competitive for the future years. Ship owners/managers will face more strict requirements which will also affect their competitiveness in the market as the technologic developments increase. Therefore, for the further years substantial investment is required to meet these requirements, and that may be a challenge on financial side of 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. New investors are well aware of the market conditions however, the traditional based family owners had lost a lot of money by possessing with the popularity of investment time as well as the type. New trends on management style will become more significant as per the comments of ship owners/managers. Merging the commercial or technical managements will provide companies to be powerful competitors by becoming together. The traditional based mentality especially not based on research and development, will cause the companies to fail in the market as some of Turkish ship owners encountered nowadays. The awareness of the ship owners/managers must be increased with seminars, meetings and conferences regarding maritime business and the current market conditions. As their perception to business activities changes, also the governance of the maritime business will have a different kind of view on development. This study is aimed to pronounce an alert on shipping market conditions transforming very fast and managers are urgently needed to take corrective and preventive actions for their ship managements by assessing all financial risks and their possible consequences. For further studies it is recommended that more specific questions can be asked to managers by providing them a well prepared questionnaire on shipping market and also more participants can be added into the study. On the other hand, this study shows qualitative and descriptive results. Further studies can be handled within more quantitative basis in order to support the ideas by statistical analyses. The market's volatility is always changing day by day and which are therefore such studies should be provided more often to attract the maritime competitors' attention.

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THE IMPACT OF TOTAL SHIP FLEET CAPACITY ON TO LINER SHIPPING CONNECTIVITY OF COUNTRIES: "STRATEGY FOR SHIP & PORT INVESTMENT"

Ayse Asli Basak[1], Erdal Nebol[2]

Abstract - Maritime transportation has constituted the biggest ratio of world trade since years. In maritime trade, ports are placed at the most strategic and significant points of logistics where being opened to international transactions. Liner Ship Connectivity Index (LSCI) has been generated by United Nations Conference on Trade and Development in order to increase contribution of countries into international trade by developing ports' effectiveness either or to measure the connectivity of countries' ports to global maritime logistics activities where keep significant role on international trade. In this study, simple regression analysis has been used between LSCI and total merchant fleet capacities of 127 countries in order to estimate tendency of ship investment participation into port investment and development. It is aimed by this research to indicate new strategies for development of emerging countries between maritime advanced countries within an analysis based on economic structure and maritime trade activities. This study reveals a one-way model to develop own economy in the scope that seaborne trade activity is one of the easiest path to survive against market's uncertainty. Increasing of cargo handling capacities in current ports and more strategic investments on port development will be a bridge to provide countries' competitive advantage in global trade market. In near future, improvement of logistic networks and researches on maritime and port development will pave way to "Must" instead of "Should" in order to maintain developments in maritime sector and economic stabilization of own country. Global success will become possible with only a global thought strategy.

Keywords – Fleet capacity, liner shipping connectivity index, ship investment, ports

INTRODUCTION

The international trade which is based on export and import activities has placed more than 80% maritime transportation in all modes of transport systems [1]. In maritime transportation, there need sophisticated infrastructures such as ports, berths and shipyards as additional to various types of ships to carry cargoes. Therefore, this situation has revealed a new mode of transportation which is called a "Multimodal" and used by combining more than one transportation mode with maritime transportation by the innovations and new researches [2]. It is necessary to develop standards for port infrastructure not only in container or Ro-Ro (Roll on-Roll off) transportations; particularly in wet, dry bulk and general cargo transportations will either be used in multimodal transportation which has an interpenetrating structure. The improvement of port activities, capacities and infrastructures provide to increase liner shipping trade on a large scale [3]. Liner shipping routes which are appeared with container transportation are still the most efficient ways that minimize costs either for dry and wet bulk Cargo transportation including chemical, petroleum product and liquefied natural gas (LNG) tankers [4]. Considering by the national economies, the liner shipping activities can be deemed as method that assist the trade volume of such country to increase. Not only in liner shipping transportation, tramp shipping which is also called free/random/uncertain transportation style keeps significant role in maritime transportation as well as global trade [5]. However, in our study, only the effect of total ship fleet capacity on to liner shipping connectivity has been analysed.

Seaborne trade has been in continuous development for recent years in Turkey due by new policy and strategies generated. Reducing taxes for Turkish flagged vessels, providing incentives to coaster ship owners and new developments on maritime based innovations are the best examples for the direction of the government supported improvement. Within the process of this development, port investment that is the basis of Turkish seaborne trade needs the utmost support. Increasing variety of high innovative

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based ships and the developments in safety requirements for ports and terminals cause more technological necessity on ports' development. Some of the ports have domestic or foreign-invested managements distributed in private sector while others are administrated by government with the policy of "Construct, Operate, Hand-over" [6]. Analysing effects of total ship fleet capacity of countries on to liner shipping connectivity will provide a different way on establishing new strategies for fleet development and port infrastructure.

In the previous literature, liner shipping connectivity of countries is stated as to measure with "Liner Ship Connectivity Index (LSCI)". LSCI is an indicator that is generally used to compare the connectivity statuses of world countries in specific to ports and shows their participation and accessibility to global trade. The higher rate of this index shows that country has reached higher capacities and frequency on cargo handling in global seaborne freight market easily. Therefore, LSCI is also an indicator of assisting maritime transportation as well as the international trade [7]. The LSCI was calculated in 2004 as first by United Nations Conference on Trade and Development (UNCTAD) and the following years have been calculated by basis of the year of 2004. It is calculated by analysis of the main components of maritime transportation such as container transportation capacities, the biggest tonnages of the fleets, number of port services, and number of container ships entered in the ports and also the number of managements/owners of those ships. All of the components are divided into the highest value of 2004 and average values are calculated. The averaged values are divided into the highest rate of 2004 and multiplied by 100 coefficients. Generally, the country which has the highest rate of 2004 is accepted as the 100 as the criteria value [8].

On the other hand of ship fleet capacity of countries, it is seen that world fleet continues to lead the demand side in shipping freight market. Global financial crisis in 2009 had affected the average freight rates very deeply [9]. Market rates directly affect second hand and new building ship prices and particularly the total ship fleet capacities of countries. By combining an analysis between total ship fleet capacity of countries and their LSCI rates will provide a two way thinking strategy both for port and national fleet developments. Therefore, this study is aimed to reveal a new quantitative based model to develop countries' national economies by using maritime transport. Additionally, this study will enlighten to empower maritime based governmental strategies for Turkish maritime economy.

METHODOLOGY & DATA

The data has been collected from UNCTAD database and selected between possible variables which may affect countries' national fleet capacity and their outlook to national shipping investment as well. There are many factors while deciding the methodology on investment analysis. Fleet diversity and structure, cash flow, companies' governance and management performances and technological innovations affect the managerial decisions. In this study, the data has been selected between possible variables which may affect countries' national fleet capacity and their outlook to national shipping investment as well. Therefore, national fleet capacity of all countries in the World is selected as the first variable. As second, countries' connectivity into international shipping routes Liner Shipping Connectivity Index was selected as second variable. The third variable was the Economic Openness Index (EOI) which is a variable that includes total trade volume and total GDP value of countries. However, EOI values were found non-significant and they are excluded from the study. All countries in the world which have all these defined variables' reports as of 2015, total 127 of them were selected including Turkey. As result of selection process, the data of nine different variables can be summarized as LSCI, EOI, GDP, GNP per capita, countries' ship total tonnage in deadweight, countries' beneficial ship ownership total tonnage in deadweight, total import, total export and sum of total export and import values were firstly tested in box plot graphics in SPSS 23.0 as first. In the countries' ship total tonnage in deadweight data some countries' values found very high and very low due to unusual flag regulations on owner taxes which is called "Flag of convenience" [10]. The countries such as Panama, Marshall Islands and Malta mostly have the biggest tonnage at ownerships as foreign affiliates. For instance, Greek ship owners prefer to fly Marshall Islands or Panama flag instead of Greek Flag on their ships due to low ship owning taxes [11]. That is why, the biggest ship's register Marshall Islands was excluded from this study. As well as Marshall Islands, Sudan was also excluded from the study due to having the less value in fleet capacity as having almost zero. The values of variables did not include any percentage or volume ratios, all were numeric. However, when the distribution and extreme values difference between countries' LSCI, EOI, own and beneficial ship deadweight capacity are seen as not normal distributed, all data was decided to use logarithmic value based on 10 as napierian logarithm for all indicators in the hypothesis. By taking logarithmic values, data types were not changed and still used as numeric type in SPSS 23.0. Using natural logs for variables on both sides in an econometric specification is called a log-log model. This model is useful when the relationship is nonlinear in parameters as in our data log. The log transformation generates the desired linearity in parameters and gives similar results however type of the log must be a natural log based on 10. The practical advantage of the natural log is that the interpretation of the regression coefficients is straightforward [12]. There are of course many statistical analysis methods to indicate the effect of all variables on liner shipping connectivity index or fleet deadweight capacity. However, in this study, due to the multiple regressions' insignificance, simple regression analysis has been conducted between all serial venue variables for 2015 as the latest reported year.

RESULTS

As the first step of the data testing, the log of fleet capacities and liner shipping connectivity of 127 countries are analysed whether is significant or not with below box plot graphics. The plot limitations are found as significant as per below shapes are normally distributed (Figure 1 and Figure 2):

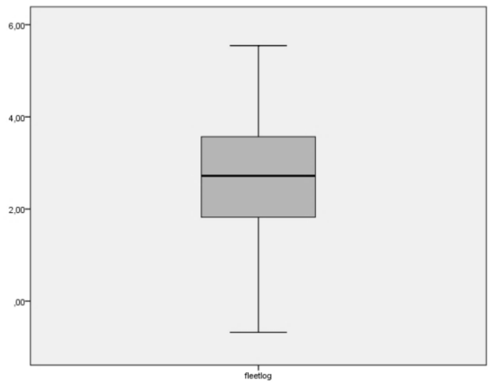

Figure 1. Box Plot Diagram of Merchant Fleet Capacities in 10 based Logarithm

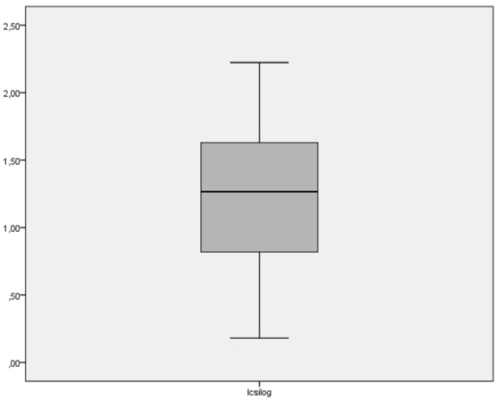

Figure 2. Box Plot Diagram of Liner Shipping Connectivity Index (LSCI) in 10 based Logarithm

The method and results of the simple regression analysis used in SPSS 23.0 and the test results have been found as in following tables (Table 1):

Table 1. Method that shows entered/removed variables

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

a. Dependent Variable: lcsilog
b. All requested variables entered.

Assumptions of the regression analysis were tested. Linearity, heteroscedasticity, auto correlation and multicollinearity assumptions were satisfied by appropriate tests as the results in Table 2 and Table 3. As displayed in below ANOVA table, model was found to be significant (p=0.000) at $\alpha = 0.05$ and null hypothesis rejected (Table 2):

Table 2. ANOVA Table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4,305	1	4,305	23,501	,000[b]
	Residual	22,896	125	,183		
	Total	27,201	126			

a. Dependent Variable: lcsilog
b. Preictors: (Constant), fleetlog

Table 3. Significance of coefficients

Model		Unstndardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,875	,082		10,672	,000
	fleetlog	,136	,028	,398	4,848	,000

Table 4. Collinearity statistics and confidence interval

Model		95,0% Confidence Interval for B		Collinearity Statistics	
		Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	,713	1,037		
	fleetlog	,081	,192	1,000	1,000

a. Dependent Variable: lcsilog

Multicollinearity test results show that VIF value is 1.00 and under the limitation of 5.00 which is assumed as significant.

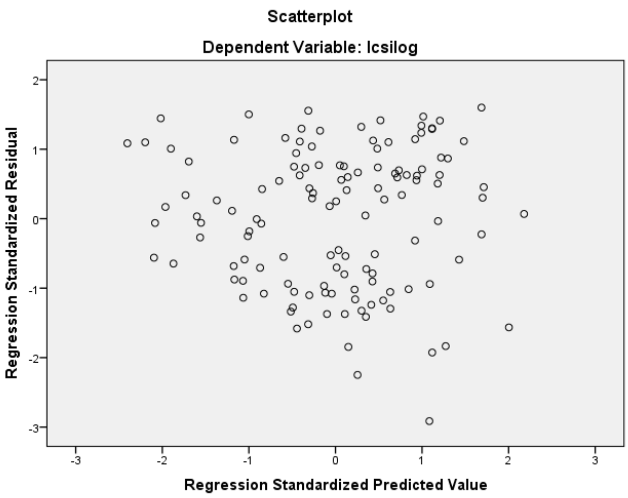

Figure 3. Scatterplot diagram of the model

To find out if the auto-correlation is existed or not, Durbin-Watson test also has been carried out and calculated as 2.14 that is between the minimum and maximum limits of 1.80 and 2.30. As the last, heteroscedasticity has been tested in scatterplot graphic and found that not shaped as funnel which is assumed as significant for this model. R square ratio is also calculated as 16% and has a less value, however it can not be disregarded due to other tests' significance levels are well compliant with the whole model.

Table 5. Model summary/significance results (R square)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	,398[a]	,158	,152	,42798	,158	23,501

Table 6. Model summary/significance results (Durbin-Watson)

Model	Change Statistics			
	df1	df2	Sig. F Change	
1	1	125	,000	2,144

a. Predictors: (Constant), fleetlog
b. Dependent Variable: lcsilog

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

$$\ln(yi) = \ln(0.875) + 0.136\ln(xi) + \varepsilon i \qquad (1)$$

(0.082) (0.028)

The above model shows that deadweight tonnage of merchant fleet of countries can be used to predict the possible liner shipping connectivity of countries in a 10 based logarithmic scale. Countries can use the basic regression model in order to estimate necessary investment and budget planning while maintaining development or master plans.

DISCUSSION

According to this model, the coefficients can be used to determine the impact of the independent variables (x) on dependent variable (y) as usual. The coefficients in log-log model show the elasticity of dependent variable as a part of linear regression. In particular, this coefficient shows the estimated percent change in the dependent side or vise-verca in the independent one [12]. To Simonoff (2016), log-log model explains a parabolic relationship between x and y and suggests enriching the model to include both linear and quadratic terms. First function of this model is having a multiplicative relationship and being consistent with proportional changes in independent variable. Therefore, this function gives an opportunity to take logarithm of both sides of the equation. It is mentioned also that this model is appropriate for Money data or any data which has very high or low values as well as investment analyses and estimation of demand functions in trade. Some calculus shows that for the log–log model, the elasticity is a constant β, and the log–log model is therefore sometimes called the constant elasticity model. Thus, if it is assumed that elasticity is constant, they can be estimated using the slope coefficient for price in a log–log regression model fit. Therefore, a very convenient interpretation of the slope in a log-log model is that holding all else fixed a 1% change in x is associated with a β% change in y [13].

There have been variations between different kind of segments however the shipping industry is currently going in a downward trend. The log-log model shows there is a direct impact on liner shipping connectivity and the total national fleet capacities of countries and the governments should consider to provide incentives on the correct investment type for ship owners/managers. For instance, dry bulk sector has seen the deepest levels in 206, however, owners still continued to invest in new dry bulk ships without analyzing the total national and beneficial fleet status, port capacities and also the liner shipping connectivitiy. Due to the fact that liner shipping is more likely related with container fleet development, the study can be enwidened with specifically to the other segments. In this study, inserting the whole tonnages of national and beneficial owned fleet will provide a global-based thought on fleet development of countries not by considering the only national development. The ship owners/managers which fly foreign flagged vessels and their participation in import and export activities from/to Turkish ports also keep significant role on development of liner shipping.

In the model fleet capacities which assumed as independent variable have a logarithmic value of 0.136 and show that the effect of the fleet capacities on to liner shipping is not too much, however it also can not be disregarded. Constant of the equation is also logarithmic based and has the value of 0.875 which reduces the errors of the model. To make further forecasts with the above model world fleet development, freight rates, time-charter rates, commodity/oil prices, import/export volumes, economic opennes levels, GDP/GNP, existence of new shipping routes and technological changes also should be taken into account as the unknown assumptions of the model. Therefore, a deeply shipping fleet analysis is necessary to incite the companies on investment or scrapping on the side of government. Maritime economy must be started as national strategy first and to be continued with global side. When at a quick glance of the fleet development in the world, it is seen that tanker segments had fairly good rates whereas containers, dry bulk and offshore related vessels struggle to balance a large inflow of new vessels when the demans is waning. Crude and product tankers have got benefit from high level of trading activity that reflects a variety of different factors such as low oil prices, new refineries etc. It seems that market is getting alert for other segments since the demand outlook remains fragile, the order book is large and few obvious scrapping candidates remain.

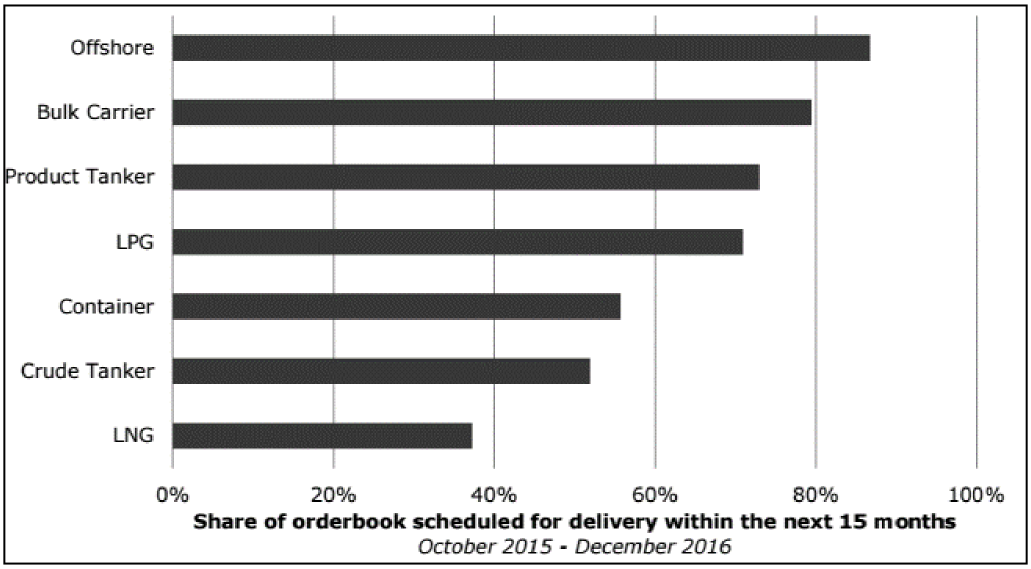

Figure 4. Orders scheduled for delivery within last 14 months [9,14]

As seen in above order book breakdown, world fleet development is still strong on offshore and bulk carrier segments despite the decreasing oil prices and dry bulk freight rates. That means the delivery schedule of the orderbook is more troubling than its actual size. The orderbook is expected to be delivered at an even pace over the next three years, it would be much more feasible for the new vessels to be enrolled. But the order book is heavily front loaded. In essence, more than 70% of the orderbook is scheduled to be delivered before year-end 2016 (Figure 4). Generally speaking , larger vessels lower the cost per moved unit and are preferred on long -haul trades. However, the economies of scale deteriorate if the vessel is not full. It is therefore vital to maintain an average size of vessels trading that reflects the need s of global demand. With a global economic outlook where the old powerhouses of growth are gradually being replaced by emerging economies that ave large population s but low disposable incomes , we are concerned that the size of the current fleet and vessels on order reflects the world of yesterday rather than the world of tomorrow. One of the key takeaways from our World demand indicators section above is that we expect to see stagnating or even declining seaborne trade volumes within the next five years. Therefore, it is essential to consider new strategies to improve national fleets and manage the fleet distribution on a government supported strategic development.

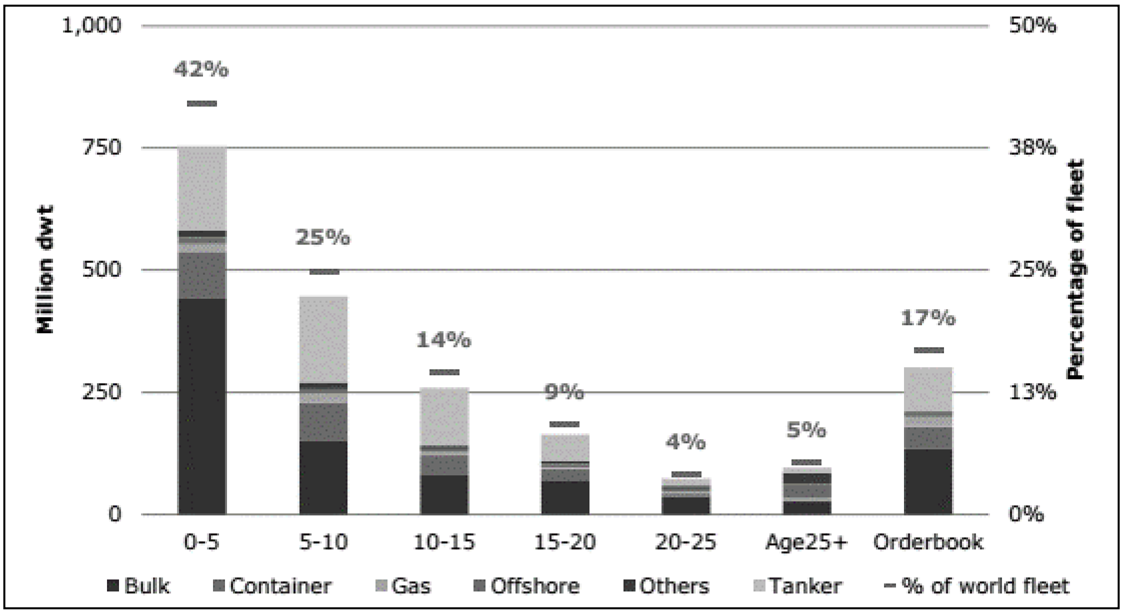

Figure 5. The world fleet and age distribution [9,14]

When an outlook to the worldwide fleet structure by ages, it is still seen that bulk carrier segment has the utmost ratio in global fleet even though the demand to bulk carrier ships still remains the same. 42% ratio of vessels have been found as between age of 0 and 5 which have relatively younger age. This means that almost half of the world fleet has younger ages than the remaining and this situation causes an increase on competition of young ships are alternative for charterers with their well based technical conditions. Therefore, our model can be specifically repeated according to the age scale of different kind of ships, for instance which type of and which age of ships mostly affect the liner shipping. Their participation to liner transportation can be measured for further studies as additional to our mentioned model.

CONCLUSION

The most important factor that provides countries well-known reputation in international trade is absolutely logistics and transportation. Developig standards for logistic networks have positive impact on economic activities as well as maritime transportation by the fleet expansion. Therefore, steps of development in maritime sector must be strategically planned. In this study, how much the total ship fleet capacity has impact on to liner shipping activities have been statistically researched. On the side of Turkey, it is highly important to increase port investment activities within a technologic and innovative infrastructure in order to contrbiute the development of national economy. There is a shift in growth as the industry transforming into services and consumer economy. There have been some fears that outsourcing and globalization are reaching their limits and there are early signs of near sourcing and nationalization. It is indeed a new shipping abnormal with constrained financing as sets deflation and shift in demand and it is likely to stay with us for long. Therefore, the governments are invited to generate new real-time models and strategies on maritime logistics and transportation particularly on investment side within cooperation philosophy. By considering the geopolitical status of Turkey, the regions where have potential to growth as infrastructural must be indicated and new investment methods must be generated. It is not only important; it is crucial for Turkish economy to determine a national fleet development based maritime strategy in order to become a leading economy in global trade competition. The model in this study is aimed to provide governments quantitative based methods to issue new development strategies. For further studies it is recommended that the more specific data can be used in regression analysis by upgrading the model to multiple regression analysis. Additionally, data is used in 10 based log-log format in this model. The logarithmic basis of the model can also be changed with appropriate values instead of 10 based and more significant results can be gathered by the statistical analysis. To conclude, the global economy is very tough to bear especially for developing countries. Therefore, Turkey is required to obtain a national development strategy on shipping in order to become a big competitor of the global trade as a developing economy.

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A NEW PRODUCT FOR CITY LOGISTICS "CITY CONTAINER"

Kayıhan Özdemir Turan[1]

Abstract - The performance of city logistics activities in crowded mega cities should be increased. The solutions of problems of cargo movements in cities will have positive effects on daily life of city people. The traffic jam which is the result of daily in & out transport activities of raw materials, semi raw materials and final products, should be minimized. As a result of these cargoactivities, traffic congestion results with high fuel consumption and greenhouse gas emissions. One part of cargo movements is the haulage of import & export containers between city ports and loading & unloading addresses within the city. Using Intermodal Transportation mode is not common for city logistics activities. Intermodal Transport is described in UNECE documentation as "The movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes". In this study, it is aimed to use "Intermodal Transport Mode" by using "City Container" which is especially designed as intermodal transport unit by targeting mainly city logistics activities. This container is not in use yet and will be useful for products which will be shipped directly from production plant to end user addresses without requiring additional value added services at another point within the supply chain route.

Keywords - Intermodal, City Container, City Logistics, Traffic, Fuel Consumption

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 (Turan, 2014). 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).

Many people prefer to live in uptown as a result of increasing noise and air pollution. As one of the success criteria of a city, level of freight traffic within the city is a longterm achievable problem for city management. In this context, EU 2050 Transport Strategy aims to minimize GGE %60 of current level and targeting to come to level zero for emission of CO2 gases in mega cities (URL1).

Freight deliveries which are done in narrow streets of cities, effecting negatively the city traffic by blocking the passage of other vehicles during minimum 15-20 minutes for unloading and loading operations. This results with delays for delivery times. To avoid such cases, the usage of sea routes, rail routes and alternative vehicles such as electric and or hybrid vehicles and special equipments such as city containers should be induced by city management.

The shareholders of city logistics are freight owners, transport companies, city managers and city people. Each of these shareholders has different targets on city logistics. The most important thing is the smooth coordination of all for a liveable and sustainable city. To realize this common target the main issue is to use ICT and ITS and change of understanding of city managers and public & private cooperation (Taniguchi, 2014).

This study consists of 5 sections . Introduction is the first section. In the second section, literature is searched and some samples are given. In the third section, general description and explanations are given

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about Intermodal Transportation, City container and releated topics. In the fourth section, one application is done in a part of İstanbul city by comparing the cost differences of deliveries done by city containers or normal way as in today operation. Fifth section is the final part with concluding remarks.

2.RELEATED LITERATURE

When we have searched the literature for both national and international studies, we could not find any study on topic "City Container". We have found a limited number of studies when we searched on topic "new aspects on city logistics" by searching key words "intermodal", "city logistics", "freight" and "transport".

Some of international studies and topics are listed below :

- "Innovative Logistics Models and Containers Solution for Efficient Last Mile Delivery", (Amico et al, 2012)
- "Improving Logistics Management Using Foldable / Collapsible Containers:A Case Study", (Bandara et al, 2015)
- "The potential for non-road modes to support environmentally friendly urban logistics", (Browne et al, 2014)
- "Urban Logistics by Rail and Waterways in France and Japan", (Diana et al, 2014)
- "City logistics through the canals? A simulation study on freight waterborne transport in the inner-city of Amsterdam", (Duin et al, 2014)
- "A sustainable perspective on urban freight transport: Factors affecting local authorities in the planning procedures", (Maria L., 2010)
- "Urban Freight Distribution: The impact of delivery time on sustainability", (Abdelhamid et al, 2015)
- "Dorothy project: Urban logistics organization in Valencian Community", (Pinoa et al,2014)
- "City Logistics in the European CIVITAS Initiative", (Tariq et al,2014)
- "Recent Trends and Innovations in modelling City Logistics", ,(Taniguchi et al, 2014)
- "Concepts of city logistics for sustainable and liveable cities", (Taniguchi, 2014)
- "Evaluation of City Logistics Solutions with Business Model Analysis", (Quak et al, 2014)
- "Improving urban freight transport sustainability by carriers – Best practices from The Netherlands and the EU project CityLog", (Quak, 2012)

We have found very limited national studies on city logictis and some of them are as below :

- Erdir Aylin, "City Logistics : An application for İzmir", Master's Thesis, 2013
- Erdumlu R.Mert, "City Logistics and Freight Village Application", Master's Thesis, 2006
- Inaç Hakan, "City Logistics Analyses in İstanbul City and Evaluation of Solution Suggestions with AHP", Master's Thesis, 2012

Total amount of studies after year 2000 is 94, out of which 82 is international and 12 is national. These studies are searched at databases of Maltepe Universitity and Yeditepe University on magazines, conference papers and thesis. The databases used are Science Direct, Taylor&Francis, Hermes, Google and Ebscohost.

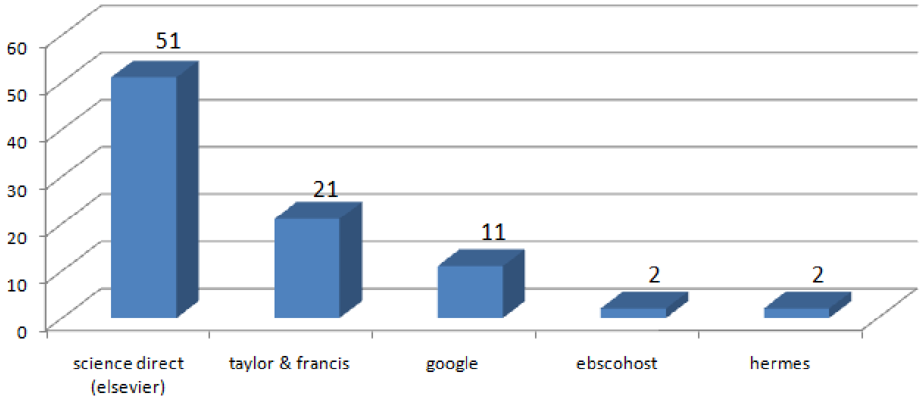


Figure 1 : Numbers of Studies per Data Base

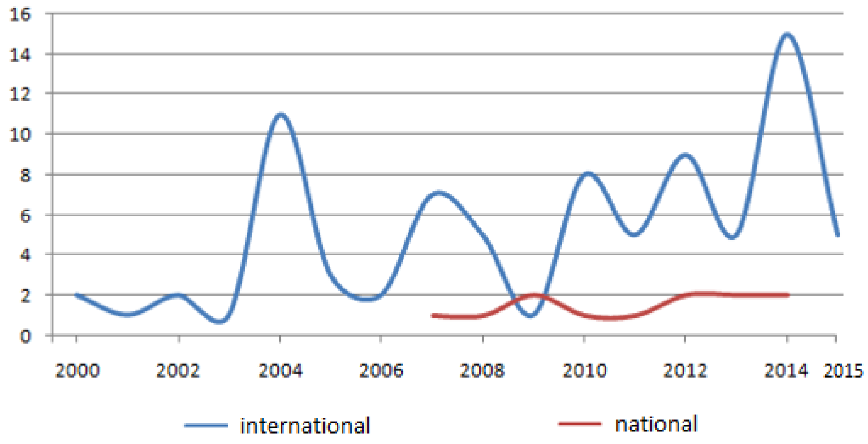


Figure 2 : Numbers of Studies per Year

International	Category	National
17	intermodal transport / terminal	4
14	regions (country, city)	3
11	transport mode	1
10	modelling & metodology	4
7	politics & planning	
6	optimization	
6	literature research	
5	innovation & technology	
4	city logistics	
1	enviroment	
1	economics	
82	Total	12

Table 1 : Categories of National & International Studies

		YEARS															
NAME OF SOURSE		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Procedia Social and Behavioral Sciences	14											5		4		5	
Transportation Research	12			1		2	1		2			1	1			3	1
Transportation Planning and Technology	5					1			1	1		1					1
Transport	5					1			2					2			
Journal of Transport Geography	4							1				1		1		1	
Maritime Policy & Management	4	1							1	1	1						
Conference Paper	4					1		1					1	1			
European Journal of Operational Research	3					1							1			1	
Transport Review	3				1	1							1				
Research in Transportation Business & Management	2															1	1
Research in Transportation Economics	2						1								1		
Others	29	1	1	1		4	1			4	1		2	2	4	6	2

Table 2 : Year & Name of Source for international Studies

3. INTERMODAL TRANSPORT CONCEPT IN CITY LOGISTICS AND CITY CONTAINER

The description of Intermodal Transport is done by UNECE as “the movements of goods in one and the same loading unit or road vehicle whihc uses successively two or more modes of transport without handling the goods themselves in changing modes” (URL2).

Intermodal transport is used mainly for international freight transports. For many years intermodal transport concept is used mainly for transport with main transport leg is sea. But within last 10 years intermodal transport concept is used for transports with main transport leg is rail.

For today, usage of railways, sea routes or waterways within city logistics transportation is commonly on test stage with minimum numbers (Duin et al, 2014). These attempts could not be sustainable after trial periods. A sustainable transport model is only possibl incase these items are considered ; logitics innovations, political items and technological developmnts (Quak, 2012). Success is the coordination of these 3 item and execution all together at the same time.

The most valuable performance criterias of city logistics are noise level and green gas emissions (GGE). To achieve this, technology is to be used efficiently. As a result of today developing technology by using electrical and hybrid vehicles, we can minimize the noise level and GGE (Quak, 2012).

A route plan is done for city logistics vehicles in the base of more than one delivery on rotue (Taniguchi and others, 2014). İnstead of this, one freight / one customer system for delivery in city logistics by using city container will contribute a lot to achieve the targets of minimizing noise level and GGE.

City container is an intermodal transport unit (ITU) same like standard 20’ dv sea container. The main difference is the size and it is a small container. This container is not in use yet (Figure 3). Especially for products which does not require any additional handling from production point to consuming point, city container will provide many profits for transport from starting point to ending point. City container can be placed on top of each other and shipped in 20 dv cntrs without any problem. The dimensions of city container will be 115x116x112 cm, WxLxH.

When we compare city container with current pallet using system, there is no loss of volume in the container. Result is better than pallet system, since most of LCL (less container load) shipments are done on pallets. There are two types of pallets with dimensions of 80x120 cm & 100x120 cm. 80x120 cm pallets are more common in use. The height of pallets including its own height as 13-15 cm, is around 100-110 cm. In a standard 20’ dv container, inner dimensions as LxWxH(door) are 589x232x228 cm. When pallets are used, there are some lost spaces in the container. Using city container will minize such loses. The loss of space in a 20’ dv container is 8,06 cbm while it is only 1.41 cbm when city container is used. This menas %82.5 of gain in lost space. The diagram of lost spaces in a 20 dv container is shown in Figure 4.

20 dv container loading volume	: 589 x 233 x 228 = 31,29 m3
Pallets volume	: (120 x 80 x 110) x 22 = 23,23 m3 →
Lost space	: 8,06 m3
City container volume	: (115 x 116 x 112) x 20 = 29,88 m3 →
Lost space	: 1,41 m3

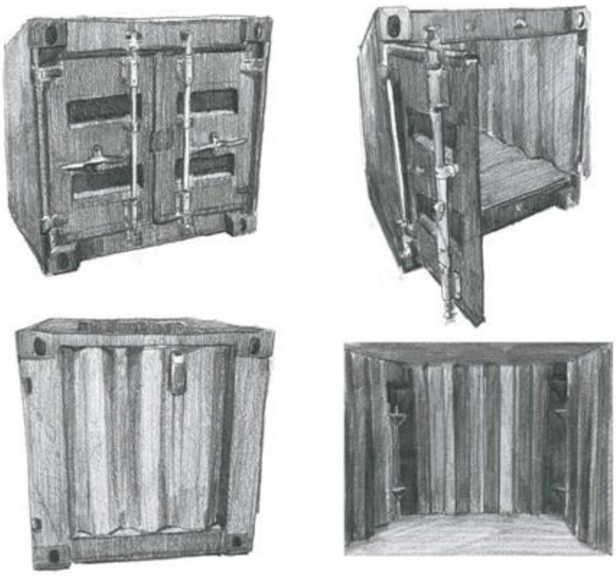


Figure 3: City Container

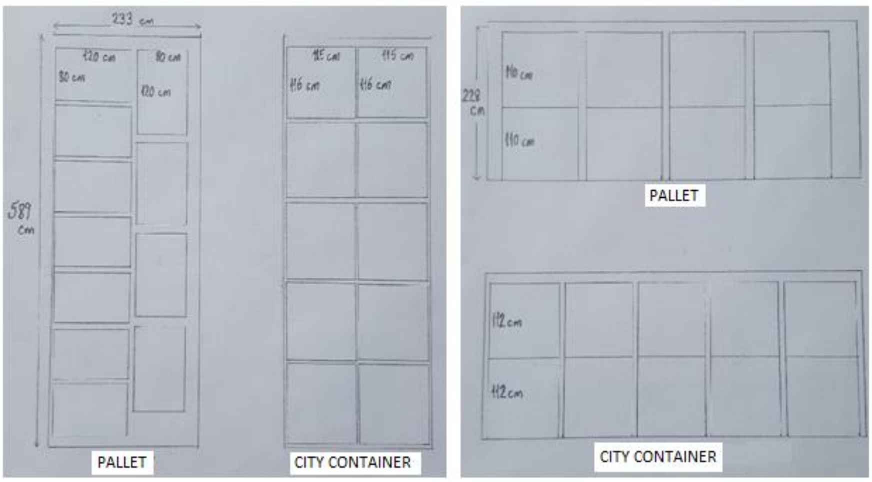


Figure 4 : Inner Volume Usage for 20 dv container (for pallets & city container)

An ITU arriving city ports and/or terminals are shipped to unloading addresses mainly by road freight. Same case is valid for export shipments, i.e. from production plant to ports and / or terminals again road freight is used. Instead of using minimum 20'containers or more such as 40' and 45' containers, between ports and final destination, it is better to have a cross dock (C/D) center out of port and unload city containers at cross docks and make final delivery leg by city contianers by using electrical and / or hybrid vehicles such as trucks or motobikes. As a result we will have less GGE and less noise and less fuel consumption and fast deliveries and less traffic congestion.

In this system containers arriving city abroad will be shipped to C/D centers by road, rail or sea. Incase sea route is used, vehicle type will be barge (Figure 5) and incase rail route is used, vehicle type will be TurKar (Figure 6) a vehicle can move both on rail an road (URL3). Incase road route is used, vehicle type will be a truck with elevator Figure 7). For final leg deliveries from C/D center to final destination, vehicle type will be electric motorbike (Figure 8).

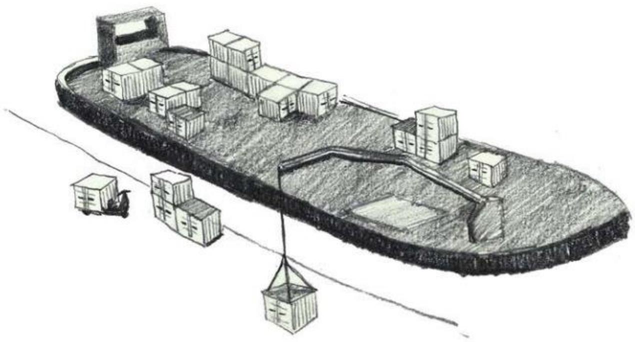


Figure 5 : Barge

Figure 6 : TurKar

Figure 7 : Truck with Elevator

Figure 8 : Electric Motorbike

4. APPLICATION

Application is done by an example in Istanbul city. There are total 39 districts in İstanbul, 25 in Europe side and 14 in Asia side. Location of districts are shown in Figure 9 with names in Table 3.

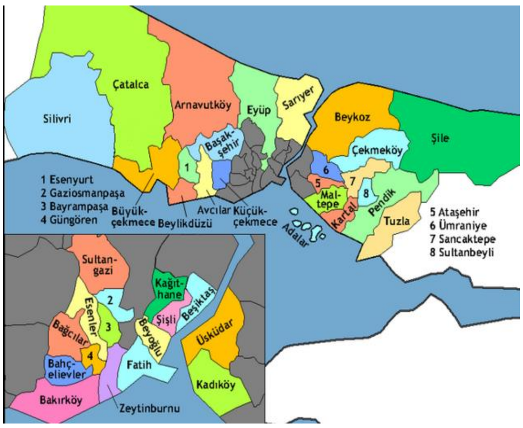


Figure 9 : Location of Districts

Europe Side			Asia Side	
Arnavutkoy	Beylikdüzü	Gaziosmanpaşa	Adalar	Pendik
Avcılar	Beyoğlu	Güngören	Ataşehir	Sancaktepe
Bağcılar	Büyükçekmece	Kağıthane	Beykoz	Sultanbeyli
Bahçelievler	Çatalca	Küçükçekmece	Çekmeköy	Şile
Bakırkoy	Eyüp	Sarıyer	Kartal	Tuzla
Başakşehir	Esenler	Silivri	Kadıköy	Ümraniye
Bayrampaşa	Esenyurt	Sultangazi	Maltepe	Üsküdar
Beşiktaş	Fatih	Şişli		
		Zeytinburnu		

Table 3 : Names of Districts

Infrastructure in Istanbul city for both sea and rail routes are good enough to have an alternative to road haulage. Figure 10 is for sea infrastructure and Figure 11 is for rail.

Figure 10 : Sea Infrastructure / Istanbul

Figure 11 : Rail Infrastructure / Istanbul

4.1. Description of the problem

The unloading & loading addresses for containers arriving and departing from Istanbul city from/to abroad are both districts of city and also other cities around Istanbul. There are two ports in Istanbul. One is Ambarlı which is in european side and the other is Haydarpaşa whch is in asian side. Cntainer transportation mode is roa for inland haulage. Haydarpaşa port is a state owned port and notused commonly for last years. We will use Ambarlı port for our problem (Figure 12).

Figure 12 : Istanbul Ports

In our problem, we will consider 1x20 dv LCL import container arriving Ambarlı port with a general cargo on pallets for 5 customers located in 5 different districts in european side of the city We will compare the logistics cost for two options. 1st one will be goods arriving on pallets and delivered by existing model. 2nd one will be goods arriving in city containers and will be delivered by an alternative model.

In alternative model, we will decidefor a crossdock (C/D) location around port to e used for deliveries of city containers to final destination. From port to this cross dock location delivery will be either road or sea haulage. Since there is no rail connection at Ambarlı port, rail option will not be considered.

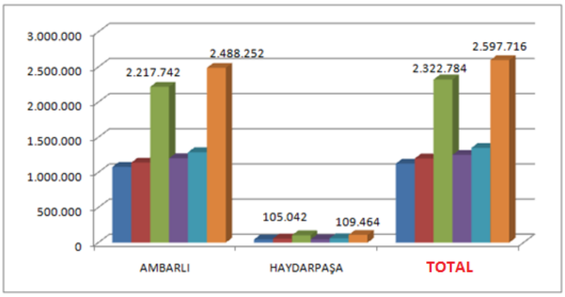
When 20 dv cntr arrives C/D, city containers will be unstuffed and thenafter the intermodal transport options such as rail+road and sea+road and direct road will be studied and compared.

For the transportation of city containers from C/D to final destination, barge, electric motorbike, TurKar, truck with elevato will be used.

City containers are easy to handle for unloading & loading and unstuffing & stuffing operations. No need for large stocking area as a result of small dimensions. As delivery of limited amount of volume, no detention costs will occur for the delay of unloading and for return cargo not ready on time issues etc. It will be possible to ship city containers directly to end point for end user and by doing so there will be some saving points in the traditional supply chain which will result with some financial profits and transit time decreases.

4.2. Application

Ambarlı port has the biggest container handlings quantity in Turkey. All containers discharged at Ambarlı port are shipped to final destination by road. Even most of the containers are FCL (full container loaded), there are LCL (less container loaded) containers also. FCL containers means one shipper and one consignee, while LCL containers has more than one shipper and consignee in the same container. After discharged at port, LCL containers are unstuffed at port warehouse. Thenafter import customs clearance formalites are completed by each consignee and then delivery to final destination is done by road by each consignee seperately. The total number of containers handled at Ambarlı port is listed in Table 4 (URL4). Within such high figures, handling of LCL containers in Ambarlı port will be time loss and area loss for a port management.



	2015			2014		
	EXPORT	IMPORT	TOTAL	EXPORT	IMPORT	TOTAL
AMBARLI	1.078.218	1.139.524	2.217.742	1.201.479	1.286.773	2.488.252
HAYDARPAŞA	46.674	58.368	105.042	48.138	61.326	109.464
TOTAL	1.124.892	1.197.892	2.322.784	1.249.617	1.348.099	2.597.716

Table 4 : Number of Containers handlings at Ambarlı & Haydarpaşa ports / TEU

In our application we will compare the two transport models. 1st one is current way. 2nd one will be the model by using city containers. We will consider that in 1x20 dv container there will be total 20 pallets/city containers for 5 consignees located in 5 different districts in european side of Istanbul city. We will compare the cost for only fuel consumption and man power to be used. We will not take into account cost for customs formalites.

We will consider that discharging port will be Kumport in Ambarlı region and there will be total 20 pallets and commodity is not dangerous goods and pallet dims will be 80x120x110 cm stackable on each other with a total weight per pallet is 1 ton.

Names of districts and number of pallets for each consignee are listed in Table 5.

Consignee	# of pallets / city containers	District
C1	3	Başakşehir
C2	2	Sultangazi
C3	3	Zeytinburnu
C4	5	Beşiktaş
C5	7	Şişli

Table 5 : Names of Districts and number of pallets/city containers for each consignee

We will take into account that all pallets will be nstuffed at Kumport warehouse and each consignee will complete import customs clearance at port and after it is completed, cargo delivery to final destination will be done by road by each consignee seperately. For calculation of port warehouse cost, we will use port tariff (URL5). The discharging of 20 dv import container is assumed as friday and the cargo exit day from port warehouse after completing import customs clearance is after 7 days which is next friday. Costs are calculated for 7 days storage at port warehouse.

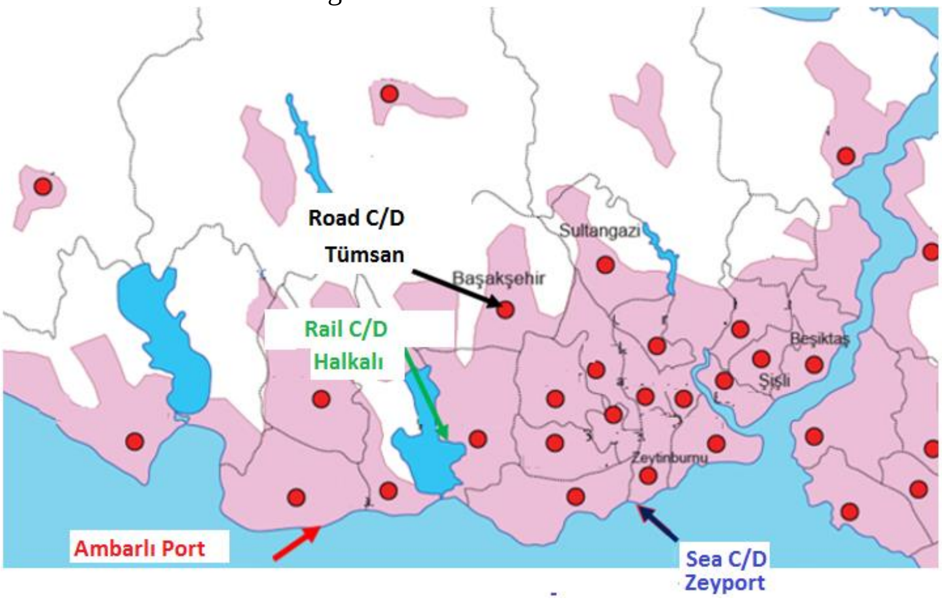
As an alternative city container will be used instead of pallets for 2nd option. In that case, there will be a C/D out of port area. So import container will be transfered to this C/D without losing time and city containers will be unstuffed from import container at this C/D and we assume that import customs clearance formalites will be done by each consignee while city containers are at C/D. We assume that city management and customs authority and other logistics shareholders will come to a mutual aggreement to solve this customs issue.

For C/D location we will use 3 different addresses, basing on that deliveres could be done by rail, sea and road from those C/Ds. Since there is no rail connection at Ambarlı port, for rail and road C/D alternative, 20 dv import container will be shipped by road while for sea C/D, it will be shipped by sea route. The location of C/Ds are listed in Table 6.

Table 6 : Location of C/Ds

C/D Transport by	Location
Road	Başakşehir
Rail	Halkalı
Sea	Zeytinburnu

Figure 13 : Location of C/Ds



We do not take into account costs for investments such as land for C/D, handling equipments such as forklifts and transpallets, barge, TurKar, truck with elavator and electric motorbike.

Personel salary at C/Ds are considered as net 1300 TL based on official 2016 announcement by goverment. The number of personnel at C/Ds are planned as follows.

- For road C/D, total 4 personnel (2 warehouse workers + 2 drivers)
- For sea C/D, total 6 personnel (2 warehouse workers + 2 barge captains + 2 motorbike drivers)
- For Rail C/D, total 6 personnel (2 warehouse workers + 2 TurKar drivers + 2 motorbike drivers)

The capacity is noted as daily 1x20 dv container, weekly 5, montly 20 and total 240x20 dv containers annually.

Based on Kumport port tariff, the cost for loading container on truck to exit from port, is usd70. If this container is unstuffed at port, then the cost is usd120 per container. The port storage cost for both option is same. So we do not include this part in our calculations. The inland haulage current cost in the market for 20 v cntr from port to road or rail C/D is 330 TL. If this import container is shipped from port to sea C/D at Zeytinburnu pier by a municipality barge then fuel cost is 36 TL. Since amortization and salary for driver and other costs are included in road fee, we will take this cost as triple, 109 TL.

Port warehouse cost for storage per ton for import cargo is usd12 per day. Based on this fee, total storage cost for total 7 days for 1x20 dv cntr with 20 tons will be usd1.680 (20x12x7). The cost of loading of pallets on truck to exit from port warehouse is usd10 per pallet. So total cost for total 20 pallets will be usd200.

The inland haulage fee in the market to final destination by local truck is 220 TL and 300 TL currently.

The cost of inland haulage of city containers from road C/D to final destination by using truck with elevator by a route as “Başakşehir, Sultangazi, Zeytinburnu, Beşiktaş, Şişli, Başakşehir” with a total 78 km, will be 92 TL.

The inland haulage of city containers from sea C/D to final destination in Zeytinburnu and Başakşehir will be done by electric motorbikes. So there will not be a fuel costs. The inland haulage of city containers from sea C/D to final destination in Sultangazi, Şişli and Beşiktaş will be done by barge to Beşiktaş and Eyüp piers. After unloading & loading operation, final leg will be executed by electric motorbikes. The only fuel costs will be sea leg with a total cost 71 TL.

The inland haulage of city containers from rail C/D to closest rail station will be done by TurKar vehicle. Rail stations will be Zeytinburnu & Başakşehir & Cebeci for final destination Zeytinburnu & Başakşehir & Sultangazi and Kabataş for final destinations Şişli & Beşiktaş. After unloading & loading operation at stations, final leg will be executed by electric motorbikes. The only fuel costs will be 134 TL for TurKar vehicle on rail & road route for total 113 km distance.

The cost for handling of city containers at C/Ds are calculated by the total salary cost of personnel and total number of city containers handled in a month. This cost is summarized at Table 7.

Table 7 : Cost of Handling of City Container at C/Ds

C/D Transport by	**Location**	**Total Personel**	**Total Salary Cost**	**Cost per Container**
Road	Başakşehir	4	5200 TL	260 TL
Rail	Halkalı	6	7800 TL	390 TL
Sea	Zeytinburnu	6	7800 TL	390 TL

For all calculations ratio for USD and TL is taken as 1 USD = 3 TL

VAT is not included in our calculations and summary of costs are listed in Table 8.

Table 8 : Summary Table

1 usd= 3 TL	CURRENT COST	COST BY CITY CONTAINER										
		by Road C/D			by Sea C/D				by Rail C/D			
VAT not included		Diesel	Hybrid	Electric	Diesel	Hybrid	Electric	Sea + Electric	Diesel	Hybrid	Electric	Rail + Electric
exit cost from port		195	195	195	195	195	195	195	195	195	195	195
inland haulage from port to C/D		330	330	330	109	109	109	109	330	330	330	330
unstuffing cost at port	360											
unstuffing cost at C/D		0	0	0	0	0	0	0	0	0	0	0
port w/h storage cost - 7 days	5040											
storage at C/D		0	0	0	0	0	0	0	0	0	0	0
exit cost from port w/h	600											
exit cost from C/D		0	0	0	0	0	0	0	0	0	0	0
inland haulage to Başakşehir - 3 tons	220											
inland haulage to sultangazi - 2 tons	220											
inland haulage to Zeytinburnu - 3 tons	220	81,26	94,95	22,01	75,60	72,26	14,56	92,57	75,60	94,13	22,35	129,48
inland haulage to Beşiktaş - 5 tons	300											
inland haulage to Şişli - 7 tons	300											
# of total personel at C/D		4	4	4	6	6	6	6	6	6	6	6
total cost per import container at C/D based on min salary 1300 TL		260	260	260	390	390	390	390	390	390	390	390
investment cost at C/D for land, equipment, vehicle		0	0	0	0	0	0	0	0	0	0	0
TOTAL COST - TL	7260	870,26	883,95	811,01	775,60	772,26	714,56	792,57	996,6	1015,13	943,35	1050,48
cost difference per container		6389,74	6376,05	6448,99	6484,4	6487,74	6545,44	6467,43	6263,4	6244,87	6316,65	6209,52
Annual Cost Benefit for total 240 cntrs		1.533.538	1.530.252	1.547.758	1.556.256	1.557.058	1.570.906	1.552.183	1.503.216	1.498.769	1.515.996	1.490.285

As seen at summary table, total profit for city containers for 3 options of C/D Operation is around 1.5 million TL. With such a huge annual profit, City Municipality, with its core aim to serve city people, can easly make relevant invesments to realize this project and also apply some discount for logistics cost for import commodity.

5.CONCLUDING REMARKS

In this study, as a new product “city container” for city logistics activities is evaluated and within an operatıın in Istanbul city the costs for fuel consumption and personnel are compared between standard operation and an operation with city container. In future studies this can be done for other cities all around the world.

A side benefit is that city container can be used for door to door shipments especially for end users. For such supply chain activites an important cost element “packaging” will be deleted. Especially cartoon box will not be needed and this cost will totaly be removed from the system. This will also minimize the handling cost since there will be less handlng activities since there will be no packaging. This will also maximize the duration of preparation of goods from manufacturing line to shipping line.

City container will minimize the risk of damage of goods compared to goods on standard pallets. Additionally with its stackability of two containers on each other it will maximize the usage of space in 20’ dv container compared to amorphous standard pallet which is not possible to load any other cargo on top.

City container will also be used for return logistics activities. Incase there is no return cargo, then it may be used as garbage collection box especially for dry garbages. This will be a mutli purpose product for city managers and all city logistics shareholders.

Enviroment friendly vehicles will be used for transportaton of city container. This will result with less GG emissions within the city. Especially using electric driven vehicles will effect city life positively. As a result city people will live in more healty land.

Within the city, city container zones can be decided. Especially within the city center area such zones and routes can be signed on roads for easy understanding and management. This will maintain a better tracking and management system for the freight distribution and collection.

Delivery time windows by city container can also be considered by night shifts so that such freight trafic will not have a negative effect on traffic congestion during daytime and rush hours.

City containers can be used for logistics activites in the Shopping Malls. It will minimize in & out time of freight to/from shopping malls. Electric motorbikes can directy go to shops by appropriate elevators without additional handling and freight acceptance ramps of shopping malls. This will speed up delivery times also.

Using city container in cities like Istanbul where sea route is available, is a new concept and this concept may force to have another new concept such as sea freight taxi like sea taxi for passengers.

The most important item for the success of city container concept and all other new ideas is to have a common aggreement between all logistics shareholders, since each shareholders has different goals and duties in city logistics system. The 3Cs, coordination and cooperation and communication between all logistics shareholders is utmost important to decide and execute a sustainable logistics solution.

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EVALUATING SUSTAINABLE CITY LOGISTIC SOLUTIONS USING INTUITIONISTIC FUZZY LINEAR PROGRAMMING

Elif Doğu[1], *Y. Esra Albayrak*[2]

Abstract *− City Logistics is defined as the process for optimizing the logistics and transport activities by private companies with support of advanced information systems in urban areas considering the traffic environment, the traffic congestion, the traffic safety and the energy savings within the framework of a market economy. The aim of this paper is to evaluate sustainable city logistics alternatives and select the best solution while considering the behavior of several stakeholders associated with urban freight transport. To reflect the decision maker's subjective preference information and to determine the weight vector of attributes, the linear programming technique for multidimensional analysis of preference (LINMAP) under intuitionistic fuzzy (IF) environments method is used. The case study of Istanbul, consisting of 4 alternatives and 12 decision criteria, is performed with five representatives of city logistics stakeholders. The best solution is determined as developing a rail system for urban freight transport in Istanbul which indicates that the LINMAP method under IF environments is applicable as an evaluation technique for sustainable city logistics solutions.*

Keywords − City Logistics, Intuitionistic Fuzzy Decision Making, LINMAP, MAGDM

INTRODUCTION

The logistic is one of the most important activity which affects city life with economic, social, safety and environmental aspects such as traffic congestion and traffic pollution. Alternative solutions are required to overcome the barriers that the city brings with itself. While we are looking for the best logistic solution for the cities, we also need to take the sustainability into the consideration to remain its attraction. Taniguchi et al. [1] defined the city logistic system as the process for optimizing the logistics and transport activities by private companies with support of advanced information systems in urban areas considering the traffic environment, the traffic congestion, the traffic safety and the energy savings within the framework of a market economy. In recent years, several studies have been conducted by researchers on city logistic solutions. Kjaersgaard et al. [2] outlines how sustainable city logistics solutions must be considered to develop accessible city centers. Anjali et al. [3] presented a hybrid approach based on Affinity Diagram, AHP and fuzzy TOPSIS for evaluating city logistics initiatives. Quak [4] gives several best practices and carrier initiatives that are actually brought in practice to improve city logistics. Stathopoulos et al. [5] propose an empirical analysis considering multiple stakeholders points of view which provides important inputs to improve freight policy design and analysis. The work by Maes et al. [6] deals with the use of bicycle messengers, also called bike couriers, in the modern logistics chain. Russo et al. [7] give an overview on the concept of city logistics sustainability and the measures to be implemented. Lindholm's work [8] investigates sustainable freight transport in urban areas from the perspective of the local authorities. Ehmke et al. [9] aim at the provision of time-dependent travel time data sets that can be incorporated in time-dependent vehicle routing models. Goldman et al. [10] discuss the concept and implementation of sustainable transport. Ruesch et al. [11] derive key factors and sustainability indicators to evaluate urban freight transport strategies. Muñuzuri et al. [12] develop a systematic model to estimate the transport of goods in a city, according to the particularities of its supply and demand. Taniguchi et al. [13] present a methodology for evaluating city logistics initiatives using a dynamic traffic simulation with optimal routing and scheduling. Crainic et al. [14] focus on the city logistics planning issue, the integrated short-term scheduling of operations and management of resources. Awasthi et al. [15] proposed a decision model for the collaboration partner selection for city logistics planning under municipal freight regulations. Pamucar et al. [16]

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employed a transport spatial decision model based on MCDM (multi-criteria decision making) method in order to optimize the green routes for city logistics centers. Rao et al. [17] incorporated sustainability concept into location selection problem of city logistics centers. Boutkhoum et al. [18] evaluated green logistics alternatives in large industrial areas of Casablanca city, Morocco. Perez et al. [19] reviewed the literature on MCDM applications of urban passenger transport systems.

Istanbul, the biggest city in Turkey which has nearly 14 million habitants, is growing fast and requires more freight movement than before; the "city logistic" concept is needed to be implemented to optimize the logistics and transport activities. With the objective of evaluating city logistics initiatives and select the best city logistics solution for Istanbul, we investigate a fuzzy linear programming technique (FLP) for multiple attribute group decision making (MAGDM) problems with preference information. In multiple attribute decision-making (MADM) problems, a decision maker (DM) is often faced with the problem of selecting, evaluation or ranking alternatives that are characterized by multiple, usually conflicting, attributes [20]. The linear programming technique for multidimensional analysis of preference (LINMAP) a MADM method and is based on pair-wise comparisons of alternatives given by decision makers and generates the best compromise alternative as the solution that has the shortest distance to the positive ideal solution (PIS) [21]. Since most of the MADM problems include both quantitative and qualitative attributes that use imprecise data and human judgments, crisp values are insufficient [22] [23] [24] [25] [26] [27]. The fuzzy LINMAP method, a linear programming model based on consistency and inconsistency indices of the preferences given by decision maker, is well suited to deal with such decision problems [28] [29] [30] [31] [32].

This paper offers an alternative instrument to fuzzy LINMAP for solving MADM problems which can be applicable to many real-life decision making problems such as sustainable city logistic solutions decisions. In this paper, to reflect the decision maker's subjective preference information and to determine the weight vector of attributes, the LINMAP under intuitionistic fuzzy (IF) environments is used and the alternatives are evaluated on qualitative attributes through using intuitionistic fuzzy sets (IFS) [33] [34] [35]. As IF set is an appropriate tool to capture the fuzziness in information, the LINMAP under IFSs describes the DM's preferences given through pair-wise comparisons with hesitancy degrees [35] [36] [37]. In the approach, the ranking order of alternatives for the group is generated using the Borda's social choice function [38].

ATTRIBUTES FOR THE EVALUATION OF CITY LOGISTIC SOLUTIONS

The impacts of logistic activities in urban areas are evaluated with 12 attributes. The high freight movements and congestion within city centers have economic, social, road safety perspectives and environmental impacts.

1. Economic attributes: The time delays caused by congestion translate to cost attributes by; **C1**: Increased travel times for the service providers, **C2**: Increased inventory carrying costs, **C3**: Lengthy "time-to-market" delays, **C4**: Higher transport costs. [39]

2. Social attributes: Social impacts are; **C5**: Traffic congestion: Noise, visual intrusion, and other quality of life issues, **C6**: Higher accident occurrence: Injuries and death resulting from traffic accidents and increased demand on social services to clear them and repair of infrastructure [39]-[40], **C7**: Loss of area: Loss of greenfield sites and open spaces in urban areas as a result of transport infrastructure developments.

3. Road Safety: The road safety attributes which have direct impact on the city logistics initiatives are [39]; **C8**: Road and vehicle design, **C9**: Traffic management and driver training

4. Environmental: Environmental impacts are; **C10**: High demand for fuel: As a result of large traffic volumes begins with the high demand for fuel, thus depleting our natural resources at a faster rate than they are replenished [39], **C11**: Pollution and emission rates (Pollutant emissions) - Physical consequences of pollutant emissions on public health (death, illness, hazards etc), **C12**: Threat to wild species - Use of non-renewable natural resources, waste products, oil and other materials and the loss of wildlife habitats and the associated threat to wild species [41].

THE SOLUTIONS IN CITY LOGISTIC

Solutions may change city by city according to geography, culture, political and financial circumstances, and other factors. However, the goal is consistent: reduce freight truck traffic in city centers without upsetting the economic viability of these areas. Based on the review of 106 initiatives, Quak [41] designed a structure to classify the urban freight transport sustainability initiatives based on the improving sustainability within the context (A) or by changing the context (B). Quak divides the each main initiative into two categories according to the stakeholder involvement. Class A initiatives aim to improve the sustainability with available infrastructure as road, vehicles, and warehouses. There are two categories of class A initiatives: (A1) policy initiatives and (A2) company driven initiatives. Policy initiatives are road pricing, vehicle restrictions, vehicle load factor controls, low emission zones and time-window. Company driven initiatives are carrier cooperation, vehicle routing improvement and technological innovations. [41] [42]. Class B initiatives mainly focus on rearranging the context to make transport more sustainable. The initiatives in class B are more radical and more difficult, expensive, and complex than class A initiatives. There are two categories of class B initiatives: (B1) physical infrastructure initiatives (the physical infrastructure which enables urban freight transport operations) and (B2) transport reorganizing initiatives [41] [43]. According to Taniguchi et al. [44], who emphasize that city logistics models should predict the behavior of the stakeholders and the consequences of their actions to each key stakeholder, there are four major stakeholders; shippers, freight carriers, residents and administrators. Each stakeholder had different goals and interest based on their own role. In this paper, a group of experts is created in Istanbul from five representatives of city logistics stakeholders; a logistic company manager as carrier (P1), a textile producer (P2) and a food wholesaler as shippers (P3), a resident (P4) and a governmental administrator (P5). The behavior of freight carriers could be considered as planning and implementing the delivery schedule of the trucks so as to minimize the transportation cost [45]. Shipper is the responsible for the goods to be delivered on time and decides the carrier for the distribution. The shipper finds the optimum way to transport its goods to the retailer or customers without affecting other stakeholders negatively with the competitive prices. Residents would demand a decrease at the negative social, economic and environmental effects of city logistics activities including less carbon emission, traffic pollution, large vehicle caused accidents and etc. are roughly divided into the higher governments and the regional and local authorities. Accessibility, congestion, quality of life, traffic safety, the protection of infrastructure and historical buildings, the reduction of emissions and noise are the main responsibilities of the governmental stakeholders [41].

LINMAP UNDER IF ENVIRONMENT METHODOLOGY FOR MAGDM PROBLEM

Definition of Intuitionistic Fuzzy Sets (IFSs)

IFSs were first introduced by Krassimir T. Atanassov in 1986 and were developed in 1999 [33] [34]. The concept of an intuitionistic fuzzy set (IFS) can be viewed as an alternative approach to define a fuzzy set in cases where available information is not sufficient for the definition of an imprecise concept by means of a conventional fuzzy set [46]. Let $X = \{x_1, x_2, \dots, x_n\}$ be a finite universal set. An IF set A in X is defined as: $A = \{\langle x_l, \mu_A(x_l), \upsilon_A(x_l)\rangle | x_l \in X\}$ with the functions; $\mu_A : X \to [0,1]$, $x_l \in X \to \mu_A(x_l) \in [0,1]$ and $\upsilon_A : X \to [0,1]$, $x_l \in X \to \upsilon_A(x_l) \in [0,1]$ defining the degree of membership ($\mu_A(x_l)$) and the degree of non-membership ($\upsilon_A(x_l)$) of the element $x_l \in X$ to the set $A \subseteq X$ and for every $x_l \in X$, $0 \le \mu_A(x_l) + \upsilon_A(x_l) \le 1$. In addition, $\pi_A(x_l) = 1 - \mu_A(x_l) - \upsilon_A(x_l)$ is Atanassov's intuitionistic fuzzy index, the degree of indeterminacy membership, of the element x_l in the set A and for every $x_l \in X$, $0 \le \pi_A(x_l) \le 1$.Distance between intuitionistic fuzzy sets was first introduced by Atanassov [34]. Let $A = \{\langle x_l, \mu_A(x_l), \upsilon_A(x_l)\rangle | x_l \in X\}$ and $B = \{\langle x_l, \mu_B(x_l), \upsilon_B(x_l)\rangle | x_l \in X\}$ be two IF sets in the set X. $\pi_A(x_l) = 1 - \mu_A(x_l) - \upsilon_A(x_l)$ and $\pi_B(x_l) = 1 - \mu_B(x_l) - \upsilon_B(x_l)$ are their IF indexes respectively. An Euclidean distance between IF sets A and B is [34] [37],

$$d(A,B) = \sqrt{\frac{1}{2}\sum_{l=1}^{n}[(\mu_A(x_l) - \mu_B(x_l))^2 + (\upsilon_A(x_l) - \upsilon_B(x_l))^2 + (\pi_A(x_l) - \pi_B(x_l))^2]} \quad (1)$$

MAGDM Problems using IFSs

Atanassov's IF sets are used in MADM problems by [35] [36] [47] [48]. Assume that there is a group consisting of P decision makers who have to rank n alternatives A_i based on m attributes C_j. Let that $A = \{A_1, A_2, \dots, A_n\}$ is an alternative set comprised of n alternatives and $C = \{C_1, C_2, \dots, C_m\}$ be the set of m attributes. Suppose that μ_{ij} and υ_{ij} are the degree of membership and non-membership of the alternative $A_i \in A$ with respect to the attribute $C_j \in C$. The evaluation of the alternative $A_i \in A$ with respect to the attribute $C_j \in C$ is an IFS. The intuitionistic indices $\pi_{ij} = 1 - \mu_{ij} - \upsilon_{ij}$ are the hesitation quantity of the decision maker where $0 \le \mu_{ij} + \upsilon_{ij} \le 1$, $\mu_{ij} \in [0,1]$ and $\upsilon_{ij} \in [0,1]$ are the degree of satisfaction and the degree of non-satisfaction, respectively. Let $D_i = (D_{i1}, D_{i2}, \dots, D_{im}) = (\langle\mu_{i1}, \upsilon_{i1}\rangle, \langle\mu_{i2}, \upsilon_{i2}\rangle, \dots, \langle\mu_{im}, \upsilon_{im}\rangle)$ be the vector of Atanassov's IFSs of all m attributes for alternative $A_i \in A$ where $D_{ij} = \langle\mu_{ij}, \upsilon_{ij}\rangle$ $(i = 1,2, \dots, n\,;\; j = 1,2, \dots, m)$ is an Atanassov's IFS. Then the MAGDM problem is defined in the matrix format;

$$D^p = \left(\langle\mu_{ij}^p, \upsilon_{ij}^p\rangle\right)_{n\times m} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_m \end{array} \\ \begin{pmatrix} \langle\mu_{11}^p, \upsilon_{11}^p\rangle & \langle\mu_{12}^p, \upsilon_{12}^p\rangle & \cdots & \langle\mu_{1m}^p, \upsilon_{1m}^p\rangle \\ \langle\mu_{21}^p, \upsilon_{21}^p\rangle & \langle\mu_{22}^p, \upsilon_{22}^p\rangle & \cdots & \langle\mu_{2m}^p, \upsilon_{2m}^p\rangle \\ \vdots & \vdots & \vdots & \vdots \\ \langle\mu_{n1}^p, \upsilon_{n1}^p\rangle & \langle\mu_{n2}^p, \upsilon_{n2}^p\rangle & \cdots & \langle\mu_{nm}^p, \upsilon_{nm}^p\rangle \end{pmatrix} \end{array}$$

D^p is an Atanassov's IF decision matrix for decision maker p and is used to represent the MAGDM problem under Atanassov's IF environment [35] [36].

Consistency and Inconsistency Measurements

Let A^+ be an Atanassov's IF positive ideal solution (IFPIS) represented by an IF set $A^+ = (\langle\mu_1^+, \upsilon_1^+\rangle, \langle\mu_2^+, \upsilon_2^+\rangle, \; , \langle\mu_m^+, \upsilon_m^+\rangle)$. It is unknown a priori and needs to be determined, where $A_j^+ = \{\langle\mu_j^+, \upsilon_j^+\rangle\} = \{\langle x_j, \mu_j^+, \upsilon_j^+\rangle\}$ $(j = 1,2, \dots, m)$ is an Atanassov's IF set on attribute C_j with $\pi_j^+ = 1 - \mu_j^+ - \upsilon_j^+$.Using Eq. (1), the square of the weighted Euclidean distance between the alternative i and the IFPIS A^+ can be calculated as

$$S_i^p = \sum_{j=1}^m \omega_j \left[d\left(D_{ij}^p, A_j^+\right)\right]^2 = \frac{1}{2}\sum_{j=1}^m \omega_j \left[\left(\mu_{ij}^p - \mu_j^+\right)^2 + \left(\upsilon_{ij}^p - \upsilon_j^+\right)^2 + \left(\pi_{ij}^p - \pi_j^+\right)^2\right]$$
(2)

where ω_j is the weight of each attribute $C_j \in C$ ($0 \le \omega_j \le 1$ and $\sum_{j=1}^m \omega_j = 1$), the vector of weights $\omega = (\omega_1, \omega_2, \dots, \omega_m)^T$ is unknown a priori and needs to be determined [35]. Assume that the decision maker gives her/his preferences between alternatives by $\Omega = \{(k,l) | A_k \rho A_l, (k,l = 1,2, \dots, n)\}$ from his/her knowledge and experience, where the symbol "ρ" is a preference relation given by the decision maker. Using Eq. (2) the decision maker can calculate the squares of the weighted Euclidean distance between each pair of alternative $(k,l) \in \Omega$ and the Atanassov's IFPIS as follows [35]. $S_k^p = \sum_{j=1}^m \omega_j \left[d\left(D_{kj}^p, A_j^+\right)\right]^2$and $S_l^p = \sum_{j=1}^m \omega_j \left[d\left(D_{lj}^p, A_j^+\right)\right]^2$

The alternative A_k is closer to the Atanassov's IFPIS than the alternative A_l if $S_l^p \ge S_k^p$. So the ranking order of alternatives A_k and A_l is determined by S_l^p and S_k^p based on (ω, A^+) which must be consistent with the preference given by the decision maker. (ω, A^+) should be properly chosen for consistency of the ranking order of alternatives A_k and A_l determined by S_l^p and S_k^p, and the preference provided by the decision maker [30]. To measure inconsistency between the ranking order of alternatives A_k and A_l, an index $\left(S_l^p - S_k^p\right)^-$ is defined as follows [35].

$$\left(S_l^p - S_k^p\right)^- = \begin{cases} S_k^p - S_l^p & (S_l^p < S_k^p) \\ 0 & (S_l^p \geq S_k^p) \end{cases} = \max(0, S_k^p - S_l^p) \tag{3}$$

$\left(S_l^p - S_k^p\right)^-$ is defined to be 0. The ranking order of alternatives A_k and A_l is inconsistent with the preferences given by the decision maker if $S_l^p < S_k^p$. [35].A total inconsistency index of the decision maker p is defined as

$$B^p = \sum_{(k,l)\in\Omega^p} \left(S_l^p - S_k^p\right)^- = \sum_{(k,l)\in\Omega^p} \max(0, S_k^p - S_l^p) \tag{4}$$

An index $\left(S_l^p - S_k^p\right)^+$ to measure consistency between the ranking order alternatives A_k and A_l and the preferences given by the decision maker preferring A_k to A_l can be defined as follows [30].

$$\left(S_l^p - S_k^p\right)^+ = \begin{cases} S_l^p - S_k^p & (S_l^p \geq S_k^p) \\ 0 & (S_l^p < S_k^p) \end{cases} = \max(0, S_l^p - S_k^p)$$

(5)

A total consistency index of the decision maker p is defined as

$$G^p = \sum_{(k,l)\in\Omega^p} \left(S_l^p - S_k^p\right)^+ = \sum_{(k,l)\in\Omega^p} \max(0, S_l^p - S_k^p) \tag{6}$$

The total inconsistency and consistency indices *B* and *G* are all IFSs.

LINMAP Model for MAGDM Using IFSs

Maximize $\left\{\sum_{p=1}^{P} \sum_{(k,l)\in\Omega^p} Z_{kl}^p\right\}$

subject to:

(7)

$$\begin{aligned}\sum_{j=1}^{m} w_j \sum_{p=1}^{P} \sum_{(k,l)\in\Omega^p} \left[\left(\mu_{lj}^{p^2} - \mu_{kj}^{p^2}\right) + \left(\upsilon_{lj}^{p^2} - \upsilon_{kj}^{p^2}\right) + \left(\pi_{lj}^{p^2} - \pi_{kj}^{p^2}\right) + 2\left(\mu_{lj}^{p} - \mu_{kj}^{p}\right) + 2\left(\upsilon_{lj}^{p} - \upsilon_{kj}^{p}\right)\right] \\ - \sum_{j=1}^{m} u_j \sum_{p=1}^{P} \sum_{(k,l)\in\Omega^p} \left[4\left(\mu_{lj}^{p} - \mu_{kj}^{p}\right) + 2\left(\upsilon_{lj}^{p} - \upsilon_{kj}^{p}\right)\right] \\ - \sum_{j=1}^{m} v_j \sum_{p=1}^{P} \sum_{(k,l)\in\Omega^p} \left[2\left(\mu_{lj}^{p} - \mu_{kj}^{p}\right) + 4\left(\upsilon_{lj}^{p} - \upsilon_{kj}^{p}\right)\right] \geq 2h\end{aligned}$$

$$\begin{aligned}\sum_{j=1}^{m} w_j \left[\left(\mu_{kj}^{p^2} - \mu_{lj}^{p^2}\right) + \left(\upsilon_{kj}^{p^2} - \upsilon_{lj}^{p^2}\right) + \left(\pi_{kj}^{p^2} - \pi_{lj}^{p^2}\right) + 2\left(\mu_{kj}^{p} - \mu_{lj}^{p}\right) + 2\left(\upsilon_{kj}^{p} - \upsilon_{lj}^{p}\right)\right] \\ - \sum_{j=1}^{m} u_j \left[4\left(\mu_{kj}^{p} - \mu_{lj}^{p}\right) + 2\left(\upsilon_{kj}^{p} - \upsilon_{lj}^{p}\right)\right] - \sum_{j=1}^{m} v_j \left[2\left(\mu_{kj}^{p} - \mu_{lj}^{p}\right) + 4\left(\upsilon_{kj}^{p} - \upsilon_{lj}^{p}\right)\right] + 2\,Z_{kl}^p \\ \geq 0 \;(k,l) \in \Omega^p, \qquad p = 1,2,\ldots,P\end{aligned}$$

$Z_{kl}^p \geq 0,\; (k,l) \in \Omega^p, \qquad p = 1,2,\ldots,P$

$u_j + v_j \leq w_j,\;\; u_j \geq 0,\; v_j \geq 0, \qquad j = 1,2,\ldots,m$

$\sum_{j=1}^{m} w_j = 1$

$w_j \geq \varepsilon, \qquad\qquad j = 1,2,\ldots,m$

where $\begin{cases} u_j = w_j \mu_j^* \\ v_j = w_j v_j^* \end{cases}$ (8)

When the problem is solved, the best values of $\langle \mu_j^*, v_j^* \rangle$ are calculated using Eq. (8)

CASE STUDY OF ISTANBUL

Solution Alternatives for City Logistics in Istanbul

There are specific solutions for each city logistics problem however some solutions can be suitable for more than one problem. In this study, four alternatives are considered as city logistics solutions for Istanbul.

(A1) Night Deliveries, Time Windows and Vehicle Weight Restrictions (Policy Initiative): Most of the local authorities plan and regulate urban freight transport with city regulations on the maximum allowed vehicle size, or weight, and delivery time-windows. In Istanbul there is not any regulation to prohibit peak time deliveries. Most of companies ship the goods during day. Big retailer stores have to receive the product at night or early in morning because of the size of deliveries. Local authorities need to regulate deliveries to take place at non traffic peak hours to eliminate small trucks from traffic as well.

(A2) Low Emission Deliveries (Company Driven Initiative): Hybrid, e-vehicles and bikes will not consume fuel; therefore they reduce NO^2, CO^2 or particles and noise. Their low range makes them feasible to be used in city logistics. Low fuel cost, low maintenance and repair cost are other reasons make them attractive.

(A3) Organizing Logistic Centers and the Integration of Logistics System (Physical Infrastructure Initiative): Logistic centers are collective of warehouses, customs, loading and off-loading areas, truck parks and benzene stations. They are located out of city but they have connections to main high ways and railways. The logistics centers cumulate the city's load density together and decrease the city's load traffic.

(A4) Developing Rail system for Urban Freight Transportation (Physical Infrastructure Initiative): Marmaray has been designed in order to serve for freight transport in the night time and for public transportation in the day time.

Numerical Application Steps

The aim of this application is to provide a LINMAP application extended with Atanassov's IF sets. The proposed method is currently applied to evaluate city logistics measures while considering the behavior of several stakeholders and the hesitations in the preferences of the decision makers. The degree of indeterminacy membership (π) represents the hesitations mathematically. Atanassov's IF sets are used to express the linguistic variables with terms using subjective judgments. The computational procedure is summarized as follows:

Step1: The experts, city logistics stakeholders, identify the evaluation attributes.
Step2: The experts, P_p (p=1,2,3,4,5) give their preference judgments between alternatives with paired comparisons as $\Omega^1=\{(1,2)\}$, $\Omega^2=\{(3,2)\}$, $\Omega^3=\{(4,2)\}$, $\Omega^4=\{(2,1)\}$, $\Omega^5=\{(3,4)\}$. Here (1,2) stands for 1 is preferred to 2 and (3,2) denotes 3 is preferred to 2.
Step 3: The experts use the linguistic variables (shown in Table 1) to evaluate the rating of alternatives with respect to each attributes.

Table 19. Linguistic Variables and Corresponding IFSs

Very Poor (VP)	$\langle 0.05, 0.95 \rangle$
Poor (P)	$\langle 0.25, 0.7 \rangle$
Fair (F)	$\langle 0.5, 0.4 \rangle$
High (G)	$\langle 0.7, 0.25 \rangle$
Very High (VH)	$\langle 0.95, 0.05 \rangle$

Step 4: Obtain the data and ratings of all alternatives A_i (*i=1,2,3,4)* on every attribute C_j (*j=1,…12*) given by five expert P_p *(p=1,2,3,4,5)* as in Table 2.

Table 2. Decision information and ratings of the four alternatives

	Attributes	***Alternatives***	***Decision Makers*** P_1	P_2	P_3	P_4	P_5
Economic	C_1 travel times	A_1	VH	H	H	H	VH
		A_2	VP	VP	VP	VP	VP
		A_3	VH	H	H	F	VH
		A_4	H	H	H	VH	H
	C_2 carrying costs	A_1	F	F	P	F	P
		A_2	VP	VP	P	F	VP
		A_3	VH	VH	H	H	VH
		A_4	H	F	F	H	F
	C_3 delays	A_1	H	H	H	F	VH
		A_2	VP	VP	VP	P	P
		A_3	VH	H	H	H	VH
		A_4	VH	H	H	VH	H
	C_4 transport costs	A_1	VH	VH	VH	VH	VH
		A_2	VP	VP	VP	VP	VP
		A_3	VH	VH	VH	H	VH
		A_4	VH	VH	VH	VH	VH
Social	C_5 Traffic congestion	A_1	VH	H	H	P	F
		A_2	H	H	F	VH	H
		A_3	VH	VH	VH	F	VH
		A_4	VH	VH	VH	VH	VH
	C_6 accident occurrence	A_1	VH	H	H	H	VH
		A_2	VP	VP	VP	VP	VP
		A_3	H	H	VH	F	VH
		A_4	VH	VH	H	H	H
	C_7 Loss of area.	A_1	VP	P	P	P	P
		A_2	VP	VP	VP	P	VP
		A_3	H	H	F	F	H
		A_4	VH	H	H	VH	VH
Road Safety	C_8 design	A_1	H	H	VH	VH	VH
		A_2	P	P	P	VP	VP
		A_3	F	H	F	F	H
		A_4	VH	VH	VH	VH	H
	C_9 driver training	A_1	VH	VH	H	H	VH
		A_2	P	P	VP	VP	VP
		A_3	F	H	H	H	F
		A_4	H	H	H	VH	VH
Environmental	C_{10} fuel demand	A_1	VH	VH	H	VH	VH
		A_2	VH	H	F	H	H
		A_3	F	P	F	H	H
		A_4	VH	VH	VH	VH	VH
	C_{11} Pollutions	A_1	VH	VH	H	H	VH
		A_2	VH	VH	VH	VH	VH
		A_3	H	H	H	F	VH
		A_4	VH	VH	VH	VH	H

C12 Threat to wild species	*A1*	F	F	P	P	F
	A2	VH	VH	VH	VH	VH
	A3	F	F	P	F	F
	A4	VH	VH	VH	VH	VH

Step 5: Construct the decision matrices D^p using IF sets for each expert. Table 3 is for the expert P_1. In the same vein, construct the matrices D^2, D^3, D^4 and D^5 for the experts P_2 , P_3 , P_4 and P_5. The columns are $\mu_{ij}, v_{ij}, \pi_{ij}$ values respectively of the alternative i for the attribute j.

Table 3. IF sets decision matrix for expert $\mathbf{P_1}$ ($\mathbf{D^1}$)

	C1			**C2**			**C3**			**C4**			**C5**			**C6**		
A1	0,95	0,05	0,0	0,5	0,4	0,1	0,7	0,25	0,05	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0
A2	0,05	0,95	0,0	0,05	0,95	0,0	0,05	0,95	0,0	0,05	0,95	0,0	0,7	0,25	0,05	0,05	0,95	0,0
A3	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0	0,7	0,25	0,05
A4	0,7	0,25	0,05	0,7	0,25	0,05	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0

	C7			C8			C9			C10			C11			C12		
A1	0,05	0,95	0,0	0,7	0,25	0,05	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0	0,7	0,25	0,05
A2	0,05	0,95	0,0	0,25	0,7	0,05	0,25	0,7	0,05	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0
A3	0,7	0,25	0,05	0,5	0,4	0,1	0,5	0,4	0,1	0,7	0,25	0,05	0,7	0,25	0,05	0,7	0,25	0,05
A4	0,95	0,05	0,0	0,95	0,05	0,0	0,7	0,25	0,05	0,95	0,05	0,0	0,95	0,05	0,0	0,95	0,05	0,0

Step 6: Construct the linear programming model Eq. (7)
Maximize $z_{12}^1 + z_{32}^2 + z_{42}^3 + z_{21}^4 + z_{34}^5$
subject to
0,11w1 + 0,00w2 - 0,57w3 - 0,34w4 - … - 0,80v9 - 1,40v10 - 0,95v11 + 0,30v12 ≤ -1
0,45w1 + 0,69w2 + 0,00w3 + 0,00w4 + … + 1,20v9 + 0,90v10 - 1,30v11 + 0,30v12 $-2\, z_{12}^1 \le 0$

-0,45w1 - 0,45w + 0,45w3 + 0,69w4 + … - 0,30v9 + 0,00v10 + 1,50v11 - 0,30v12 $-2\, z_{32}^1 \le 0$
0,24w1 - 0,24w2 + 0,24w3 + 0,24w4 + … + 0,00v9 + 1,20v10 + 1,20v11 - 0,30v12 $-2\, z_{42}^2 \le 0$
-0,45w1 - 0,69w2 + 0,00w3 + 0,00w4 + … - 0,50v9 + 0,50v10 + 1,80v11 - 0,30v12 $-2\, z_{21}^3 \le 0$
0,00w1 + 0,69w2 + 0,45w3 - 0,24w4 + … + 1,20v9 + 0,20v10 - 1,30v11 + 0,00v12 $-2\, z_{34}^4 \le 0$
$-\omega_j + u_j + v_j \le 0$, $\sum_{j=1}^{12} \omega_j = 1$, $\omega_j \ge 0.01$ $(j = 1,2, \dots ,12)$
$z_{12}^1 \ge 0, z_{32}^2 \ge 0,\ z_{42}^3 \ge 0,\ z_{21}^4 \ge 0,\ z_{34}^5 \ge 0$

Step 7: Solve linear programming problem: To obtain the best weights and the IF Positive Ideal Solution (IFPIS), taking $h = 1.0$ and using D^p and Ω^p, solve Eq. (7). By solving linear programming problem, using MATLAB R11 on a Pentium IV PC with a 3 GHz CPU and 4 GB RAM, these results are obtained:

$\omega = (\omega_1, \omega_2, \dots \omega_{12}) = (0.07, 0.08, 0.21, 0.03, 0.14, 0.17, 0.12, 0.03, 0.07, 0.05, 0.03)$

$$u = (u_1, u_2, \ldots, u_{12})$$
$$= (0.012, 0.059, 0.002, 0.030, 0.003, 0.024, 0.004, 0.019, 0.027, 0.005, 0.002, 0.085)$$

$$v = (v_1, v_2, \ldots, v_{12})$$
$$= (\ 0.025, 0.038, 0.055, 0.003, 0.043, 0.034, 0.103, 0.070, 0.004, 0.028, 0.074, 0.054)$$

Using w, u and v values with Eq. (8), the IFPIS set is calculated: $A^{+} = \{\langle \mu_j^{+}, \upsilon_j^{+} \rangle\ (j = 1,2, \ldots, 12)\} = \{\langle 0.37,0.33 \rangle, \langle 0.16,0.66 \rangle, \ldots\ , \langle 0.03,0.91 \rangle\}$

Step 8: Calculate the square of the weighted Euclidean distance S_i^p between each pair of alternative, D_i^p, and the fuzzy positive ideal solution, A^{+}. The results are obtained using Eq. (1) and shown in Table 4.

Table 4. Weighted Euclidean Distances

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{array}{ccccc} P_1 & P_2 & P_3 & P_4 & P_5 \end{array} \\ \begin{pmatrix} 1.46 & 1.45 & 1.48 & 1.42 & 1.52 \\ 1.43 & 1.42 & 1.42 & 1.41 & 1.44 \\ 1.48 & 1.49 & 1.44 & 1.44 & 1.48 \\ 1.50 & 1.50 & 1.59 & 1.49 & 1.43 \end{pmatrix} \end{array}$$

Table 5. Borda's scores

	P_1	P_2	P_3	P_4	P_5	Borda's Score
A_1	1	1	2	1	3	**8**
A_2	0	0	0	0	1	**1**
A_3	2	2	1	2	2	**9**
A_4	3	3	3	3	0	**12**

According these distances, the ranking orders of the four alternatives for the five experts are as follows: For P_1: $A_4 \rho A_3 \rho A_1 \rho A_2$ (Symbolizing "the expert P_1 prefers A_4 to A_3" by $A_4\, \rho\, A_3$) . For P_2: $A_4 \rho A_3 \rho A_1 \rho A_2$. For P_3: $A_4 \rho A_1 \rho A_3 \rho A_2$.For P_4: $A_4 \rho A_3 \rho A_1 \rho A_2$.For P_5: $A_1 \rho A_3 \rho A_2 \rho A_4$.

Step 9: The group ranking order of all alternatives can be obtained using social choice functions such as Borda's function [38] as shown in Table 5. The ranking order of the four alternatives is A4, A3, A1 and A2 according to the Borda's scores. In this study, with IF sets tool, the best city logistic solution for Istanbul is determined as developing rail system for urban freight transportation. This city logistic solution is a physical infrastructure initiative.

CONCLUSION

The logistic is one of the most important activity which affects city life with economic, social, safety and environmental aspects such as traffic congestion and traffic pollution. The aim of this paper is to evaluate city logistics initiatives and select the best city logistics solution while consiring the behavior of several stakeholders associated with urban freight transport. This study searches the answers of questions why city logistic is required to be implement to Istanbul, and what the most suitable solutions for Istanbul are. Since the evaluation of city logistic initiatives is a MCDM problem and considers the imprecise judgments of decision makers, the LINMAP under Atanassov's IF environment, which is a multi-attribute group decision making technique, is used to evaluate of different alternatives. IF sets are used to capture the fuzziness in decision information and describe the decision makers preferences given through pair-wise comparisons with hesitancy degrees. This method is a fuzzy prioritization method based on an optimization problem with linear constraints, considering the imprecise judgments of decision-makers which model the uncertainty with fuzzy numbers and use paired comparison judgments directly to derive crisp priorities. In the application, Borda's social choice function is used to determine the ranking orders of alternatives.

In this paper, the use of FLP to city logistic planning has been discussed and this approach to city logistics problems has not yet been appeared in the literature. The usefulness of the model was observed by its effect on the decision-making process in selecting an appropriate alternative and the case study shows that the LINMAP model under IF environment is applicable as an evaluation technique for city logistic initiative alternatives. The current fuzzy linear programming model offers the decision maker some flexibility to incorporate his/her own priority in the model. Consequently, city managers can use such approaches in making their strategic decisions in case of incomplete information and vagueness.

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AN INTEGRATED FUZZY DECISION APPROACH FOR SELECTING SHIPS IN MARITIME LOGISTICS

Michele CEDOLIN[1], Zeynep SENER[2]

Abstract *–Ship selection decisions are critical for efficiently managing maritime logistics operations. This paper proposes an integrated multiple criteria decision making framework to evaluate ships in maritime transportation. The proposed approach combines fuzzy regression, 2-tuple linguistic representation model and fuzzy goal programming methodologies. Due to the fact that the relationships between ship characteristics are vague and imprecise, fuzzy regression can be employed in ship selection problem. Linguistic assessments are used to incorporate the imprecise judgments inherent in ship evaluation process.*

Keywords–Fuzzy goal programming, fuzzy regression, linguistic variables, maritime transportation.

INTRODUCTION

Maritime logistics systems become more and more important since they allow companies to transport large amount of cargo between distant locations in a cost effective manner. Ship evaluation and selection is one of the key issues faced by managers to increase the competitive advantage in the marketplace.

The process of evaluating ships in maritime transportation is complicated by the fact that a number of conflicting criteria must be considered in the modeling phase, and by the existence of uncertainty and subjectivity [1]. Hence, multiple criteria decision making (MCDM) approaches can be used to obtain an effective solution for a ship selection problem [1]. The number of research papers using MCDM techniques for ship selection is very limited. Xie et al. [2] present a method based on the evidential reasoning approach to select a preferred ship. Yang et al. [3] use approximate TOPSIS for reliable vessel selection under uncertainty. An intelligent decision support system for the ship selection process is proposed by Wibowo and Deng [1]. In addition to these researches, the critical criteria to be considered in a ship evaluation and selection problem can be found by analyzing previous papers concerning operational reliability assessment of maritime transportation system [4] and maritime risk assessment [5-6].

In this study, a multiple criteria decision making approach is developed for solving ship evaluation problems. The proposed approach uses fuzzy regression in order to define relationships between ship selection criteria. These regression equations constitute goals for a fuzzy goal programming model. The desirable achievement degrees of fuzzy goals are determined by using 2-tuple linguistic representation model. The rest of the paper is organized as follows: the following section presents fuzzy regression methodology. Concise information on fuzzy goal programming is given in Section 3. Section 4 delineates the proposed fuzzy MCDM approach. The application of the integrated decision making framework is provided in Section 5. Conclusions are given in Section 6.

FUZZY REGRESSION

Fuzzy regression, which firstly introduced by Tanaka et al. [7], aims to model a fuzzy phenomenon by a fuzzy functional relationship [8].

Tanaka et al. [7] delineated a fuzzy linear regression function as

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$$\tilde{y}_i^* = \tilde{A}_0 + \tilde{A}_1 x_{i1} + \tilde{A}_2 x_{i2} + \ldots + \tilde{A}_N x_{iN}$$
(1)

Fuzzy parameters are assumed to be symmetric triangular fuzzy numbers in order to make the model simpler. The problem addressed in the fuzzy linear regression model is to determine fuzzy parameters estimates $\tilde{A} = \{(m_0, m_1, \ldots, m_N), (s_0, s_1, \ldots, s_N)\}$ where m_j and s_j represent respectively the center and spread of fuzzy number, such that the membership value of the dependent variable y_i to its fuzzy estimate $\tilde{y}_i^*$ is at least H which is selected by the decision-maker [9]. The objective of the fuzzy linear regression analysis is to minimize the total fuzziness of the predicted values for the dependent variables. This problem leads to the following linear programming model [10]:

$$\text{Min } Z = \sum_{j=0}^{N} \left(s_j \sum_{i=1}^{M} |x_{ij}| \right)$$
(2)

subject to

$$\sum_{j=0}^{N} m_j x_{ij} + |L^{-1}(H)| \sum_{j=0}^{N} s_j |x_{ij}| \geq y_i \text{ , } i = 1, 2, \ldots, M,$$

$$\sum_{j=0}^{N} m_j x_{ij} - |L^{-1}(H)| \sum_{j=0}^{N} s_j |x_{ij}| \leq y_i \text{ , i} = 1, 2, \ldots, M,$$

$x_{i0} = 1$, $i = 1, 2, \ldots, M$,

$s_j \geq 0$, $j = 0, 1, \ldots, N$

where L is equal to $L(x) = \max(0, 1 - |x|) \rightarrow |L^{-1}(H)| = (1 - H)$.

In this paper fuzzy linear regression is employed for modeling vague relationships between ship characteristics.

FUZZY GOAL PROGRAMMING

Goal programming (GP) is a multi-objective optimization tool which deals simultaneously with conflicting objective measures for MCDM problems. GP is first employed by Charnes et al. [11] and GP model are developed and detailed by numerous authors [12, 13, 14, 15]. However, in real-life problems, certainty and deterministic information is not always available and there exist certain kind of uncertainty associated with linguistic or intuitive information and to incorporate the imprecision, fuzzy sets are used [16, 17, 18]. In the literature, satisfaction degrees, goal deviations and threshold values are employed in order to reformulate the GP models for fuzzy environments and fuzzy goal programming models (FGP) appeared [19]. In this study, the linear membership function of Zimmerman [20] is adapted, the membership function is as follows:

$$\mu_i = \begin{cases} 1 & \text{if } G_i(x) \geq g_i, \\ \dfrac{G_i(x) - L_i}{g_i - L_i} & \text{if } L_i \leq G_i(x) \leq g_i, \\ 0 & \text{if } G_i(x) \leq L_i, \end{cases} \tag{3}$$

or

$$\mu_i = \begin{cases} 1 & \text{if } G_i(x) \leq g_i, \\ \dfrac{U_i(x) - G_i(x)}{U_i - g_i} & \text{if } g_i \leq G_i(x) \leq U_i, \\ 0 & \text{if } G_i(x) \geq U_i, \end{cases} \tag{4}$$

where L_i is the lower tolerance limit, U_i is the upper tolerance limit for the i^{th} fuzzy goal and g_i is the aspiration level. The simple additive fuzzy goal programming model [21] is as:

$$\textit{Maximize} \qquad f(\mu) = \sum_{k=1}^{n} \mu_k \tag{5}$$

$$\begin{aligned} \text{subject to} \qquad & \mu_i = \frac{G_i(x) - L_i}{g_i - L_i} \quad \text{for some } i, \\ & \mu_j = \frac{U_i - G_i(x)}{U_i - g_i} \quad \text{for some } j, \quad j \neq i, \\ & \mathrm{A}x \leq b, \\ & \mu_i, \mu_j \leq 1, \\ & x, \mu_i, \mu_j \geq 0; \qquad i, j \in \{1, \ldots, n\}, \end{aligned}$$

where $\mathrm{A}x \leq b$ are the crisp system constraints and μ_i, μ_j are the goal's achievement degree.

PROPOSED FUZZY MCDM FRAMEWORK

In this study, the criteria determined to evaluate and select ships are reliability and cost. The decision makers, from a list of factors that affect the reliability [4], decided that the age of the ship, the technological condition of the ship and the duration of detentions (history of the ship) are the independent variables of the regression analysis. As the relationships between these variables are vague and imprecise, a fuzzy linear regression model is built to relate reliability to age of the ship (X_1), technological condition (X_2), and duration of detentions (X_3) using previous reliability assessments of decision makers about the ships that transported merchandises for the company. Likewise, a fuzzy regression equation is developed to define the relationship between cost and age of the ship.

The obtained fuzzy equations are employed to develop a fuzzy goal programming model. For each fuzzy goal, a desirable achievement degree is determined as in [21]: the more important the goal, the higher the desirable achievement degree. This paper uses 2-tuple linguistic representation model to define the importance of the fuzzy goals. The fuzzy 2-tuple linguistic approach allows making computations with linguistic values without loss of information [22].

ILLUSTRATIVE PROBLEM

The ship selection problem considered in here uses hypothetical data. Data sets given in Table 1 and Table 2 are used to obtain fuzzy regression equations. The reliability and the cost of ships reflect the subjective assessments of experienced decision makers.

Table 20. Data Related to Reliability

	Age of the ship	Technological condition	Duration of detentions	Reliability
Ship 1	10	80	3	77
Ship 2	27	60	6	60
Ship 3	5	90	1	93
Ship 4	16	75	8	72
Ship 5	21	75	7	68

Table 2. Data Related to Cost

	Age of the ship	Cost ($/ton)
Ship 1	10	20
Ship 2	27	17
Ship 3	5	25
Ship 4	16	19
Ship 5	21	18

Table 3. Importance of Fuzzy Goals

	Decision maker 1	Decision maker 2	Resulting importance
Goal 1 (Reliability)	H	H	(H, 0)
Goal 2 (Age)	M	L	(M, -0.5)
Goal 3 (Cost)	VH	VH	(VH, 0)

The resulting predictive equations obtained by using fuzzy linear regression formulation (2) are as follows:

Reliability = $-0.087*X_1 + 0.839*X_2 - 1.000*X_3 + 16.174$
(6)
Cost = $-0.364*X_1 + 25.227$
(7)

The ship evaluation problem with three fuzzy goals, namely; reliability, age of the ship and cost is developed. Their tolerances are 10, 5 and 3, respectively.

G1: $-0.087*X_1 + 0.839*X_2 -1.000*X_3 \geq 63.826$ (for a minimum of %80 reliability)
G2: $X_1 \leq 10$
G3: $0.364*X_1 \geq 5.227$ (for a maximum cost of 20$/ton)

The importance of the goals are determined using the linguistic term set (where DL: (0, 0, 0.16), VL: (0, 0.16, 0.33), L: (0.16, 0.33, 0.50), M: (0.33, 0.50, 0.66), H: (0.50, 0.66, 0.83), VH: (0.66, 0.83, 1), DH: (0.83, 1, 1)) which is shown in Figure 1. According to the data which is shown in Table 3, goal 3 is more important than goal 1, and goal 1 is more important than goal 2. The resulting achievement degrees for three fuzzy goals are 0.735, 0.400 and 0.835, respectively with X_1 = 13.000, X_2 = 80.223, and X_3= 5.

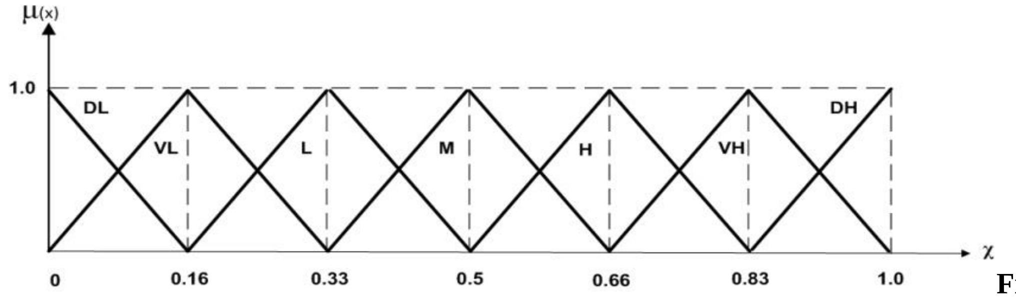

Figure 1. Linguistic Term Set

CONCLUSIONS

This study presents a multiple criteria decision making approach solving ship evaluation problems. The proposed approach uses fuzzy regression in order to define relationships between ship selection criteria. These regression equations constitute goals for a fuzzy goal programming model. The desirable achievement degrees of fuzzy goals are determined by using 2-tuple linguistic representation model. Future research will focus on using different fuzzy decision making methodologies for solving ship evaluation and selection problems with real data.

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DATA ENVELOPMENT ANALYSIS AND MALMQUIST INDEX APPLICATION FOR LOGISTICS PERFORMANCE EVALUATION OF COUNTRIES

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Abstract − *Commerce is an important factor for the development of countries in the global world. One of the indicators related to trade volume is logistic operations. It can be say that countries which operate more logistics operations have more trade volume and countries which operate less logistics operations have less trade volume. Moreover, countries' logistics operations performances are measured periodically. But performance measurement is not enough for evaluation of logistics operations. Therefore, efficiency of logistics performances should be analyzed. In this study data envelopment analysis is used in order to examine logistics performances of 10 OECD (Organization for Economic Co-operation and Development) countries. Logistic performance score efficiency is measured by using CCR model and two inputs related to logistic operations taken into consideration. Additionally, Malmquist index is calculated to investigate total factor productivity change between 2010, 2012 and 2014 years. Results of efficiency analysis and Malmquist index scores can be used to determine the way in improving logistics performance score.*

Keywords − *Logistic operations, data envelopment analysis, logistic performance, Malmquist index.*

INTRODUCTION

In a globalizing world, the importance of trade activities is increasing with each passing day. Logistics and commercial activities are interrelated issues. Hence remaining local is not enough for most companies. Therefore, the importance of logistics activities has increased substantially. Because of interrelation of logistics and commerce, volume of logistics activities can give an idea about trading volume.

Evaluation of the efficiency of logistics operations is important to an understanding of the volume of commercial activity. Effectiveness analysis is performed to measure and improve efficiency. Data Envelopment Analysis is one of the outstanding techniques for efficiency analysis. Data Envelopment Analysis method is used commonly for measurement of effectiveness in the same input and output systems. It should be examined annually the volume change in the logistics activities for monitoring the development of commercial activities.

In the past literature, there are a considerable number of studies about DEA approaches to evaluate the efficiency in logistics. Data envelopment analysis used by Holden et al. [1] to measure of greenhouse gas related logistics activity. They utilized variable-returns-to-scale (VRS) model for their purpose. Relationship between transport logistics performance and CO2 emissions from transport sector is analyzed with window analysis and Malmquist index methods [2]. Lee et al. used a slacks-based data envelopment analysis (SBM-DEA) for environmental efficiency evaluation of port cities [3]. Network Data Envelopment Analysis (NDEA) is used for measurement of aeronautical service efficiency and commercial service efficiency of East Asia airport companies [4]. Green supply chain management is evaluated by using of Novel network DEA Model [5]. Lau analyzed a part of the retail network of a major retailer in Australia [6]. Transportation costs and sales data are used for measurement and Charnes, Cooper and Rhodes (CCR), Banker, Charnes and Cooper (BCC) models are utilized. Constant return to scale (CRS) model of Charnes, Cooper, and Rhodes (CCR) technique is used for evaluation the efficiency of genetic algorithms on solving the vehicle routing problem [7]. Route-based CCR (RCCR) model and route-based BCC (RBCC) model are proposed by Chiou et al. for measurement the route-level and company-level efficiencies amongst transport carriers [8]. Fourteen large logistics provider services in Korea are evaluated with CCR model, BCC model, Window Analysis, Malmquist

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Analysis techniques [9]. Bray et al. measured efficiency of sixteen international container ports with a fuzzy input as delay time [10]. They used fuzzy CCR model to measure efficiency.

In this study, data envelopment analysis is used to analyze logistics performances of 10 OECD (Organization for Economic Co-operation and Development) countries. In this purpose, CCR model and Malmquist index have utilized. The rest of the paper is organized as follows. Section 2 gives a brief information about CCR Model and Malmquist Index. A case study including 10 OECD countries is conducted in Section 3. The study is completed by presenting conclusions and research directions for further studies in the fourth section.

CCR MODEL

The first of the basic DEA model developed in 1978 by Charnes, Cooper and Rhodes. This model which is known as CCR is based on the scale constant returns hypothesis. Output-oriented CCR model is mathematically expressed by the following linear programming model [11].

$$
\begin{aligned}
& Maxh_j = \sum_{r=1}^{n} u_r y_{rj} \\
& \sum_{i=1}^{m} v_i x_{ij} = 1 \\
& \sum_{r=1}^{n} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \geq 0 \\
& u_r, v_i \geq 0
\end{aligned} \tag{1}
$$

Output-oriented CCR model tries to determine maximum output level with constant input amount for j decision making unit. On the other hand, input-oriented CCR model tries to find minimum input level with constant output level. m is number of inputs; n is number of outputs; vi is decision variables for inputs; ur is decision variable for outputs; xij is the value of ith input in terms of jth decision making unit and yrj is the value of rth output in terms of jth decision making unit. Linear programming model of input-oriented CCR is as follows:

$$
\begin{aligned}
& Ming_j = \sum_{i=1}^{m} v_i x_{ij} \\
& \sum_{r=1}^{n} u_r y_{rj} = 1 \\
& -\sum_{r=1}^{n} u_r y_{rj} + \sum_{i=1}^{m} v_i x_{ij} \geq 0 \\
& u_r, v_i \geq 0
\end{aligned} \tag{2}
$$

In the first place of data envelopment analysis is to determine decision points, inputs and outputs. Then it is determined that the analysis will be input-oriented or output-oriented and model runs. Thus efficiency values have been evaluated for all decision making units. Decision making units which have efficiency values 1 are named as efficient decision making units. On the other hand, decision points which not equal to 1 called as inefficient decision making units. The rule for determining decision variable number is using $J \geq 3(n+m)$ equation, while J is decision point number; m is input number and n is output number.

MALMQUIST INDEX

Malmquist Total Factor Productivity Index measures the change in total factor productivity between the two data points, while calculating the ratio of the difference of each data point based on a common technology. Malmquist Total Factor Productivity Index is calculated by the following formula [12].

$$M_o\left(x^t, y^t, x^{t+1}, y^{t+1}\right) = \sqrt{\left[\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)} \times \frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^t, y^t\right)}\right]} \tag{3}$$

Malmquist index is the geometric average of the changes in technology between period t and period (t+1) and the changes in technical efficiency between period t and period (t+1). Technical efficiency change refers to the degree of decision-making units closer to the efficient frontier. Additionally, technological change refers to the change of the efficient frontier. Changes in technical efficiency and technology change formulas are given below:

$$Changes\,in\,Efficiency = \frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)} \tag{4}$$

$$Changes\,in\,Technology = \sqrt{\left[\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)} \times \frac{D_o^t\left(x^t, y^t\right)}{D_o^{t+1}\left(x^t, y^t\right)}\right]} \tag{5}$$

CASE STUDY

In this study logistics performances of 10 OECD countries are analyzed by DEA. CCR model has used to measure logistic performance index efficiency. Additionally, Malmquist index is calculated to determine total factor productivity change between 2010, 2012 and 2014 years. Countries that taken into consideration in this study are Austria, Bulgaria, Croatia, Czech Republic, France, Germany, Hungary, Romania, Serbia and Slovakia. Input variables are taken as railway transportation volume and inner water lines transportation volume and output variable of this analysis is defined as logistic performance index of the country. These data are obtained from World Bank's database of World Development Indicators [13] and International Transport Forum's Key Transport Statistics Reports [14- 16] and given in Table 1 as follows:

Table 21. Data for the efficiency analysis

Country	Goods Transport by Railway (million T-km)			Goods Transport by Inland Waterways (million T-km)			Logistics Performance Index		
	2010	2012	2014	2010	2012	2014	2010	2012	2014
Austria	14166	21582	14413	2375	2192	1707	3.76	3.89	3.65
Bulgaria	3063	2907	3439	580	425	407	2.83	3.21	3.16
Croatia	2613	2346	2119	56	42	42	2.77	3.16	3.05
Czech Republic	13868	14268	14526	42	37	27	3.51	3.14	3.49
France	30110	32171	32209	8059	7738	7737	3.84	3.85	3.85
Germany	107317	110065	112628	57511	53949	59093	4.11	4.03	4.12
Hungary	8799	9023	10126	28388	1955	1508	2.99	3.17	3.46
Romania	12373	9977	11693	14317	9544	8436	2.84	3.00	3.26
Serbia	3521	2769	2987	876	605	759	2.69	2.80	2.96
Slovakia	7932	7262	7319	819	753	693	3.24	3.03	3.25

By considering the structure of input and output data, it is expected for a country to have higher logistics performance index value with the same input levels. Hence, under constant return to scale assumption output oriented data envelopment analysis is much suitable for this analysis. The data given in Table 1 is written into DEAP package software to measure efficiency scores of countries. Efficiency values are given in Table 2 as follows:

Table 2. Efficiency analysis results

Country	2010	2012	2014	Mean
Austria	0.250	0.134	0.176	0.186
Bulgaria	0.872	0.820	0.638	0.777
Croatia	1.000	1.000	1.000	1.000
Czech Republic	1.000	1.000	1.000	1.000
France	0.120	0.089	0.083	0.097
Germany	0.036	0.027	0.025	0.029
Hungary	0.321	0.261	0.237	0.273
Romania	0.217	0.223	0.194	0.211
Serbia	0.721	0.751	0.688	0.720
Slovakia	0.385	0.310	0.309	0.335

Croatia and Czech Republic are seen as the efficient countries in terms of logistics performance index in all time periods of this analysis. Germany is the least efficient country at evaluation of logistics performance index in terms of inland waterway and railway transportation volumes.

Malmquist index values for efficiency change between 2010 and 2012 are given in Table 3 and 2012 – 2014 are given in Table 4, respectively. Total efficiency change is given in TEC column, technical change is given in TC column, pure efficiency change is given in PEC column, scale efficiency change is given in SEC column and total factor efficiency change is given in TFEC column.

Table 3. Malmquist index results for efficiency change between 2010 and 2012

Country	TEC	TC	PEC	SEC	TFEC
Austria	0.534	1.271	1.000	0.534	0.679
Bulgaria	0.941	1.271	1.000	0.941	1.195
Croatia	1.000	1.375	1.000	1.000	1.375
Czech Republic	1.000	1.006	1.000	1.000	1.006
France	0.739	1.271	0.986	0.749	0.938
Germany	0.752	1.271	1.000	0.752	0.956
Hungary	0.814	1.271	1.023	0.795	1.034
Romania	1.031	1.271	1.100	0.937	1.310
Serbia	1.042	1.271	0.934	1.116	1.324
Slovakia	0.804	1.271	0.902	0.892	1.021
Mean	0.850	1.251	0.993	0.856	1.063

Table 4. Malmquist index results for efficiency change between 2012 and 2014

Country	TEC	TC	PEC	SEC	TFEC
Austria	1.315	1.069	1.000	1.315	1.405
Bulgaria	0.779	1.069	1.000	0.779	0.832
Croatia	1.000	1.020	1.000	1.000	1.020
Czech Republic	1.000	1.415	1.000	1.000	1.415
France	0.935	1.069	1.014	0.922	0.999
Germany	0.935	1.069	1.000	0.935	0.999
Hungary	0.910	1.069	1.083	0.841	0.973

Romania	0.868	1.069	1.068	0.813	0.927
Serbia	0.917	1.069	1.068	0.813	0.927
Slovakia	0.996	1.069	1.087	0.916	1.064
Mean	0.957	1.094	1.033	0.927	1.047

For efficiency change values between 2010 and 2012, it is seen in the TFEC column that Croatia, Serbia and Romania are the countries with positive change in total factor efficiency. Czech Republic's and Slovakia's efficiency stays almost at the same position. Total factor efficiency change for Austria is 0.679 and it means Austria lose efficiency 32.1%. For all of the ten countries 6.3% positive change in total factor efficiency is seen on average.

For efficiency change values between 2012 and 2014, it is seen in the TFEC column that Austria, Czech Republic and Slovakia are the countries with positive change in total factor efficiency. Croatia, France and Germany's efficiency stays almost at the same position. Total factor efficiency change for Bulgaria is 0.832 and it means Austria lose efficiency 16.8%. For all of the ten countries 4.7% positive change in total factor efficiency is seen on average.

CONCLUSIONS

As a result of increasing number of trade activities, logistics operations are growing continuously. Countries should improve their logistics performances, in order to improve the quality of their trade activities. At this point, analysis of efficiency of logistics performances becomes very important.

In this study, logistics performance indexes of 10 countries are evaluated in terms of inland waterway goods transportation and railway goods transportation amounts. Malmquist index value is calculated in order to analyze the total factor efficiency change between 2010 – 2012 and 2012 – 2014 years.

For the analysis between 2010 and 2012 years, mean of total factor efficiency change for all 10 countries shows 6.3% efficiency increase. Croatia, Serbia and Romania are seen as the countries which improve their logistics performance index efficiency most. On the other hand, Austria's logistics performance index efficiency shows a great decrease.

For the analysis between 2012 and 2014 years, mean of total factor efficiency change for all 10 countries shows 4.7% efficiency increase. Countries that improve their logistics performance index efficiency most are Austria, Czech Republic and Slovakia. On the other hand, Bulgaria reduces their logistics performance index efficiency. Countries can use this results for seeing their position against other countries.

This results can be compared by making the analysis in terms of different inputs and outputs. Obtaining data of more countries for this analysis can present more consistent results. Using more different years' data can present different results for efficiency change of countries. Another extension for this study is the usage of different DEA models for analysis.

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WHICH LOGISTICS PERFORMANCE INDICATOR INFLUENCE EXPORT MOST? A SCENARIO ANALYSIS BASED APPROACH

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Abstract − *This study aims to investigate the relationship between logistics performance and exports and attempts to answer the question of which logistics indicators especially influence the country's export level. For this purpose, a scenario analysis-based approach is proposed to analyze the relationships between exports and the six indicators of the logistics performance index reported by World Bank every two years: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness. A novel mathematical model is proposed in order to find an eligible number of scenarios, and the results of this proposed model are used to determine the most important logistics performance indicators that influence the export level of the country. Finally, Turkey is selected as a case study, and possible scenarios are investigated for Turkey to suggest policy proposals in order to improve its export.*

Keywords − *Export, Logistics Performance, Scenario Analysis*

INTRODUCTION

As the backbone of international trade, logistics encompasses freight transportation, warehousing, border clearance, payment systems and many other functions that are mostly performed by private service providers for private traders and owners of goods. However, logistics is also important for the public policies of national governments and regional and international organizations [1]. If a country can obtain a competitive advantage in terms of logistics performance, then there will be an increase in its international trade, helping to open new markets and encouraging business. Country-based logistics performance evaluation will also help understand the relative position of the country and provide a guide on deciding which areas to focus on, such as infrastructure, services, procedures and regulations, to improve the logistics performance level. Companies with access to high-quality cost-efficient logistical capabilities can often outsource certain logistics tasks and devote fewer internal resources to these tasks. The development of the logistics sector is expected to have a positive impact on increasing production, consumption and trade and thus stimulating the economic growth. Better infrastructure will also contribute to attracting foreign direct investment [2]-[5].

A number of studies have been conducted to identify the impact of logistics on increasing international trade. Gupta el al. [6] use a series of semi-structured interviews with 35 logistics and related firms operating in Association of Southeast Asian Nations (ASEAN). Their analysis reveal that the custom authorities of some countries require a large number of documents which increases the inefficiency in the documentation process at the customs and, thus, result with custom-related barrier to international trade. Inconsistency of many customs officials in goods inspection, different classification of goods, lack of border crossing coordination, inefficient inbound clearance process, arbitrary independent rulings, volatility in border traffic, multiple uncoordinated offices and improper penalties are other similar barriers. They also reveal the importance of foreign investment-related barriers such as discriminatory licensing, as well as mode specific barriers.

Portugal-Perez and Wilson underline that trade facilitation does not only include border- related issues but also beyond the border issues such as business environment, the quality of infrastructure, transparency and domestic regulations [7]. They estimate the impact of aggregate indicators of soft and hard infrastructure on the export performance of developing countries. They use factor analysis to obtain

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aggregate indicators and they adapt a gravity model to incorporate hard and soft infrastructure of an exporter as part of trade costs.

Saslavsky and Shepherd [8] found that logistics performance is particularly important for trade among the developing countries in the Asia-Pacific region. They use a gravity model to investigate the relationships between logistics performance and the growth international production networks. They found that trade in parts and components is more sensitive to improvements in logistics performance than the trade of final goods.

Lean et al. [9] use Granger causality analysis to show that economic growth Granger-causes logistics output. In other words, economic development result with more demand for logistics services and leads to logistics development. According to the results, the improvement of transport conditions will help to increase the development of the economy. Improved land transport conditions to lead to economic development through reducing travel time and cost, increasing access of the producers to distant markets, reducing inventory and attracting investment. There is also a feedback effect. The improvement of transport network will increase the economic growth and the economic growth, in its turn, will cause the development of transport infrastructure.

The Logistics Performance Index (LPI) is a very commonly used index for evaluating the logistics performance of the countries. The index evaluates the performance of 160 countries based on six areas, namely; customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing and timeliness [1, 10]. LPI is a comprehensive index created to help countries identify the challenges and opportunities they face in trade logistics performance [11]. The World Bank and the Turku School of Economics have administered the index every two years since 2007, rating countries based on a scale of 1 (worst) to 5 (best) [1]. LPI is a good indicator of trade facilitation for a broad group of countries. Marti et al. [12] analyze the impact that the LPI and each of its components have on trade in emerging countries with a maritime boundary using a gravity model. By incorporating the LPI into a gravity model, they were able to quantify how important this indicator is for the export flow of the emerging countries.

Jhawar et al. [11] classify the factors that influence the logistics performance index as enablers and results and use a causal loop diagram and system dynamics model to show that in the Indian logistics sector, investment done in human resources, which is one of the enablers, will improve the logistics performance.

Puertas et al. [13] estimate several gravity equations using LPI and its components as proxy variables of trade facilitation. Their estimation using the two-stage Heckman model for all the 26 EU countries for 2005 and 2010 show that logistics is more important for exporting nations than importing nations and especially the Competence and Tracking has greater importance in recent years due to weak domestic demand in European countries after the crisis and the search for new international markets.

Banomyong et al. [14] propose policies and integration roadmap for the ASEAN logistics sector based on survey results from seven logics sectors, namely; ports, rail, road, inland waterway, air and logistics service providers.

Most of the studies that have been conducted so far, either focus on a limited number of countries or use deterministic forecasting models to observe 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 that they do not include qualitative systemic change [15]. Indeed, particularly for long-term planning, backcasting, scenario analysis and foresight techniques are accepted as suitable for providing information to logistics and transportation decision makers in highly uncertain future conditions [16].

That is why, in this study, to analyze the interaction between logistics and exports, a scenario analysis approach is proposed. It is necessary to understand logistics performance at the country level to better evaluate and target trade and transport facilitation policy efforts over time and across countries. The main contribution of this study is the use of objective information rather than subjective expert judgments to evaluate the consistency of the scenarios which is the most important property of an efficient scenario analysis. Additionally, a mathematical program is proposed to select significantly different, consistent and efficient scenarios. Based on the selected scenarios, a new approach is suggested to specify the most important logistics indicators that have the greatest impact on exports.

The next section presents the methodology and its application to analyze the interaction between logistics and export. results of the application of the proposed methodology and provides an example for Turkey through an interpretation of the results to highlight which key areas of logistics should be improved in the first run to obtain the highest increased in Turkey's export level. Finally, conclusions are given.

INTERACTION BETWEEN LOGISTICS AND INTERNATIONAL TRADE

In this research, in order to analyze the interaction between logistics performance indicators and export level, a scenario-based methodology proposed in Kabak et. al. [18] is applied.

As is underlined in the introduction section, most of the studies in the literature focus on transport infrastructure, only analyzing the impact of logistics on international trade. However, logistics should be investigated from a wider perspective. For this reason, in this study, the LPI is used to represent countries' logistics performance.

Scenario analysis provides an important tool in the strategic planning process. Scenarios are not forecasts, but they give an internally consistent view of what the future may be. Scenario analysis has emerged as a useful tool for long-term planning when the future is perceived as being subject to a high degree of uncertainty and complexity [19]. The internal consistency of the scenarios is of primary importance. Indeed, 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 in mentally processing these interdependencies [20]. Therefore, different scenario analysis techniques are developed. Scenario analysis consists of phases of problem analysis, system analysis and synthesis. Problem analysis helps the related experts and shareholders have a common understanding of the problem at hand. System analysis defines the problem as a set of interrelated subsystems, identifying the relevant external influences on the investigated problem. Brainstorming, brain-writing, the Delphi technique etc. can be used for these two stages. Finally, the process of synthesis 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 and Goal Programming) (for a detailed overview of these techniques, see [19], [21] and [22]).

Developing a small number of scenarios that represent possible states of a system is another appealing alternative. Scenario analysis provides 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 may develop. They are used to highlight the consequences and thus provide a basis for policies that may influence future developments or help governments to address future issues. Projections are sets of future conditions based on different scenarios.

A scenario selection method that yields consistent scenarios and that supports the quality of scenario analysis is desirable. Indeed, inconsistent scenarios draw no realistic image of the future. Therefore, scenario selection should take into consideration the following rules [15]:

- 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 for having a small number of scenarios is that decision makers can hardly compare numerous 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: These are the most consistent scenarios within a group of similar scenarios.

In this research, taking into consideration the above-given rules, an approach proposed in Kabak et al. [18] is used for scenario selection.

Data used for the analysis

Scenario analysis procedure proposed in Kabak et al. [18] enables the use of objective data instead of expert opinions. For the application of the procedure to the interaction between logistics and export, the logistics performance indicators and export levels of 154 countries in 2007, 2010, 2012, 2014 and 2016 are used. 717 cases are taken into consideration (notice that only the available data series of the countries are used). The related LPI indicator data are provided from World Bank's webpage (http://lpi.worldbank.org/).

To specify the level of the variables, a 5-term linguistic set, defined as Very High (VH), High (H), Medium (M), Low (L), and Very Low (VL), is used.

The LPI indicators are measured on a scale of 1 (worst) to 5 (best) where values lower than 2 and higher than 4 are considered very low and very high, respectively. Therefore, the values corresponding to the LPI indicators are divided into five categories, as shown in Table 1, where values lower than 2 are classified as VL, higher than or equal to 4 as VH, and the values in between are dived into three equal intervals.

The export variable is measured by exports per capita to avoid any bias that may occur due to the population size of the country. The data (exports of goods and services (BoP, current US$) and Population, total) provided by the World Bank database (http://data.worldbank.org/) are used to construct the export data. When the data are analyzed, it is observed that the data are highly skewed (skewness = 5.74). For this reason, a logarithmic transformation is applied to the data to obtain a more symmetric distribution (skewness drops to -0.04). Finally, the categorization is made based on the final transformed data by dividing entire range into five equal intervals (see Table 1.).

Table 1. Intervals specified for leveling the data

Level	LPI values	Export per capita
VL	$x < 2$	< 77
L	$2 \leq x < 2.67$	$77 \leq x < 564$
M	$2.67 \leq x < 3.33$	$564 \leq x < 4149$
H	$3.33 \leq x < 4.00$	$4149 \leq x < 30476$
VH	$4.00 \leq x < 5.00$	≥ 30476

By transforming the data to linguistic levels, we had 717 different scenarios to be analyzed, examples of the data are given in Table 2.

Table 2. Examples of scenarios

Country	Series	Customs	Infrastructure	International Shipment	Logistics quality and Competence	Tracking and Tracing	Timeliness	Export
Germany	2016	VH	VH	H	VH	VH	VH	H
Luxembourg	2016	H	VH	VH	VH	VH	VH	VH
Sweden	2016	H	VH	VH	VH	VH	VH	H
Netherlands	2016	VH	VH	H	VH	VH	VH	VH
…								
Sierra Leone	2007	VL	VL	VL	VL	L	L	VL
Djibouti	2007	VL	VL	L	L	VL	L	L
Tajikistan	2007	VL	L	L	VL	VL	L	L
Rwanda	2007	VL	VL	VL	VL	VL	L	VL

Consistency

The key issue in projecting the future by scenario analysis is the consistency of the scenarios produced [17]. The consistency of a scenario is estimated by assessing the consistency of the levels of all pairs of impact factors [15]. The consistency analysis is the core part of a formative scenario analysis because inconsistent scenarios do not draw any realistic image of the future. In 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 that yields a consistent, reliable, different and small number of scenarios is generally desirable [15].

In the literature, consistency is based on a specific scale, the consistency indicator. However, the consistency rating of all pairs of impact variables is performed by the experts. Subsequently, these ratings, which are summarized in the consistency matrix, are 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 (for the calculation details and characteristics of these indicators, see [15].

In this research, instead of relying on experts, the consistency of a scenario as a whole is estimated by assessing the consistency of the levels of all pairs of variables. The frequency of the levels of variables generated from past data is used to determine the consistency. The consistency of the levels of a pair of variables is calculated by the following formula:

$$c\left(y_i^{m_i}, y_j^{m_j}\right) = \max\left(\frac{f\left(y_i^{m_i}, y_j^{m_j}\right)}{f\left(y_i^{m_i}\right)}; \frac{f\left(y_i^{m_i}, y_j^{m_j}\right)}{f\left(y_j^{m_j}\right)}\right)$$

where i , j = 1,...,7 are the impact variables (1: Customs, 2: Infrastructure, 3: International Shipment, 4: Logistics quality and Competence, 5: Tracking and Tracing, 6: Timeliness, 7: Export) , and m is an index for linguistic terms to state the levels of the variables ($m_i \in$ {VL, L, M, H, VH }) ;

$f\left(y_i^{m_i}, y_j^{m_j}\right)$ is the number of scenarios where the level of variable i is m_i and the level of variable j is m_j; and

$f\left(y_i^{m_i}\right)$ is the number of scenarios where the level of variable i is m_i.

For instance; in our evaluation;

$f\left(y_1^{\mathrm{M}}, y_2^{\mathrm{L}}\right) = 26$ (the number of scenarios where Customs is "Medium" and Infrastructure is "Low")

$f\left(y_1^{\mathrm{M}}\right) = 167$ (the number of scenarios where Customs is "Medium")

$f\left(y_2^{\mathrm{L}}\right) = 334$ (the number of scenarios where Infrastructure is "Low")

Therefore; $c\left(y_1^{\mathrm{M}}, y_2^{\mathrm{L}}\right)$, the consistency of "Customs is Medium and Infrastructure is Low" is calculated as follows:

$$c\left(y_1^{\mathrm{M}}, y_2^{\mathrm{L}}\right) = \max\left(\frac{f\left(y_1^{\mathrm{M}}, y_2^{\mathrm{L}}\right)}{f\left(y_1^{\mathrm{M}}\right)}; \frac{f\left(y_1^{\mathrm{M}}, y_2^{\mathrm{L}}\right)}{f\left(y_2^{\mathrm{L}}\right)}\right) = \max\left(\frac{26}{167}; \frac{26}{334}\right) = 0.156.$$

The consistencies are calculated similarly for all pairs of variables for all levels.

The consistency of a scenario $S_k = \left(y_1^{m_1}, y_2^{m_2}, \ldots, y_7^{m_7}\right)$ is calculated based on the consistency of the levels of a pair of variables as follows:

$$C(S_k) = \min_{\substack{j=1,\ldots 7,\\ i=2,\ldots 7,\\ i>j}} c\left(y_i^{m_i}, y_j^{m_j}\right)$$

For instance;

$$S_{268} = \left(y_1^{\mathrm{M}}, y_2^{\mathrm{L}}, y_3^{\mathrm{M}}, y_4^{\mathrm{M}}, y_5^{\mathrm{M}}, y_6^{\mathrm{H}}, y_7^{\mathrm{L}}\right) =$$

$$Min\begin{pmatrix} c\left(y_1^{\mathrm{M}}, y_2^{\mathrm{L}}\right), c\left(y_1^{\mathrm{M}}, y_3^{\mathrm{M}}\right), c\left(y_1^{\mathrm{M}}, y_4^{\mathrm{M}}\right), c\left(y_1^{\mathrm{M}}, y_5^{\mathrm{M}}\right), c\left(y_1^{\mathrm{M}}, y_6^{\mathrm{H}}\right), c\left(y_1^{\mathrm{M}}, y_7^{\mathrm{L}}\right), \\ c\left(y_2^{\mathrm{L}}, y_3^{\mathrm{M}}\right), c\left(y_2^{\mathrm{L}}, y_4^{\mathrm{M}}\right), c\left(y_2^{\mathrm{L}}, y_5^{\mathrm{M}}\right), c\left(y_2^{\mathrm{L}}, y_6^{\mathrm{H}}\right), c\left(y_2^{\mathrm{L}}, y_7^{\mathrm{L}}\right), c\left(y_3^{\mathrm{M}}, y_4^{\mathrm{M}}\right), \\ c\left(y_3^{\mathrm{M}}, y_5^{\mathrm{M}}\right), c\left(y_3^{\mathrm{M}}, y_6^{\mathrm{H}}\right), c\left(y_3^{\mathrm{M}}, y_7^{\mathrm{L}}\right), c\left(y_4^{\mathrm{M}}, y_5^{\mathrm{M}}\right), c\left(y_4^{\mathrm{M}}, y_6^{\mathrm{H}}\right), c\left(y_4^{\mathrm{M}}, y_7^{\mathrm{L}}\right) \\ c\left(y_5^{\mathrm{M}}, y_6^{\mathrm{H}}\right), c\left(y_5^{\mathrm{M}}, y_7^{\mathrm{L}}\right), c\left(y_6^{\mathrm{H}}, y_7^{\mathrm{L}}\right) \end{pmatrix} =$$

$$min\begin{pmatrix} 0.156, 0.749, 0.719, 0.605, 0.695, 0.108 \\ 0.437, 0.35, \ 0.47, 0.234, 0.701, 0.796 \\ 0.731, 0.682, 0.335, 0.721, 0.652, 0.192 \\ 0.592, 0.24, 0.126 \end{pmatrix} = 0.108$$

With a similar approach, we have calculated consistency of the all possible scenarios considering the combinations of levels of variables. As a result, 5^7 = 78,125 (i.e., 7 variables and 5 linguistic terms) scenarios are identified, and their consistencies are calculated. Calculated consistency of the most scenarios are zero, therefore we've kept scenarios with non-zero consistency (a total of 1421 scenarios) for further evaluations.

Neighborhood

To have significantly different and efficient scenarios, the closeness of the scenarios must be considered. We used the neighborhood definition between scenarios based on their closeness to each other to ensure that neighbor scenarios are not selected in the final set of scenarios.

To define the neighborhood relation, the following generic rules are proposed:

Neighborhood rules:

1) Two scenarios differ at most in the 2 variables;
2) The total linguistic variable difference is at most 3;
3) The linguistic variable difference in the variable "export" is at most 1;

The first rule defines the neighborhood based on the number of different variable levels. The second and the third rules are based on the distance between the variable levels. The second rule considers the total difference, whereas the third rule is for the difference between "export" variable. We have added the third rule since the export is the variable of interest in our application.

According to these rules, the distance between the scenarios is calculated as follows:

$$d(S_k, S_l) = Max\left(\frac{\sum_{i=1}^{7}\begin{cases}1 & if \ \ y_i(S_k) \neq y_i(S_l) \\ 0 & otherwise\end{cases}}{2}, \frac{\sum_{i=1}^{7}|y_i(S_k) - y_i(S_l)|}{3}, |y_i(S_k) - y_i(S_l)|\right)$$

A scenario S_k is a neighbour of scenario S_l if $d(S_k, S_l) \leq 1$.

We have calculated the neighborhood relation of the 1421 scenarios in pairwise manner and identified the 68,934 neighbor scenario pairs.

Scenario Selection

As the final stage of scenario selection we used a mathematical programming model as suggested in Kabak et al. [18]. The objective of using a mathematical model in the scenario selection is to eliminate the heuristic perspective that is used in [7] and thus provide an optimum scenario set.

In this study, we use the following mathematical program to select a small set of efficient and consistent scenarios:

$$Max \sum_{k} C(S_k)\, x_k$$

$$\text{subject to} \qquad x_k + \textstyle\sum_l N_{kl} x_l \leq 1 \qquad k = 1, \dots, 1421$$

$$x_k \in \{0, 1\} \qquad k = 1, \dots, 1421$$

where $C(S_k)$ is the consistency of scenario Sk;

Nkl is a binary parameter to indicate whether scenario k and l are neighbors; and

xk is a binary variable to identify whether scenario k is selected or not.

This model is designed to have the basic properties of a well-organized scenario, i.e., being consistent, being significantly different, being efficient, having a small number and having a reliable set of scenarios. The objective function maximizes the total consistency of the selected scenarios. Significantly different and efficient scenarios are gathered by the first constraint. The reliability of the scenarios is ensured by checking the alternative solutions.

When the proposed mathematical program is applied using the consistencies and neighborhood relations in order to select the scenarios, 16 scenarios are selected, as shown in the following Table 3.

Scenario Evaluation

After finding the consistent and efficient scenarios, these 16 scenarios are evaluated to show the interaction between logistics performance and export. For this, the average level of the logistics variables for each particular export level is calculated, and the weighted sum of the logistics variables is specified. The consistency of each scenario is considered to be its importance weight of the selected scenarios for each export level. The results are presented in the Table 4, which shows that, for instance, because scenarios 91, 137 and 963 have a VL export level, the weighted sum of these three scenarios are calculated etc.

Table 3. Selected scenarios in the application

Scenario ID	Customs	Infrastructure	International Shipment	Logistics quality and Competence	Tracking and Tracing	Timeliness	Export	Consistency
3	H (4)	H (4)	H (4)	H (4)	H (4)	VH (5)	H (4)	0.495
12	H (4)	VH (5)	VH (5)	VH (5)	VH (5)	VH (5)	VH (5)	0.444
16	L (2)	VL (1)	VL (1)	L (2)	L (2)	L (2)	L (2)	0.429
40	L (2)	L (2)	M (3)	M (3)	M (3)	M (3)	M (3)	0.350
60	VL (1)	VL (1)	L (2)	VL (1)	L (2)	M (3)	M (3)	0.309
91	L (2)	L (2)	L (2)	L (2)	VL (1)	M (3)	VL (1)	0.300
107	M (3)	M (3)	M (3)	M (3)	H (4)	H (4)	H (4)	0.248

137	VL (1)	VL (1)	VL (1)	VL (1)	VL (1)	VL (1)	VL (1)	0.217
379	L (2)	L (2)	L (2)	L (2)	L (2)	H (4)	H (4)	0.084
667	M (3)	M (3)	L (2)	M (3)	L (2)	M (3)	L (2)	0.048
915	M (3)	H (4)	H (4)	M (3)	M (3)	M (3)	VH (5)	0.021
963	VL (1)	VL (1)	M (3)	L (2)	M (3)	H (4)	VL (1)	0.017
1106	M (3)	H (4)	M (3)	H (4)	M (3)	H (4)	L (2)	0.008
1128	H (4)	M (3)	M (3)	L (2)	L (2)	M (3)	VH (5)	0.008
1182	H (4)	M (3)	L (2)	L (2)	M (3)	VH (5)	M (3)	0.008
1239	L (2)	M (3)	H (4)	L (2)	H (4)	H (4)	L (2)	0.008

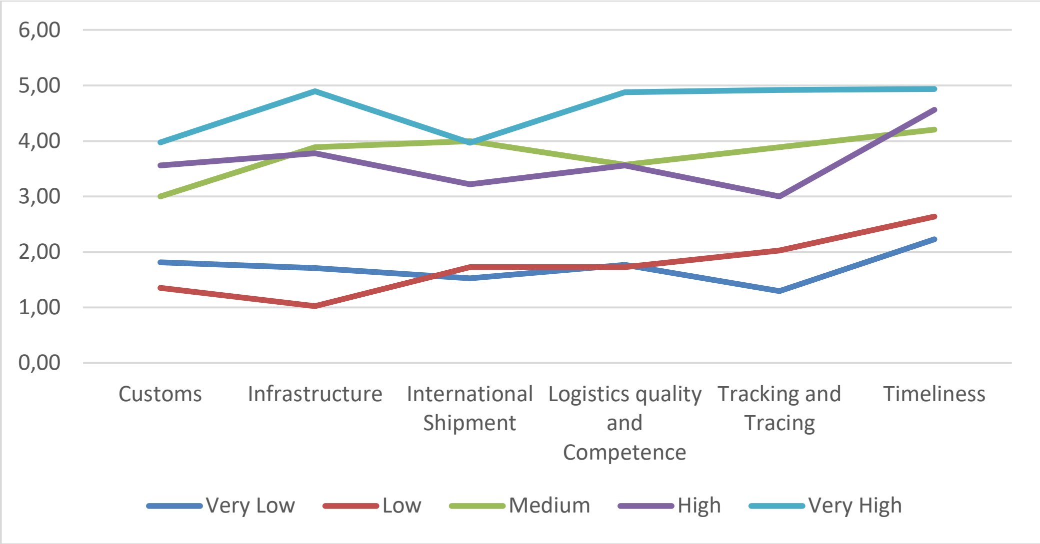
Table 4 shows that there is a direct relationship between the logistics indicators and exports, which supports the basis on which our research is built. For example, when the export level is VH, then infrastructure, International shipments, logistics quality and competence, tracking and tracing, and timeliness are VH (i.e., >4.5) and level of the customs is H (i.e., >3.5) and when export level is VL then level of all variables except timeliness are very low or low (i.e., <2). Figure 1 shows the logistic indicator values for export levels

Table 4. Weighted average level of variables for the levels of export

Export Level	**Related Scenarios**	**Customs**	**Infrastructure**	**International Shipment**	**Logistics quality and Competence**	**Tracking and Tracing**	**Timeliness**
VL – Very Low	91, 137, 963	1.56	1.56	1.62	1.59	1.06	2.22
L – Low	16, 667, 1106, 1239	2.11	1.28	1.18	2.13	2.05	2.16
M – Medium	40, 60, 1182	1.56	1.55	2.52	2.06	2.54	3.02
H – High	3, 107, 379	3.50	3.50	3.50	3.50	3.80	4.60
VH – Very High	12, 915, 1128	3.96	4.92	4.92	4.86	4.86	4.88
TURKEY							
Export level – M		M (3)	H (4)	H (4)	M(3)	H(4)	H(4)
Difference to							
Export H level		**0.50***	-0.50	-0.50	**0.50***	-0.20	**0.60***
Difference to							
Export VH level		**0.96***	**0.92***	**0.92***	**1.86***	**0.86***	**0.88***

* the variables in which Turkey needs improvement.

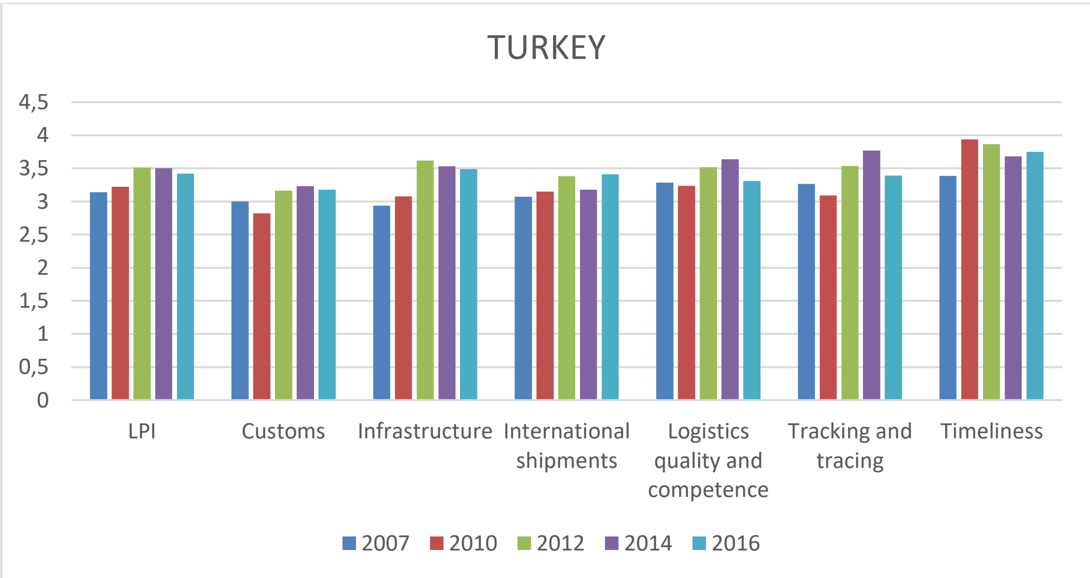
Figure 1. Logistic indicator values for export levels.



POLICY SUGGESTIONS FOR TURKEY

After evaluating the scenarios for specific export levels, Turkey is selected as an example to show how these values are used for policy development. As an important logistics center in Europe, Turkey exhibits high trade values with its regional partners and has a large population, diversified economy and strategic geographical location. It is considered a critical actor in the trade between Europe, the Commonwealth of Independent States (CIS) and the Middle East [23]. Turkey is ranked 30th out of 160 countries in the LPI 2014, and 34th out of 160 countries in LPI 2016. Given its 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 remains stable since 2012, whereas it decreased slightly from 2014 to 2016 [1, 10] (see Figure 2).

Figure 2. Turkey's logistics indicator values through the years.



The indicators that Turkey must focus on are investigated by comparing Turkey's current level of exports (M) with the H and VH levels of exports. The results show that Turkey should improve all logistics indicators to achieve a VH level of exports but should particularly focus on *customs*, *logistics quality and competence*, and *timeliness* for a H level of exports (see the last two rows of Table 4).

This result is slightly different when compared to the results of the period 2014 and before [18]. The basic difference is that logistics quality and competence is suggested to focus on instead of international shipment. In fact, this change is understandable since during the transition from 2014 to 2016 Turkey made a sufficient level of improvement in International Shipment (from 3.18 to 3.41 respectively) whereas there has been a significant decline in logistics and quality (from 3.64 to 3.31).

Export supply chains typically face fewer procedural burdens than imports, as evienced by the shorter lead time for exports than for 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 must reduce the number of government agencies and the documentary requirements. Turkey must also 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 transit procedures that make the movement of goods possible with the payment of duties and excessive control.

Timeliness measures the punctuality of shipment delivery times. Due to the existing high level of competition, timeliness is an important factor for consideration, and failure to comply with delivery schedules is unacceptable [12]. Logistics service providers are generally required to submit import/export documentation at the custom border of the respective country. When there is a lack of full automation electronic data interchange (EDI), the documentation lacks efficiency and a large number of documents are required to be completed. Additionally, there is a lack of documentation format as well as the lack of transparent regulations. All these issues result with a consumption of a large dwell time [6]. Number of documents to export/import as well as the number of days to export/import will directly influence the timeliness. The logistics system should have efficiently coordinated custom offices and border coordination and clear rules for customs. Similarly the latest ICT technology should be provided [7].

Logistics quality and competence is also of crucial importance for trade facilitation. The parties within logistics organizational structure should be efficiently coordinated to increase the quality of service to the customer. It is also necessary to optimize the relationship between organizations and consumers. In fact, the logistics quality and competence that reflect the performance of private sector in particular acquired greater importance for export flows following the financial crisis from 2007 onwards. This is not only valid for Turkey but also for many European countries facing weak domestic demand and searching for export markets [13]

CONCLUSIONS AND FURTHER SUGGESTIONS

Globalization and increased competitiveness resulted made logistics one of the key elements in international trade. Efficient logistics services guarantee safe and high speed movement of products, facilitate the mobility of products and reduce the trade cost among the countries. Therefore it is of crucial importance to provide policymakers information about which factors to focus on and help them to prepare a tentative prioritization of their efforts in order to increase the logistics performance of their country. This study makes two contributions. First, a novel scenario-based methodology is proposed based on the LPI levels of the countries for 154 countries in 2007, 2010, 2012, 2014 and 2016 are used. Indeed, the most important part of scenario analysis is generating a consistent, reliable, different and small set of scenarios. For this purpose, in this paper a mathematical model is proposed for scenario generation.

Because a scenario is a combination of *n* impact variables that have *m* possible levels, different combinations of these variables do not generate consistent scenarios each time. For this reason, a consistency check is initially required in the scenario generation procedure. However, in the literature, these consistency checks have been performed using expert judgments, which are subjective in nature.

Another factor that is very important in the scenario generation procedure is obtaining a small number of consistent scenarios. The literature suggests using a neighborhood distance to achieve this goal. However, calculating the size of differences between two levels is impossible with a number of variables that is on a nominal scale (which is the general case in the literature). To obtain a final set of scenarios, three different procedures are used: the local efficiency, distance-to-selected and max-min selection procedures [15]. Nevertheless, all of these procedures depend on consistency scores, which, as stated above, are subjective in nature.

In this study, we propose using a mathematical model to select a small set of efficient and consistent scenarios. Initially, different from the studies found in the literature, we propose calculating consistency with a completely objective method based on observed frequencies of levels of variables. In addition, because we use an ordinal scale to generate scenarios, simply taking the difference between two levels of a variable is an easy and efficient method that we use in the neighborhood calculation step. Subsequently, the research proposes a method to determine the most important variables to focus on to improve the variable of interest in relation to its target value. This task is performed by finding the scenarios that provide the target level for this variable and obtaining the weighted average of the levels of the other variables. In this manner, it becomes possible to find the variables that are important for improving a specific variable.

The second contribution of this research is the use of the proposed methodology to analyze the interaction between a country's logistics performance and its export performance. For this purpose, six LPI indicators and the export level of countries are used to find the interactions between them.

Subsequently, 16 different and efficient scenarios are generated based on the proposed methodology. After the identification of the scenario set, Turkey has been selected as a case study. The detailed analysis of the scenarios shows that Turkey should improve all logistics indicators to achieve a very high (VH) level of exports but should particularly focus on customs, logistics quality and competence, and timeliness to reach a high (H) level.

The scenario results are interpreted for Turkey selected as case. Study. The relationship between Turkey and its export level is worth examining not only because its own future policies depend on specifying the basic logistics performance indicators to focus on but also, it will be a good example for other developing countries. The results obtained in this paper show that the indicators to focus on changed slightly from international shipments and infrastructure to timeliness and logistics quality and competence. This is especially due to the high level of investment on infrastructure as well as international shipment activities that have been realized until 2016. As a further suggestion, there is a need for future research to conduct similar analysis for different countries and in temporal contexts. It is also necessary to show the mechanism through which improvement in specific logistics indicators will induce trade growth in the related country. The methodology could also be replicated in different regions of the world in need of regional logistics development policy.

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AN EMPIRICAL STUDY ON SUPPLY CHAIN RISK MANAGEMENT IN TURKISH DEFENSE INDUSTRY

Hüseyin Şen[1], M. Atilla Öner[2]

ABSTRACT:

The purpose of the study is to find out methods and tools used in supply chain risk management by analyzing the current issues of supply chain risk management in Turkish defense industry firms and investigate how supply chain risk management influences supply chain performance.

Survey method was used as a quantitative research method in the study. Literature-based questionnaire was applied to 49 defense industry firms operating in Turkey. According to the results, the most significant supply chain risks perceived in defense industry firms are *technological change*, *variability in customer demands*, *increasing raw material prices*, *fluctuations of exchange rate* and *import and export restriction*.

Findings show that 42.9 % of the sample have supply chain risk management department/unit in their organizations. The frequency of usage of risk management tools in supply chain risk management explained 20 % of the variance of supply chain performance ($F(2.46)=5.817$, $p<0.01$).

This is the first empirical study on supply chain risk management in defense industry. The impact on supply chain performance of the risk management tools usage in supply chain risk management was investigated for the first time.

KEYWORDS

Defense Industry, Risk, Supply Chain, Supply Chain Risk, Supply Chain Risk Management, Supply Chain Performance, Turkey.

INTRODUCTION

Competition has seen between supply chains rather than solely firms in our globalizing market [15]. Therefore, supply chains have had significant role in highly competitive environment and a firm has operated in more than one supply chain[25]. A supplier's competitiveness rely on its ability of agile response to different supply chains and this affect the competitiveness of whole supply chain.

Supply chains have become more complex and interdependent in order to sustain their competitive advantages. Trends like globalization, lean and agile supply chain applications, technological changes, shortened product life cycles, cost pressures, uncertainties in supply and demand, outsourcing and dependency on suppliers have brought on increases vulnerabilities, risks and uncertainties in supply chains [12]. Supply chain risk management has become necessary for firms to compete in this ever-changing environment and emerged a significant issue in supply chain management.

Supply chain risk management can be viewed as a strategic management activity in firms in that it can influence operational, market and financial performance of firms [20]. Supply chain risks cause disruptions in material, service, information and cash flow in supply chains [13] and hence, costs increase and sales decline. Any disruption occurred in a supplier affect the whole supply chain negatively.

Some prominent special editions or special sections published about supply chain risk management are as following; The Journal of the Operational Research Society Journal (January 2008, Vol.59, No.1),

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Journal of Operations Management Journal (April 2009, Vol.27, No.2), International Journal of Production Economics Journal (September 2012, Vol.139, No.1).

Some leading academics and researchers stated three research gaps in the field of supply chain risk management: (1) there is shortage of empirical research in the area of SCRM [26,27]; (2) more empirically grounded research on supply chain risk management for specific supply chains and industries is needed [13]; (3) the relationship between supply chain risk and supply chain performance has not yet been investigated empirically [31]. In addition to shortages of empirical studies, the impact on supply chain performance of the risk management tools usage in supply chain risk management has not been investigated yet. Furthermore, we have not been able to reach any study on supply chain risk management in defense industry in Turkey or any other country although several defense industry firms took part in the sample of some studies.

Not only is defense industry a different industry, it includes various sub-sectors such as automotive, electronics, apparel, metal and machine industry. On the other hand, defense industry is differed from other sectors in terms of its indigenous product and market characteristics and these differentiated defense industry supply chain structure and design. Defense industry firms manufacture commercial products as well as defense products as part of dual use. That defense industry includes various sub-sectors and it has significance in terms of country's security emphasize this study's importance and contribution.

The main objective of this research is threefold. First, we try to find out methods and tools used in supply chain risk management by analyzing the current issues of supply chain risk management in Turkish defense industry firms. For this purpose, we constructed literature-based questionnaire, then searched the supply chain risk management structure in firms. Second, we assessed the risks perceived in defense supply chain and searched the attitudes towards supply chain risks. Third, we investigated how supply chain risk management influences supply chain performance.

The rest of this study is organized as follows. In section 2, we review the literature on supply chain risk management and supply chain performance. Section 3 explains the research methodology used in the study. Section 4 presents the findings. Section 5 discusses the results. Section 6 expresses the conclusion, and the final section explains limitation and suggests implications for managerial practice and future research.

LITERATURE REVIEW

The literature review section of this study focuses on key variables of this study including risk, supply chain risk, supply chain risk management and supply chain performance.

Risk

Although risk is a universal concept, there is no commonly accepted definition. The concept of risk has multiple dimensional structure and can be differ based on business functions[35]. Upon examining the literature, even though there are some similarities in risk definitions made by different authors, they can be differ regarding the containing elements. Elements in risk definitions are probability, uncertainty, negative impact/outcome, loss and subjectivity.

Risk and uncertainty, one of its element, are different concepts, but they are used interchangeably. Probability of risk is measurable while probability of uncertainty is unmeasurable. Briefly, risk is a concept that its negative/positive outcomes is predictable, but the outcome of uncertainty is unpredictable [14].

Risk is potential losses in case of an event occurs and probability of this losses[19]. Yates and Stone (1992) made a notation on risk calculation [33]. They characterized the probability of loss as $P(Loss_i)$

and impact of loss as $I(Loss_i)$. Risk index equal to the multiplication of $P(Loss_i)$ and $I(Loss_i)$. Conceptual equation is as following for event i;

$$Risk_i = P(Loss_i) \times I(Loss_i) \quad (1)$$

Supply Chain Risk

Definition of risk and uncertainty has been made in various disciplines such as managerial decision making, strategy, operation, accounting, finance and transportation, but little and narrow content have been done in supply chain field in the context of risk definition. The concept of supply chain risk has been begun to be used since 2000's by several academics and practitioners. Meaning of supply chain risk can differ according to factors such as industry, source, and outcome [35].

Few researchers has addressed the definition of supply chain risk. Zsidisin (2003) defined supply chain risk for the first time as "The probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety". He also defined the suuply risk as "The transpiration of significant and/or disappointing failures with in-bound goods and services is supply risk" [37].

Supply chain risks are any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user. In simple terms, supply chain risks refer to the possibility and effect of a mismatch between supply and demand [13].

Suuply chain risk stem from product, sevice, information and cash flow disruptions in supply chain [12]. Supply chain risk is defined related to the performance as the negative deviation from the expected value of a certain performance measure, resulting in undesirable consequences for the focal firm [30]. Supply chain risk can be broadly defined as an exposure to an event which causes disruption, thus affecting the efficient management of the supply chain network [6].

Risk sources are any variables that cannot be predicted with certainty and from which disruptions that affect the supply chain performance [3]. Many different categorization of supply chain risk sources was made in the literature. In this study, we applied to supply chain risk categorization of Jüttner (2005) [13], which is more comprehensive and simple compared to the other researches. There are three main supply chain risk sources;

1. **Organizational risk sources;** labour uncertainty (labour unrest, strikes and employee safety), input supply uncertainty (raw material shortages, quality changes and spare parts restrictions), IT system uncertainties and production uncertainty (machine failures) [6].

2. **Supply chain network related risk sources;** generally stem from supplier, customer and market which take part in supply chain but out of the organization [36]

3. **Environmental risk sources;** Accidents (fire, etc.), social uncertainties (terorist attacks, social unrests, etc.), natural disasters (earthquake, flood, epidemic, etc.), globalisation, goverment policies (import and export restrictions, regulations, etc.), macroeconomic uncertainties (inflation, economic crises and exchange rate fluctuations) [6].

Supply Chain Risk Management

Supply chain risk management concept can be found in the literature since 2000's, but commonly accepted definition of supply chain risk management has not been constructed. Jüttner et al.(2003) and Hauser (2003) are the researchers having defined the supply chain risk management for the first time. The formers put emphasis on risk identification and management processes, identifying as the identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole [13]. The latter pointed out that risk management in the supply chain does not equate to disaster response. Rather, it means keeping an increasingly complex process moving efficiently at the lowest total cost and without compromising the quality of the product or customer satisfaction [10].

Most commonly used elements in supply chain risk management definitions in the literature are risk management process, coordination, collobration, risk management strategies and performance. Although supply chain isk management processes are variable in the literature, they have four steps such as risk identification, risk assessment, implementation of appropriate strategies and monitoring and control of risk. Supply chain risk management strategies can comprehensively be categorized into six groups; risk transfer, risk sharing, risk finance, risk acceptance, elimination or mitigation of risks by singlehandedly in firm, elimination or mitigation of risks by with the partners in the supply chain [17].

Supply Chain Performance

Performance measurement is a necessary tool for supply chains in order to create competitive advantage [16] while increasing productivity and customer satisfaction in continuously changing, complex and uncertain environment. Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of the actions. Effectiveness is the extent to which a customer's requirements are met and efficiency measures how economically a firm's resources are utilized when providing a pre-specified level of customer satisfaction. Performance measurement systems are described as the overall set of metrics used to quantify both the efficiency and effectiveness of action [21].

As the level and quantity of suppliers and customers in supply chain management increase, it is hard to measure supply chain performance. Supply chain performance consists of total performance of all the members of supply chain from the raw material producer to the ultimate customer. Therefore, any disruption occurred in any stage, point or member in the supply chain influence the supply chain performance.

Numerous researchers categorized the supply chain performance measures into various groups in the literature [2,4,7,8,18,21,23,24]. Although researchers continue the attempts to build the new measures and metrics for supply chain management, most of the current performance measurement systems of supply chain in place are harassed by too many defects to meet with the requirements of supply chain management [4]. For example, most of the performance measures solely focus on cost and profit [32]. These conventional measures have the drawbacks of tending toward inward looking, fail to include intangibles and lagging indicators [8].

In this study, we adopted the supply chain performance measures developed by Shepherd and Günter (2006) [24] and Leuschner vd. (2013) [18]. As seen on figure 1, our supply chain performance measures consists of five measures; cost, delivery, quality, flexibility and innovativeness.

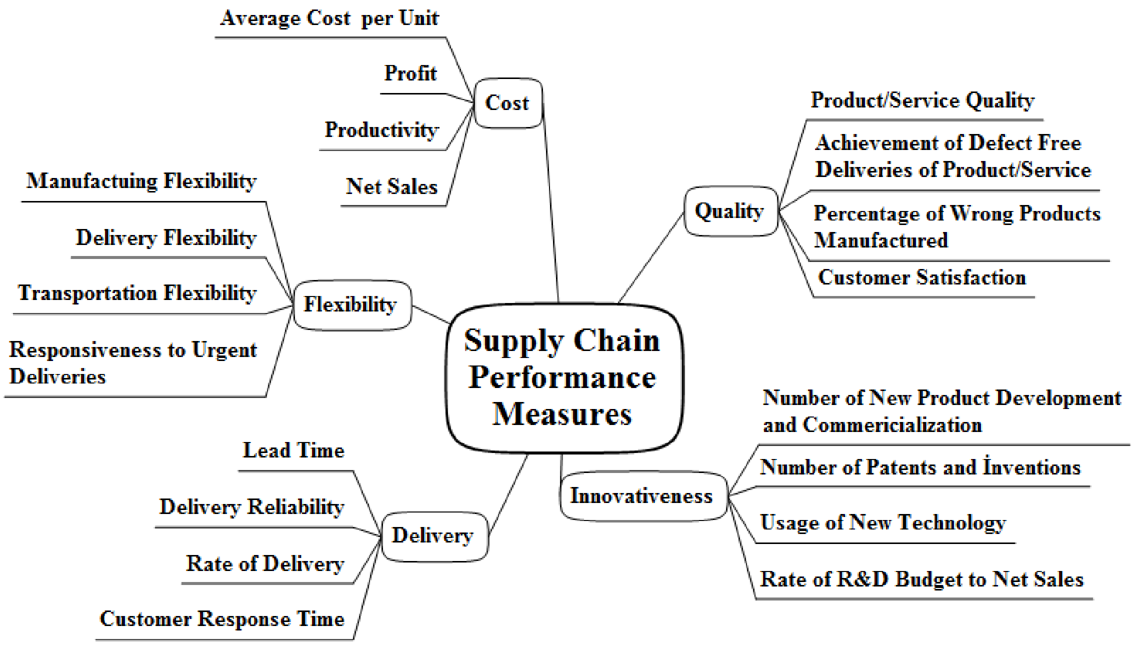

Figure – 1. Supply Chain Performance Measures

RESEARCH METHODOLOGY

Survey method was used as a quantitative research method in the study. Research design is on the purpose of descriptive. Main aim of the descriptive researches are to find out and describe the characteristics of phenomenons, objects, humans, groups or organizations [34]. The population of this study is defense industry companies operating in Turkey. 157 of the defense industry companies operating in Turkey are member of Defense Industry Association. Therefore, these 157 companies registered to Defense Industry Association are determined as the sample of this study. The unit of analysis of the study is defense industry companies.

Table 1. Basic Demographic Information of Respondents

Respondents Characteristics	Frequency	Percentage (%)
Gender		
Female	10	20.4
Male	39	79.6
Age		
20-29	4	8.2
30-39	26	53.1
40-49	16	32.7
50-59	3	6.1
Education Level		
Associate Degree	2	4.1
Bachelor Degree	28	57.1
Master Degree	17	34.7
Doctoral Degree	2	4.1
Experience in the Defense Industry		
< 1 year	2	4.1
1 - 3 years	2	4.1
4 - 5 years	4	8.2
6 - 7 years	6	12.2
8 - 10 years	11	22.4
> 10 years	24	49.0
Experience in the Current Department		
< 1 year	3	6.1

1 - 3 years	9	18.4
4 - 5 years	11	22.4
6 - 7 years	7	14.3
8 - 10 years	7	14.3
> 10 years	12	24.5
Department		
Top Management	9	18.4
Logistics	5	10.2
Procurement	11	22.4
Manufacturing/Operation	2	4.1
Marketing	2	4.1
Sales	2	4.1
Strategy and Planning/Business Development	6	12.2
Accounting/Finance	2	4.1
Technology Management and R&D	3	6.1
Quality Management	1	2.0
Program/Project Management	4	8.4
Others	2	4.1

Data collection were carried out in three steps. Firstly, literature according to the research questions was reviewed and literature-based questionnaire was prepared. Most of the questions were adopted from Lavastre et al. (2012) [17]. While Lavastre et al. (2012) [17] used seven point Likert Scale in their study, we used six point Likert Scale in this study. Because, in seven point Likert scale, respondents marked the answer choice of “four or no opinion” when they don’t have any knowledge about the questions. This situation influences the reliability and validity of the data collection tool.

Sample Characteristics		**Frequency**	**Percentage (%)**
Sub-sector			
Naval Platforms		4	8,2
Land Platforms		18	36,7
Aviation and Space		24	49,0
Electrical and Electronics		19	38,8
Weapon		9	18,4
Ammunition		3	6,1
Rocket and Missile		10	20,4
Materials-Mould-Parts		9	18,4
Apparel		2	4,1
Information Technology		5	10,2
R&D - Engineering		16	32,7
Training		3	6,1
Other Manufacturer		1	2,0
Consultancy Services		1	2,0
Other Service Providers		2	4,1
Others		1	2,0
Number of Employees			
Small Sized	10 - 49	10	20,4
Medium Sized	50 - 99	7	32,7
	100 - 249	9	
Large Sized	250 - 499	9	46,9
	500 - 999	3	
	1000 - 1.999	5	
	2.000 and more	6	
Sales (Million TL)			
Small Sized	1 - 9	12	24,5
Medium Sized	10 - 49	12	24,5
Large Sized	50 - 99	5	51

	100 - 249	2	
	250 - 499	4	
	500 - 999	4	
	1000 - 1.999	5	
	2.000 and more	5	
Share of Foreign Affiliation (Percentage)			
0		46	93,9
1-20		1	2,0
41-60		2	4,1

Table – 2. Sample Characteristics

Secondly, pilot test of the questionnaire was administered to six managers (two of them are purchasing managers, two of them are strategy and planning managers, one of them are supply chain manager, and one of them sales manager). Last step is the implementation of the questionnaire. Questionnaire was administered to the managers working in defense industry companies by face-to-face or from web site on "surveymonkey.net". Questionnaire was sent to 157 defense industry companies. 34 of them responded by internet. In addition, 15 of them filled the hard copy of the questionnaire. Consequently, 49 defense industry companies responded to the questionnaire with a return rate of 31.2 %.

Descriptive statistics, regression analysis and correlation analysis were performed using IBM SPSS 22.0 program. Reliability analysis of the scale used in the study were performed. As a rule of thumb, Cronbach's alpha coefficients have to be above 0.7 in reliability analysis [5,22]. In this study, Cronbach's alpha coefficients of the variables range from 0.836 to 0.944.

Basic demographic information of respondents is presented on Table 1. According to descriptive statistics, 79.6 % of the respondents are male and 20.4 % of them are female. Average age of the respondents is 38.6 and most of the respondents (57.1 %) have bachelor's degree. Concerning experience of respondents in the defense industry, 49 % of respondents have been working over ten years in defense industry, 73.6 % of them have been working for more than six years in defense industry and 53.1 % of the respondents have been working at least for six years in their current department. Furthermore, 44.1 % of respondents are working in logistics and supply chain department, 18.1 % of them are working in top management and 8.4 % of them are working in program/project management department. One of the respondents who selected the other choice is working in supplier management department and the other is planning and purchasing department.

Sample characteristics of the study is summarized on Table 2. While 83.7 % of the companies have operated in defense industry for more than11 years, 61 % of the companies have had logistics department for 11 years or more. Most of the companies participated in the study have been operating in more than one sub-sector. Most of the sub-sectors operated in are respectively aviation and space, electrical and electronics, land platforms, and R&D and engineering. One respondent stated that his/her company have been operating in simulator systems. Regarding the number of employees for the company size; 46.9 % of the companies are large sized companies and 53.1 % of the companies are small and medium sized companies. According to the annual sales quantity, 51 % of the companies are large sized companies, 49 % of the companies are small and medium sized companies. 93.9 of the companies do not have any share of foreign affiliation.

RESULTS

Supply chain risk management organizational structure of the companies in the study is presented on Table 3. According to the results, 42.9 of the companies have department/unit dedicated to supply chain risk management. Average number of people working full time is five people. But, the responsible department or person for supply chain risk management in the company is variable.

Availability of department/unit assigned to SCRM	Frequency	Percentage (%)
Yes	21	42,9
No	28	57,1
	Avg.	**S.D.**
Number of SCRM employees working fulltime	5,3	4,4
Responsible for SCRM in the Company	**Frequency**	**Percentage (%)**
Top management (General managers, Board of managers)	7	25,0
Directors of Departments	5	17,9
Functional (Middle management)	4	14,3
Operational (Specific employees)	4	14,3
All units in the company	2	7,1
Nobody in particular	2	7,1
Other	4	14,3

Table 3. Organizational Structures of Supply Chain Risk Management

Supply chain risk sources perceived in defense industry are presented on Table 4. Risk index was generated via multiplying possibility of occurrence of perceived risk sources and their impacts on company. The highest possibility of occurrence of perceived risks are variability in customer demand, technological change, increasing prices of raw material and exchange rate fluctuations. The most significant risks that have impact on companies are import and export restrictions, variability in customer demand, technological change and exchange rate fluctuations.

Table 4. Risk Sources Perceived In Turkish Defense Industry

No.	Risk Sources	Probability of Occurence		Impact on Firm		Risk Index
		Avg.	S.D.	Avg.	S.D.	Avg.
1	Supplier failure	2.7	0.8	3.4	1.1	9.3
2	Supplier quality problems	2.6	0.9	3.4	1.1	9.1
3	Oil crisis	1.8	0.9	2.1	1.1	3.8
4	Terrorist attacks	2.6	1.3	3.0	1.4	7.8
5	Strike	1.7	1.0	2.8	1.3	4.8
6	Insufficient information sharing in supplier network	2.5	1.0	3.1	0.9	7.7
7	Inflation	2.7	0.9	3.2	1.0	8.8
8	Accident (e.g. fire)	2.2	0.8	3.2	1.0	7.1
9	Natural disaster (e.g. earthquake, flooding)	2.0	0.8	3.2	1.1	6.4
10	Machine breakdowns	2.5	0.9	3.0	1.1	7.5
11	Import and export restrictions	2.7	0.9	4.1	1.1	11.2
12	Transportation failure	1.8	0.9	2.5	1.2	4.5
13	Problems in distribution channel	2.0	0.8	2.6	1.1	5.2
14	Increasing customs duty	2.4	1.0	2.6	1.2	6.3
15	Variability in customer demand	3.2	1.0	3.8	1.1	12.2
16	Technological changes	3.5	0.8	3.8	0.9	13.5
17	Increasing prices of raw material	3.1	0.8	3.4	1.2	10.6
18	Intellectual property infringement	2.5	1.1	3.0	1.2	7.3
19	Exchange rates fluctuations	3.5	0.8	3.5	1.0	12.2
20	Globalisations	2.7	0.8	3.1	1.0	8.5
21	Legal regulation	2.5	0.8	2.9	1.0	7.3

22	Outsourcing	2.7	0.9	2.9	1.1	7.7

Risk indexes are calculated by categorizing the supply chain risk sources as organizational, supply chain network and environmental. According to the result obtained from the calculation, supply chain risks perceived in defense industry from the highest to the lowest are respectively supply chain risks (R_i=8,9), environmental risks (R_i=8,3) and organizational risks (R_i=6,3).

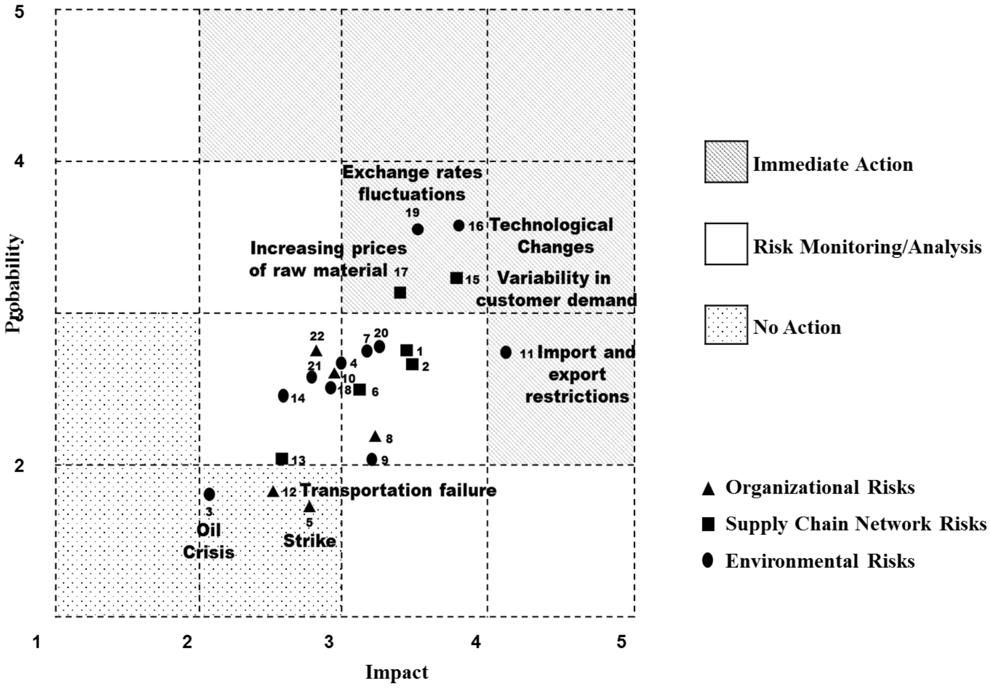

Figure 2. Probability and Impact Matrix

Supply chain risk indexes are put on the probability and impact matrix. Probability and impact matrix generated is presented on Figure 2. Organizational risks, supply chain network risks and environmental risks are exhibited with a different shape.

According to the probability and impact matrix; the highest risks are, respectively, technological change, variability in customer demand, increasing prices of raw material, exchange rate fluctuations and import export restrictions. The lowest risks on the matrix are, respectively, oil crisis, transportation failure and strike. Supply chain risk that has the biggest standard deviation is terrorist attacks.

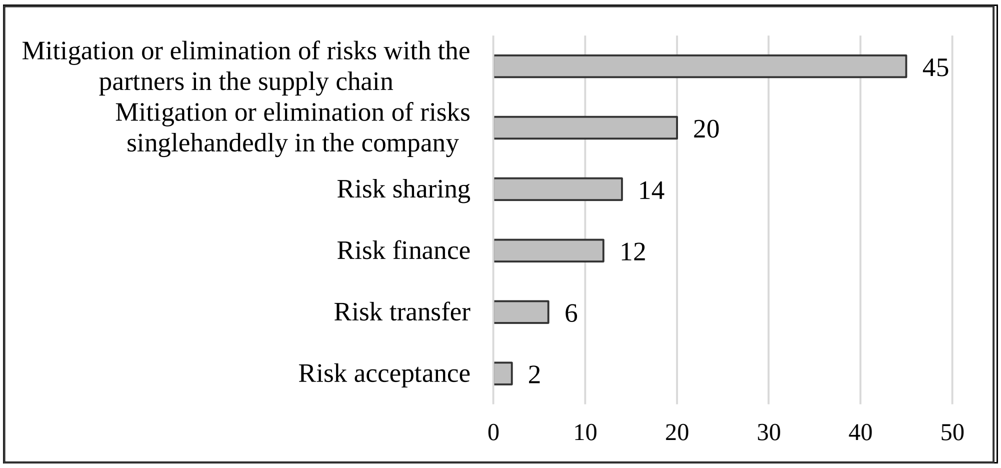

Figure 3. Attitudes towards Supply Chain Risks in Turkish Defense Industry

Attitudes towards supply chain risks summarized on Figure 3. According to the results, 45 % of the respondents replied that they mitigate or eliminate supply chain risks with the partners in the supply chain and 20 % of the respondents answered that they mitigate or eliminate supply chain risks singlehandedly in the company. A surprising answer emerged as risk acceptance. In this framework, one manager (aged between 50-59) stated that he do nothing as ignoring the risk.

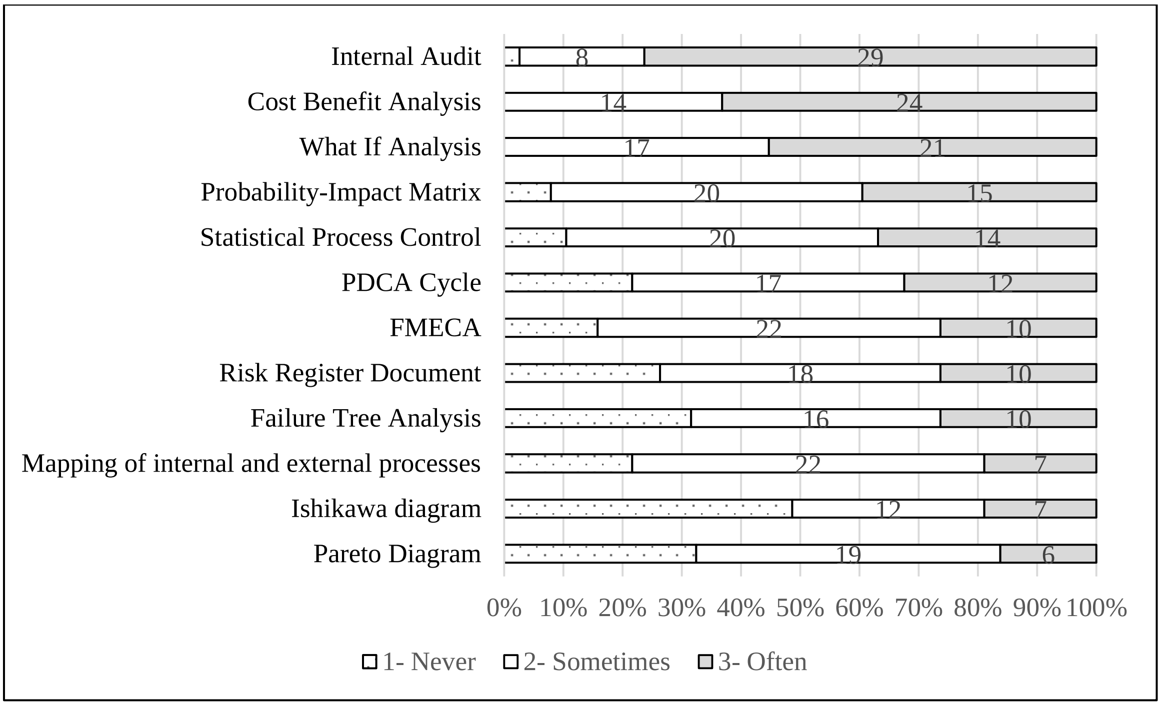

Figure 4. Frequency of Usage of Risk Management Tools

The frequency of usage of risk management tools in supply chain risk management is exhibited on Figure 4. According to the results, the most often used tools are, respectively, internal audit, cost-benefit analysis and what if analysis. The least used tools are, respectively, Pareto diagram, mapping of internal and external process and Ishıkawa diagram (Fishbone diagram).

The impact on supply chain performance of frequency of usage of supply chain risk management tools and attitudes towards supply chain risk is investigated via multiple regression analysis. Summary statistics and correlation matrix are presented on Table 5. and results of the regression analysis are exhibited on Table 6.

Table 5. Summary Statistics and Correlation Matrix

Variables	Avg.	S.D.	(1)	(2)	(3)
(1) Overall Performance Average	4,48	0,0,72	-		
(2) Attitudes and Behaviors Towards Supply Chain Risks	3,49	1,14	0,242*	-	
(3) Frequency of Usage of Risk Management Tools	2,14	0,32	0,425**	0,237	-

**p<0,01

*p<0,05

Table 6. Regression Analysis Results

Variables	B	S.H.	β	p
Attitudes and Behaviors Towards Supply Chain Risks	0,095	0,086	0,150	0,275
Frequency of Usage of Risk Management Tools	0,888	0,309	0,390	0,006
Model Summary: $F(2,46)=5,817$, $R^2=0,20$, $p<0,01$				

Results of the multiple regression analysis are statistically significant ($F(2.46)=5.817$, $p<0.01$). Adjusted R^2 coefficient is 0.20. This result explained 20 % variance of the supply chain performance by frequency of usage of supply chain risk management tools and attitudes towards supply chain risk. However, regarding the β coefficients on Table 5., when two independent variables were put into the regression analysis, only the frequency of usage of supply chain risk management tools supported with a statistically significant and positive impact on overall supply chain performance ($\beta=0.390$, $p<0.01$). The other independent variable, attitudes towards supply chain risk do not have any statistically significant support and impact ($\beta=0.150$, $p>0.05$).

DISCUSSION

Compared with the previous researches, results of the study indicates that supply chain risks perceived by managers can vary. In this study, the most critical supply chain risks are technological change, variability in customer demands, increasing raw material prices, fluctuations of exchange rate and import and export restriction. In previous studies, the most significant risks are supplier failure [11], supplier and labor problems [28], quality, increasing prices and technological changes [29].

Findings about the frequency of tools used in supply chain risk management resembles to results of the previous studies. According to this study, the most often used tools are, respectively, internal audit, cost-benefit analysis and what if analysis. The least used tools are, respectively, Pareto diagram, mapping of internal and external process and Ishıkawa diagram (Fishbone diagram). Based on the results of previous studies, the most often used tools are what if analysis [1], plan do control act cycle [17], internal audit [9].

We could not find any empiric study on the relationship between supply chain risk management tools and supply chain performance. However, the relationship between supply chain risks and supply chain performance was investigated [31]. Results of the study indicates that the frequency of usage of supply chain risk management tools have a positive impact on overall supply chain performance.

CONCLUSION

In the light of the findings obtained from study, the most critical supply chain risks perceived in defense industry are technological change, variability in customer demands, increasing raw material prices, fluctuations of exchange rate and import and export restriction. Results of the study revealed that supply chain risks perceived in defense industry from the highest to the lowest are respectively supply chain risks, environmental risks and organizational risks.

Results of the study have two significant contributions to the literature. First, this is the first empirical study on supply chain risk management in defense industry. Second, the impact of the tools used in supply chain risk management on supply chain performance was investigated for the first time. According to the findings, tools used in supply chain risk management influenced supply chain overall performance positively.

LIMITATIONS AND FUTURE RESEARCH IMPLICATIONS

With the simplest and most comprehensive definition, supply chain consists of a company, a supplier, and a customer involved in the upstream and/or downstream flows of products, services, finances, and/or information. In the context of the limitation and scope of this study, research was done on the side of defense industry supply chain firms and suppliers which are member of Defense Industry Association and operate in Turkey, but supply chain risks perceived by customer (public) was out of scope of this study. This study is limited with the data obtained from respondents participate in survey.

This study opened new avenues for further researches. On the basis of the results, future researches should focus on risks perceived by customer (public) and supplier in Turkish and other countries' defense industry supply chain in and in other industry in a comparative manner. Furthermore, we suggest a case study aiming the relationship between managers' demographic information, supply chain risk perception and attitudes and behavior towards risk.

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AN APPLICATION OF LEAN & SIGMA APPROACH AND LOGISTICS

Büşra Nur Tetik[1] Ayşegül Ay[2] Zerrin Aladağ[3]

Abstract - In the Business World today, even more so with each passing day, and "excellence" aimed at achieving an ambitious goal of 6 Sigma as the Word carries the nature of work required and implemented in each sector. In this study, Lean 6 Sigma uses of all stages of the process was made and the company in volved in the logistics sectore examined all steps of the process in a certain order types and is made of how taking place in the actual Lean 6 Sigma Project solutions will be introduced. In this study, Automotive Logistics in Port Factory Break System Efficiency and Performance Enhancement Project aimed Theme Lean 6 Sigma. The second stage Lean 6 Sigma implementation study and the steps are given. The results of the work done in the last section were evaluated and various suggestions have been made this project.

Key Words: Automotive Logistics, Lean 6 Sigma, Performance Enhancement

1. INTRODUCTION

Who made a name in the business world today, even more so with each passing day, and "excellence" aimed at achieving an ambitious goal of 6 Sigma as the word carries the nature of work required and implemented in each sector.

Lean Six Sigma is a quality improvement in organizations is an approach that aims to eliminate waste and reduce variability. Lean Six Sigma, Six Sigma and Lean Management approach is based on the development of the two programs. Six Sigma is a quality management and philosophy; as well as to reduce variability, measurement and product defects, it is a methodology that aims to improve the quality of processes and services. Six Sigma concept was developed by Motorola Company in the early 1980s. The popularization of the concept in the late 1990s, General Electric Company and the company's CEO, Jack Welch realized by the application. Lean entity is a methodology focused on reducing the total processing time of the reduction of waste and process. Toyota Motor Plant in the first approach emerged as the Toyota Production System, it has increased in popularity after the 1973 energy crisis. "Lean Thinking" is the term used for the first time in the book James P. Womack and Daniel T. Jones, Lean Thinking in the literature (Womack and Jones, 1996). "Lean Enterprise" concept from the field of lean manufacturing program is expanded to include the entire organization (Alukal, 2003). Six Sigma methodology uses the DMAIC problem-solving approach and many quality problem-solving techniques. The techniques used will vary according to the type of examination process and the problems encountered. Likewise, Lean Approach to destroy waste, uses many Lean Techniques to organize and simplify business processes. [1]

In this study, between the port automobile logistics companies to increase efficiency and performance on the factory system is intended to 6 Sigma projects. In the second part of the study, lean and 6 Sigma

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implementation steps are given. Various proposals have been evaluated and the final chapter the results of the study have been introduced.

2. LEAN 6 SIGMA APPLICATION

2.1: DEFINE

Business Situation: 2014 -15 years of Automobile Company - B Logistics in the field of making the tool in the factory and return vehicles, domestic shipments, top constructive delivery, such as the functioning and organization of the operations provided and maintained operational processes and team management. Further instead of approaching the management of the operations team in 2016 in the field of management and senior staff level of the work done is aimed to ensure the controllability. Ensuring determining and eliminating operational losses suffered as a result, improving operational processes, field and staff efficiency increase compared to the current situation, it is aimed addressing with zero error.

Opportunity Statement: the staff at the level of control and efficiency will be examined. Team of the lap times depending on the distance average calculation will be provided instead of evaluating the efficiency calculation and tracking software. Whereby the field can be taken measures are determined people on low. Obstacles to the operation of the field and detailed examination of the loss can be made overlooked. Manual handling without damage caused tracking will be provided. Fields also experienced he connected will be prevented from breaking and incorrect addressing the problem would have prevented problems getting up automatic address software.

Target Release: Foc of the team in 2015 (handheld) use at the operational level are managed and evaluated on the basis of the work done team. This automatic system without addressing the cause should apply to all sites and all staff should be given a FOC. Poka-Yoke solutions as the transition to RFID applications are intended to solve the problem of incorrect addressing. Thus fingerprint operational staff will be created.

Project Scope: (The Automobile Company and The Company of Logistics Field)

Domestic Scope: Automobile factory car purchase operations (A1-A2), domestic shipments.

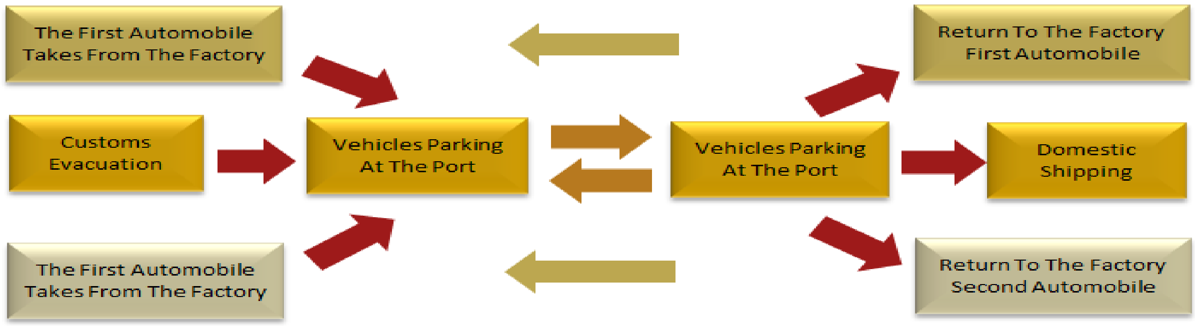
Excluded: International shipment, battery operation, and shipping operations

Project Plan: Define phase 04.03.2016 - 18.03.2016 between these dates cover a period of 15 days.

Project Team: Sponsor, process owner, black belt, green belt specialist, financial representatives, IT representative, was created as 5 green belts and 2 project interns

Process Map; Macro Map

Figure 1: Macro Proses Mab



SIPOC: the transformation of inputs to outputs between the customer and the supplier is a system that we can examine the process. A2 This system - A1sevk and field tools to get the Handover we examine the placement process, the pitch means reading and systematic placement process takes place. Domestic shipments of tar and if we examine the installation site without vehicles, fuel - pack station and the platform of the towing process takes place.

Process Flow: 2 process between factory and field takes place in 3 parts loop. First, the handheld tool with barcode is read from the handover. Vehicle components and controls are done if the problems are considered vehicles and damage is detected entering the handheld terminal. Damage form (VLDR Form) regulated. If a tolerable error "tolerated" it will be systematically checked and accepted. The vehicle will be returned and will not be tolerated systematic adoption does not occur and damage to vehicles go back again when we come across "Traded will be accepted. After checking the results by hand the positive terminal of the vehicle matched the CDM barcode RFID card is considered to be systemic and placed on RFID cards on the torpedo the process ends. Next proceed to the vehicle and the system continues cyclically. If the Automobile traded, the driver will go to anoder park fielt**.** To get next vehicle handover to walk again. The cycle continues in this way. 3. personnel with service tool used by the team leader in the field of the buffer stage is brought to the area. Meanwhile, let the staff team leader means to be taken. Ynkp' from the car through the field with hand-held CDM menu bar code is read. After opening the vehicle's mirrors, manual mirrors automatically if the vehicle is located right platform location tag must be read and tools addressing process must be completed. Addressing the vehicle after the vehicle service must exit the route and should be staffed with service tool and recur the cycle again going towards the buffer.

2.2: MEASURE

Plans of the person to be identified after the measurement of operational process has been created. Once they have determined the period of time losses experienced in the field chronometrage method using the Black Belt 's proposal with 100 data were collected by the person identified in three weeks. This was done with 5N 1K metod.

Measurement Plan: Station team time measurement process will be identified and measured time by being next to the driver until the time left to field the tools from the platform of release from the factory with imported vehicles buffer to buffer again the starting pitch to leave the vehicle driver taken by shuttle to the output from the field. Aysegul Ay 116 data from the field, Busra Nur Tetik and 1 Personnel 14.04.2016 - 03.05.2016 between would be completed by taking the notes. (Similar systems have been implemented in other operations.)

Sampling: First in the meetings later formed group provided data to determine the number of samples and will allow us to contribute to this process and data is selected. In this way, by sampling the data, it has tried to obtain information that can be tried on all the data of the population. So long as the effect rather than collect all the data by sampling data set that has been distinguished more, a study was conducted on more objective and solution of the confidence interval, which will be planned spots.

A2 Mesasurement Factory

Table 1: A2; Station Measure Values

	Step	Recruitment T.	Toning T.	Recruitment	Toning	shift	Transfer
1	From the front of the factory	0	0	single	Made	1	1
2	From the front of the factory	95	0	plural	Made	1	1
3	From the front of the factory	51	0	plural	Made	1	1

(A2) Summary report

Anderson Darling is above normal test results as shown in the graph in the lower level of 249 seconds, 729 seconds maximum level is reached. On average it rose 395.62 times per second. Average time is 6 minutes 36 seconds. Value P-value <0.05 has seen as not fit a normal distribution. Located Boxplot chart below shows the values of the graph and found her under a pile of Tukey scheme value.

I-MR Grafiği

Chart type of observation I-MR is selected. Red boxes appear as shown in the graph goes beyond limit. Coming out of these points must be examined.

Test Resultsfor I Chart of sıkılaştırma S.

TEST 1. Onepointmorethan 3,00 standarddeviationsfromcenterline.
Test Failed at points: 12; 37; 40; 89
TEST 2. 9 points in a row on sameside of centerline.
Test Failed at points: 57; 67; 68; 69; 70; 71; 72; 73; 74; 75; 76; 77; 78; 79; 80; 81

Test Resultsfor MR Chart of sıkılaştırma S.
TEST 1. Onepointmorethan 3,00 standarddeviationsfromcenterline.
Test Failed at points: 12; 13; 37; 38; 40; 89; 90
TEST 2. points in a row on sameside of centerline.

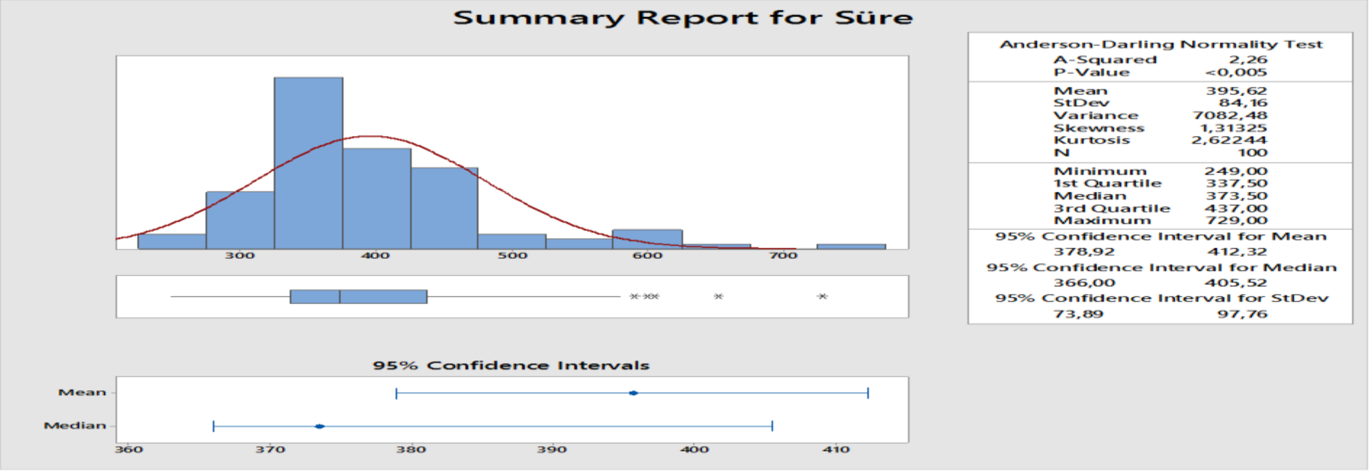


Figure 2: Normal Distribution A2

Test Failed at points: 68; 69; 70; 71; 72; 73; 74; 75; 76; 77; 78; 79; 80; 81
* WARNING * If graph is updated with new data, the results above may no longer be correct.

2.3: ANALYZE

5 Reasons Technique: Shuttle round time of no more waiting to be factory.

Why is anticipated to be taught the CDM

-WHY- ?

-WHY- ?

-WHY- ?

Second Factory Analysis

ANOVA

1. **Time-Firming Relationship**

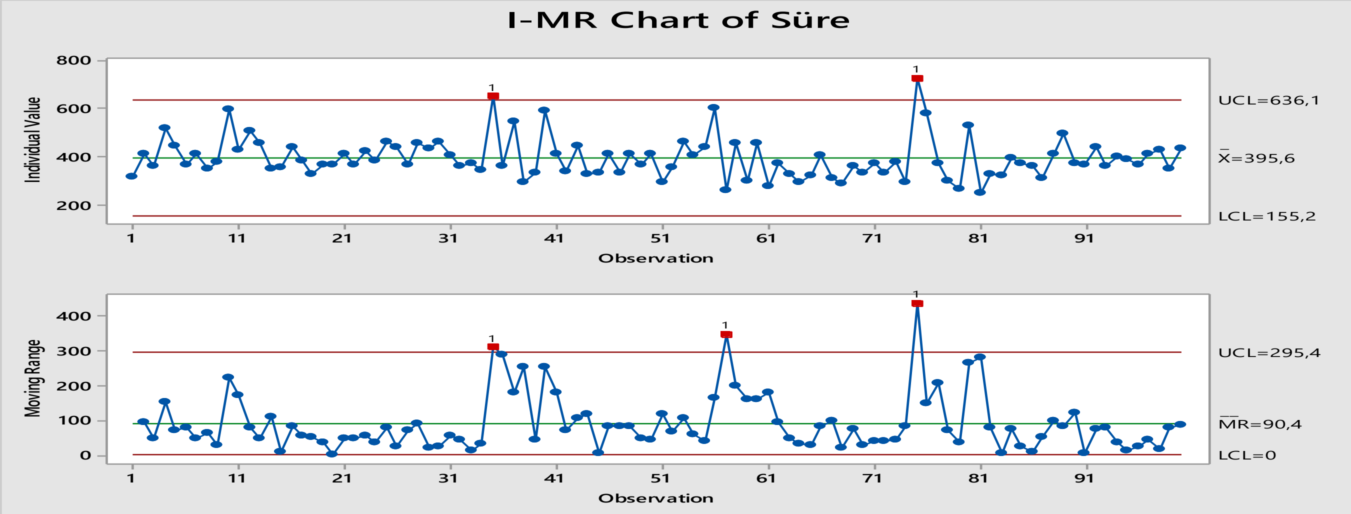


Figure 3:A2 I-MR Graphic

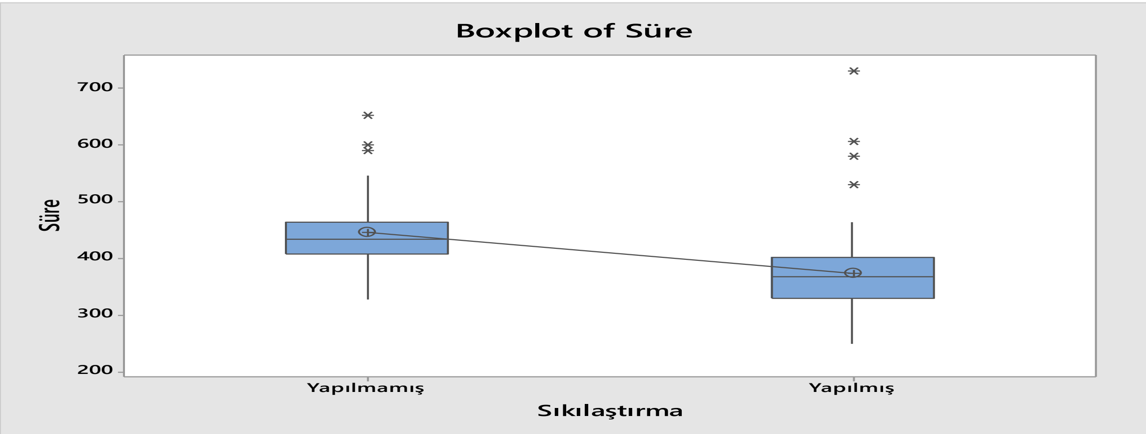


Figure 4: Firming effect of the duration of the process

Boxplot made tightening in the above chart, and yet two cases were compared in terms of time. In comparison results by tightening the field to begin the process of accelerating earnings provide approximately 120 seconds. This situation should be examined in more detail in the healing process.

Correlation: Time; Staffing T. ; Firming T. ; Terminal Usage T.

	Time	Staffing T.	Firming T.
Staffing T.	0,261		
	0,009		
Firming T.	**0,468**	-0,079	
	0,000	0,434	
Terminal Usage	0,267	0,106	0,106
	0,011	0,318	0,321

Factor Information

FactorLevelsValues
Firming 2 Unmade; Made
Analysis of Variance
Source DFAdj SS Adj MS F-Value P-Value
Firming 1 111564 111564 18,54 0,000
Error 98 589602 6016
Total 99 701166
Model Summary
S R-sq R-sq(adj) -sq(pred)
77,5651 15,91% 15,05% 12,50%
Means
Firming NMeanStDev 95% CI
Unmade 31 445,5 75,2 (417,8; 473,1)
Made 69 373,23 78,57 (354,70; 391,76)
PooledStDev = 77,5651

Quality Tools

Capacity Analysis: where the data is located in the chart below capacity analysis LSL (0.83 * 8.5 * 60 = 423) value and USL (1.33 * 8.5 * 60 = 678) values are displayed. Our goal is (7.5 * 1 * 60 = 450) is shown with a dashed green line. And it is closer to the bottom mold between USL and LSL. In this case, workers may be working at a lower pace or identified in earlier made when the preliminary study average time of 8.5 minutes (510 seconds) to investigate a relatively low state is it in terms of the current field conditions.

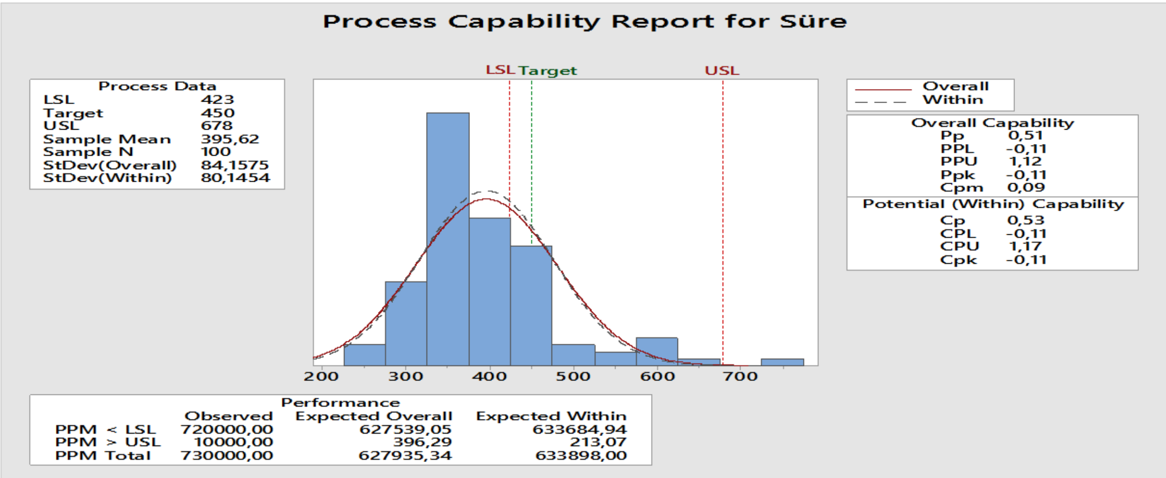


Figure 5: Parking space - time process capability analysis for

2.4:IMPROVE

Table 2: Method of and proof the root cause

Potential Root Reasons	Method of proof	Summary	Result
Complete transactions made and unmade at times friming Second Factory	ANOVA	Have a major effect on the duration of the friming process.	Root Reason
Recruitment to the service, whether it is singular or plural affects the amount of time (Second Factory)	ANOVA	Whether it is singular or plural doesn't affect the amount of time of recruitment.	Not The Root Cause
The number of workers affects the amount of time First Factory	Regresyon	The number of workers doesn't affect much the time between 8 and 11.	Not The Root Cause

First Factory also studied the number of the field affects the amount of time	Regresyon	The number of field affects the amount of time.	Root Reason
Staffing the duration of the service affects the duration of the tour (First Factory)	Regresyon	Time staffing affects lap times.	Root Reason
Fuel-packag: package and fuel processing to be completed at different times of	ANOVA	Process the packet according to the fuel processing can be completed in a longer period.	Root Reason

2.5: CONTROL

Other visual control means widely used especially in lean application is as follows.

1. Occupational Safety Indicators
2. Information Panels
3. The Staff Boards

Table 3:Concluded In The Parking Area For The Number Of Species

1	00:08:30	**11**	01:33:30	**21**	02:58:30	**31**	04:23:30	**41**	05:48:30
2	00:17:00	**12**	01:42:00	**22**	03:07:00	**32**	04:32:00	**42**	05:57:00
3	00:25:30	**13**	01:50:30	**23**	03:15:30	**33**	04:40:30	**43**	06:05:30
4	00:34:00	**14**	01:59:00	**24**	03:24:00	**34**	04:49:00	**44**	06:14:00
5	00:42:30	**15**	02:07:30	**25**	03:32:30	**35**	04:57:30	**45**	06:22:30
6	00:51:00	**16**	02:16:00	**26**	03:41:00	**36**	05:06:00	**46**	06:31:00
7	00:59:30	**17**	02:24:30	**27**	03:49:30	**37**	05:14:30	**47**	06:39:30
8	01:08:00	**18**	02:33:00	**28**	03:58:00	**38**	05:23:00	**48**	06:48:00
9	01:16:30	**19**	02:41:30	**29**	04:06:30	**39**	05:31:30	**49**	06:56:30
10	01:25:00	**20**	02:50:00	**30**	04:15:00	**40**	05:40:00	**50**	07:05:00

3. CONCLUSION

The results of the analysis concluded that the lack of induced tightening of the problems encountered in the park field work was concluded. This reason, the measurements made by evaluating the results by ANOVA study is provided to reveal rationally. Brainstorm about improvements identified problems in the implementation phase and will be made achievements in the field (quality, yield, cost) has to be judged in terms of benefits. Here in the number of workers in the field of these two cases, the average lap time is given to be compared in terms of the number of vehicles delivered daily and earnings.

Table 4:The Layout Of The Parking Area

Normal Field Work ;	
Number Of Employees	4
Average Cycle Time	00:08:30
The Actual Hours Worked On That Day	07:10:00
Man/Hours Number Of Vehicles That Are Shipped To The Field	7
Number of vehicles that are dispatched to the site of a person in a day	50
Number Of Vehicles That Are Dispatched A Day To The Team Site	200
The Number Of Automobile Production Factory (Daily)	310
Log Shipping Rate	0,65

As noted above normal course park round time is 8 minutes 30 seconds. In this case, throws in 1 hour 7 rounds, 50 rounds throwing 1 work day is completed as shown in the above table 1 working day. 4 people referred to a team of 200 vehicles per day.Park field has the capacity to produce an average of 240 vehicles per day. In this case park team carries a daily rate of 83.33% of vehicles produced in the field.

Table 5:The Effect Of The Tightening Process To The Parking Area

Firming Made Field Work;	
Number Of Employees	4
Average Cycle Time	00:06:06
The Actual Hours Worked On That Day	07:10:00
Man/Hours Number Of Vehicles That Are Shipped To The Field	10
Number of vehicles that are dispatched to the site of a person in a day	70
Number Of Vehicles That Are Dispatched A Day To The Team Site	280
The Number Of Automobile Production Factory (Daily)	310
Log Shipping Rate	0,90
Number Of Employees	7000

The average round time improvements made as a result of tightening area park exit 6 minutes 6 seconds. In this case, one worker will take 10 rounds in 1 hour as it was said above, the end of the day the team will dispatch 280 car field. In this case the vehicle will be shipped in 80 days thanks to the improvements to more areas. Thus, the rate will be shipped daily rate of around 90%. , Which means will be increased by 40%.

Table 6: Addressing The Situation To The Parking Area

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
4574	5950	7017	7623	3857	7049	7140	5338	7809	7847	6359	6901	77464

Park shows the number of fields referred to in the above table means the month. Which in this case would be referred to as a percentage of these tools after working without improvement. The table below and to rate the situation that illustrates the process of improving as more rational.

Table 7: Working In The Field Percent Of Normal

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avarage
0,91	**1,19**	**1,40**	**1,52**	0,77	**1,41**	**1,43**	**1,07**	**1,56**	**1,57**	**1,27**	**1,38**	1,29

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avarage
0,65	0,85	1,00	**1,09**	0,55	1,01	1,02	0,76	**1,12**	**1,12**	0,91	0,99	0,92

Table 8: Percent Firming worked with

Two field studies as seen above percentages are shown. 12 months while working in the normal process is studied by approximately 100% over the 10-month performance. However, this field is encountered after the tightening improving only 3 months. Thus, the pitch contribution to the healing process seems to be that way.

Table 9: Normal Idle Percentage Field

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avarage
0,09	**-0,19**	**-0,40**	**-0,52**	0,23	**-0,41**	**-0,43**	**-0,07**	**-0,56**	**-0,57**	**-0,27**	**-0,38**	-0,29

Table 10: Firming The Idle Percentage

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avarage
0,35	0,15	0,00	**-0,09**	0,45	-0,01	-0,02	0,24	**-0,12**	**-0,12**	0,09	0,01	0,08

Considering the above average when working in a normal work pace is there such a situation vacant. 8% idle state is experiencing tightening only after improvement. In this case, if thought to be about 303 days a year working day consists of a number of workers idle state 24 days. the remaining time in this period of time, these people can go to help the other team can work instead of taking the wages of workers will be so also reduce costs.

The number of vehicles produced in the factory is approximately 240 daily. Daily time spent to be referred to the entire area of the vehicle, if known to be 8.5 minutes of a vehicle to be shipped in 2040 will be multiplied by 240 * 8.5 minutes. These figures with 34 hours 4 employees 2040/60 made when this work is completed in 8.5 hours. Either the overtime thick or buffer may be provided with release means. However, there are many vehicles had to request more hours in the thick buffer next day. However, improvements made after tightening round time fell to 6 minutes and 1440 minutes.1440 240 * 6/60 when it is completed in 6 hours for 24 hours when the team considered. In this case, the operation seems to be completed before the thick of earnings as overtime beyond time.

The gain in overtime for 120 minutes start to tighten process will allow a worker to work in the field. In this way, it won 600 minutes, 480 minutes and 120 minutes reserve to tighten the net earnings situation will happen. If staff are thought to work, it will earn 1,14 person/hour. It is understood that the man was more than 1.14 at present. But the removal of the work of the person determined to be greater at the location instead of the park field to make it work during normal office hours, if necessary, the role of helping to eliminate other operations to the congestion situation by shifting. (Who played the Joker role will be to include in the field.)

As a result of this situation is resolved and prevented the time overtime during normal operation (between 08:00 to 16:00) it will be made operational.

The Multi-Reduction One Field From The Field Of The Improvement The Result;

One field Remediation of Multi-Site Result; to prompt improvement phase, in case of change of systematic data flow achieved an occupancy rate of one pitch at or above 90% and second field allow the vehicle to be shipped field is provided. This fast action was taken, the process is readily adapted to this situation and has experienced return positively.

Gains from the field of common result of these improvements;

1) Cost reduction: Field studies in the number of employees as a result of increased and more cases are resolved by rendering cost reduction is made.

2) The result of the field's regular quality process flow: Employee of the field work has also been made easier, prevented unnecessary vehicle maneuvering and provided quality process to occur.

3) Provide Returns: As a result of the improvements made in the field of handling manually or automatically achieved an increase in the pitch made addressing this issue and has led to the cost of providing earnings.

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THE OPERATIONAL PERFORMANCE RANKING OF TURKEY-DHMI'S MAJOR AIRPORTS

Emre Kaplanoğlu[1]

Abstract – Management of Turkish airports and mission of regulation and control of Turkish airspace are performed by General Directorate of State Airports Authority (DHMI). The paper evaluates and ranks the operational performance of four major airports which DHMI manages. The measure of operational performance is based on selected indicators and these're employee productivity, airline service level, passenger service level and rescue and fire service level with total of 28 criteria. TOPSIS method is used to rank and to compare operational performances of four airports according to indicators.

Keywords – Airport, DHMI, Performance Ranking, TOPSIS

INTRODUCTION

General Directorate of State Airports Authority (DHMI), which has carried on its services under different names and status since 1933 with its facilities and equipment that constitute infrastructure of Turkish Civil Aviation, has continued providing services as a state owned enterprise since 1984 within the framework of Law Decree numbered 233 and the Principle Statute. DHMI is a state economic enterprise (SEE), which has legal entity, autonomy over its activities, liability limited with its capital, is associated with Ministry of Transportation, and its services are accepted as privilege with latest legal regulation. The Authority`s purpose and subject of activities that are defined by Principle Statute are as follows; Air transport required with civil aviation activities, management of airports, performing ground services at airports and air traffic control services, establishment and operation of air navigation systems and facilities and other related facilities and systems, and to maintain them at the level of modern aeronautics. DHMI that has to perform its undertaken tasks according to international civil aviation rules and standards is in this sense a member of International Civil Aviation Organization (ICAO), which was launched according to Civil Aviation Agreement that entered into force to ensure safety of life and property at international aviation and to provide regular economic working and progress. Furthermore, it is a member of relevant international organizations, especially such as EUROCONTROL and Airports Council International (ACI). As part of air navigation and airport management services by DHMI, traffic of airplanes and passengers, which are offered service, has increased significantly in recent years. DHMI manages 50 airports from total 55 airports in Turkey. Other 5 airports managed by private companies. 50 airports are given below at Table 1. [1]

Table 1. Airports Under DHMI Management

İstanbul Atatürk	Amasya Merzifon	Hakkari Yüksekova Selahattin Eyyubi	Kapadokya
Ankara Esenboğa	Balıkesir Koca Seyit	Hatay	Ordu-Giresun
İzmir Adnan Menderes	Balıkesir Merkez	Iğdır	Samsun Çarşamba
Antalya	Batman	Isparta Süleyman Demirel	Siirt
Muğla Dalaman	Bingöl	Kahramanmaraş	Sinop
Milas-Bodrum	Bursa Yenişehir	Kars Harakani	Sivas Nuri Demirağ
Adana	Çanakkale	Kastamonu	Şanlıurfa GAP
Trabzon	Gökçeada	Kayseri Kocaeli Cengiz Topel	Şırnak Şerafettin Elçi
Erzurum	Denizli Çardak	Konya	Tekirdağ Çorlu
Gaziantep	Diyarbakır	Malatya	Tokat
Adıyaman	Elazığ	Mardin	Uşak
Ağrı Ahmed-i Hani	Erzincan	Muş	Van Ferit Melen

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Especially, there has been significant progress at international flight airplane and passenger traffic of the international airports. Istanbul/Ataturk Airport and Antalya Airport are among the leading airports of Europe due to increase in the international traffic.

The purpose of this study is to rank and compare operational performance of four major airports, İstanbul Atatürk, Ankara Esenboğa, İzmir Adnan Menderes and Antalya, which are under management of DHMI. In this paper, section headings organized as introduction, conceptual framework, TOPSIS, application and conclusions.

CONCEPTUAL FRAMEWORK

Airports are business place like any other markets where suppliers and consumers meet and run their business. Suppliers of air transportation services are airline companies and consumers are users of these services. Managing and operating this business place thus the same as other business from the view of general business goals. However, some operations of airports have more importance like rescue and security than any other business. So, the operational performance effected by four factors; airport, airline companies, passengers and rescue and fire services. In the context of this paper, operational performances of airports are divided into four levels (indicators) with 28 substitutes. Indicators adopted and modified from Wang et al.[2] These are given below at Table 2.

Table 2. Operational Performance Indicators For Airports

Employee Productivity	Airline Service Level	Passenger Service Level	Rescue and Fire Service Level
Number of take-offs and landings to number of employees	Floor area of terminal to number of airlines	Take-offs and landings to number of passengers	Number of rescuer and firefighter vehicles to number of take-offs and landing
Cargo tonnage to number of employees	Size of apron to number of airlines	Number of airlines to number of passengers	Number of rescuer and firefighter vehicles to the number of airlines
Floor area of terminal building to number of employees	Volume to number of airlines	Number of routes to number of passengers	Number of rescuer and firefighter vehicles to number of passengers
Revenue to number of employees	Volume to number of take-offs and landings	Number of car parks to the number of passengers	Number of rescuer and firefighter vehicles to floor area of terminal
Non-aviation income to number of employees	Volume to the number of routes	Degree of congestion	Number of rescuer and firefighter vehicles to number of car parks
Number of passengers to number of employees	Service standards of runway	Number of boarding gates to number of passengers	Number of rescuer and firefighter vehicles to the size of the apron
Net Income (Total Income-Expenditure) to number of employees		Number of check-in counters to number of passengers	Number of rescuer and firefighter vehicles to the number of flight routes

TOPSIS

The TOPSIS method has the advantage of being simple and yields an indisputable preference order.[3] But it does assume that each indicator takes monotonic (increasing or decreasing) utility. TOPSIS is based on the concept that the chosen indicator should have the shortest distance from the ideal solution and the farthest from the worst solution. The ideal solution is the one that enjoys the largest benefit indicator value and the smallest cost factor.[4][5] The steps involved in carrying this out are:

Step 1: Normalization of indicator values
Normalization aims at obtaining comparable scales. There are different ways of normalizing the indicator values. Here vector normalization is used. This utilizes the ratio of the original value (r_{ij}) and the square root of the sum of the original indicator values. The advantage of this approach is that all indicators are measured in dimensionless units, thus facilitating inter-indicator comparisons. This procedure is usually utilized in TOPSIS using

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad (i = 1, \dots\dots.., m \ ve \ j = 1, \dots\dots\dots, p) \tag{1}$$

where i is the *i*th airport, j is the *j*th evaluation indicator, r_{ij} is the indicator value after vector normalization for the *i*th airport and *j*th evaluation indicator, x_{ij} is the original value of indicators for the *i*th airport and *j*th evaluation indicator, and *m* is the number of airports.
Step 2: To determine ideal (A^+) and worst (A^-) solution

$$A^+ = \{(\max_i r_{ij}\, j \in J), (\min_i r_{ij}\, j \in J') \,|i = 1,2, \dots.., m\} \tag{2}$$

$$=\{A_1^+, A_2^+, \dots\dots\dots\dots\dots, A_j^+, \dots\dots\dots.., A_k^+\},$$

$$A^- = \{(\min_i r_{ij}\, j \in J), (\max_i r_{ij}\, j \in J') \,|i = 1,2, \dots.., m\} \tag{3}$$

$$=\{A_1^-, A_2^-, \dots\dots\dots\dots\dots, A_j^-, \dots\dots\dots.., A_k^-\},$$

where J={j=1,2,………, k|k} positively relates to the benefit criteria, J'={j=1,2,………k|k} positively relates to the cost criteria.

Step 3: To calculate the separation measure
The separation of each airport from the ideal airport (S_i^+) and the worst airport (S_i^-) uses

$$S_i^+ = \sqrt{\sum_{j=1}^{k}(r_{ij} - A_j^+)^2}\ ; \ S_i^- = \sqrt{\sum_{j=1}^{k}(r_{ij} - A_j^-)^2} \quad i = 1, 2, \dots\dots., m. \tag{4}$$

Step 4: To calculate the relative closeness to the ideal solution (C_i^*) This is defined as

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-} \quad 0 < C_i^* < 1. \tag{5}$$

Step 5: To rank the preference order according to the descending order of C_i^*.

APPLICATION

İstanbul Atatürk, Ankara Esenboğa, İzmir Adnan Menderes and Antalya airports are used in the analysis as considered airplane traffic and passenger traffic as major airports from DHMI's annual report in 2015. The data for operational performance indicators and equations are obtained from annual report of DHMI's 2015 annual report on official web site. Microsoft EXCEL 2010 is used to calculate equations and apply TOPSIS method. Four groups formed as main criteria; employee productivity, airline service level, passenger service level and rescue and fire service level, with 28 indicators as sub criteria. Four main criteria are weighted equally for total operational performance ranking and for each main criteria ranking of airports. The operational performance indicators, equations for indicators and weights of criteria are given below at Table 3.

Table 3. Operational Performance Indicators, Equations and Weights of Indicators

Group/Main Criteria	Code	Sub criteria Name of Indicator	Equation for Indicator	%
EMPLOYEE PRODUCTIVITY (%25)	OP1	Number of take-offs and landings to number of employees	Number of take-offs and landings/Number of employees	4
	OP2	Cargo tonnage to number of employees	Cargo tonnage/Number of employees	4
	OP3	Floor area of terminal building to number of employees	Floor area of terminal building/Number of employees	4
	OP4	Revenue to number of employees	Total revenue/Number of employees	4
	OP5	Non-aviation income to number of employees	Non-aviation income/Number of employees	4
	OP6	Number of passengers to number of employees	Number of passengers/Number of employees	4
	OP7	Net Income (Total Income-Expenditure) to number of employees	Net Income (Total Income-Expenditure)/Number of Employees	4
AIRLINE SERVICE LEVEL (%25)	OA1	Floor area of terminal to number of airlines	Floor area of terminal/Number of airlines	4
	OA2	Size of apron to number of airlines	Size of apron/Number of airlines	4
	OA3	Volume to number of airlines	Traffic volume/Number of airlines	4
	OA4	Volume to number of take-offs and landings	Traffic volume/Number of take-offs and landings	4
	OA5	Volume to the number of routes	Traffic volume/Number of routes	4
	OA6	Service standards of runway	Traffic volume/take-offs and landings during peak hours	4
PASSENGER SERVICE LEVEL (%25)	OC1	Take-offs and landings to number of passengers	Take-offs and landings/Number of passengers	4
	OC2	Number of airlines to number of passengers	Number of airlines/Number of passengers	4
	OC3	Number of routes to number of passengers	Number of routes/Number of passengers	4
	OC4	Number of car parks to the number of passengers	Number of car parks/Number of passengers	4
	OC5	Degree of congestion	Floor area of terminal/Number of passengers	4
	OC6	Number of boarding gates to number of passengers	Number of boarding gates/Number of passengers	4
	OC7	Number of check-in counters to number of passengers	Number of check-in counters/Number of passengers	4

RESCUE AND FIRE SERVICE LEVEL (%25)	OS1	Number of rescuer and firefighter vehicles to number of take-offs and landing	Number of rescuer and firefighter vehicles/Number of take-offs and landing	4
	OS2	Number of rescuer and firefighter vehicles to the number of airlines	Number of rescuer and firefighter vehicles/Number of airlines	4
	OS3	Number of rescuer and firefighter vehicles to number of passengers	Number of rescuer and firefighter vehicles/Number of passengers	4
	OS4	Number of rescuer and firefighter vehicles to floor area of terminal	Number of rescuer and firefighter vehicles/Floor area of terminal	4
	OS5	Number of rescuer and firefighter vehicles to number of car parks	Number of rescuer and firefighter vehicles/Number of car parks	4
	OS6	Number of rescuer and firefighter vehicles to the size of the apron	Number of rescuer and firefighter vehicles/Size of the apron	4
	OS7	Number of rescuer and firefighter vehicles to the number of flight routes	Number of rescuer and firefighter vehicles/Number of flight routes	4

The values of the indicators are converted into performance scores through TOPSIS method. The operational performance of İstanbul Atatürk, Ankara Esenboğa, İzmir Adnan Menderes and Antalya airports are rated according to employee productivity, airline service level, passenger service level, rescue and fire service level and total performance. The ranking of İstanbul Atatürk, Ankara Esenboğa, İzmir Adnan Menderes and Antalya airports according to their performance score are given below at Table 4.

Table 4. Ranking of Airports

Aspects	Rank 1	Rank 2	Rank 3	Rank 4
Employee productivity	İstanbul Atatürk (0.920)	Antalya (0.546)	İzmir Adnan Menderes (0.214)	Ankara Esenboğa (0.000)
Airline service level	İstanbul Atatürk (0.901)	İzmir Adnan Menderes (0.317)	Ankara Esenboğa (0.260)	Antalya (0.214)
Passenger service level	İzmir Adnan Menderes (0.901)	Ankara Esenboğa (0.751)	Antalya (0.274)	İstanbul Atatürk (0.099)
Rescue and fire service level	Antalya (0.680)	İzmir Adnan Menderes (0.446)	Ankara Esenboğa (0.339)	İstanbul Atatürk (0.241)
Total performance	İstanbul Atatürk (0.572)	Antalya (0.453)	İzmir Adnan Menderes (0.424)	Ankara Esenboğa (0.350)

The analysis allows comparisons between the operational efficiency of selected airports. In terms of total operation performance, selected airports are ranked, İstanbul Atatürk, Antalya, İzmir Adnan Menderes and Ankara Esenboğa. Each has some particular operational challenges to meet. Employee productivity from selected airports is ranked highest score to lowest as İstanbul Atatürk, Antalya, İzmir Adnan Menderes and Ankara Esenboğa. Employee productivity is the poorest in Ankara Esenboğa and best in İstanbul Atatürk airport. Airline service level from selected airports is ranked highest score to lowest as İstanbul Atatürk, İzmir Adnan Menderes, Ankara Esenboğa and Antalya airport. Airline service level is the poorest in Antalya Esenboğa and best in İstanbul Atatürk airport. Passenger service level from selected airports is ranked highest score to lowest as İzmir Adnan Menderes, Ankara Esenboğa, Antalya and İstanbul Atatürk airport. Passenger service level is the poorest in İstanbul Atatürk and best in Ankara Esenboğa airport. Rescue and fire service level from selected airports is ranked highest score to lowest as Antalya, İzmir Adnan Menderes, Ankara Esenboğa and İstanbul Atatürk airport. Rescue and fire service level is the poorest in İstanbul Atatürk and best in Antalya airport. In overall evaluation İstanbul Atatürk airport has the best rating scores for both employee productivity and airline service level and also has the poorest rating scores for both passenger service level and rescue and fire service level in operational performance groups.

CONCLUSIONS

The paper has applied the TOPSIS method in ranking of operational performance for evaluation of four major airports under management of Turkey-General Directorate of State Airports Authority (DHMI). This study suggests that the various airports either domestic or international under government management may find it useful to pursue a variety of measures to enhance their performance when compared privately managed airports. The results indicate that the total performance rating and each group's performance ratings differ when examined separately. In doing so, the poorest operations can be detected easily and developed to increase efficiency and quality. For further studies, it is suggested to apply other multi criteria decision making methods with different weights and compare airports' which are under management of state and private companies.

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ANALYSIS OF OECD COUNTRIES IN COMPARISON WITH OTHER COUNTRIES IN TERMS OF LOGISTICS PERFORMANCE INDEX

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Abstract

Logistics industry has become an extremely important industry for the country and the world economy in recent years. Increased competition not only affects international business in terms of logistics, also seriously affects the countries of the world. Especially, well-organized logistics activities affect positively such as production, export, import, marketing and distribution concepts. Logistics industry creates crucial impacts on the national economy thanks to its employment, national income and directing foreign capital. Therefore, logistics industry is extremely important for the growth of the national economy. As a result of these conditions has made an important logistics industry and logistics industry has the biggest share of the industry position in the service sector in many countries.

Logistics almost have an inclusive structure due to all industries and the emphasis on the development of the national economy, at the research analyzes were conducted on the scores of countries in the Logistics Performance Index. The World Bank Logistics Performance Index (LPI) reports were published in 2007, 2010, 2012 and 2014. There are six main components of the 160 countries scores. At the research, a total of 34 developed and developing OECD countries and the other 126 countries at the index were compared according to their overall scores and subscores.

Within the scope of this research, for analysing OECD countries and the other countries their overall scores and subscores at the index, data for all the countries in the index were entered to the PASW Statistics 18 SPSS packaged software and firstly, through this program was applied the "factor analysis/principal component analysis" method to the six core components at the index. After this process, the data has been processed with SPSS 18 package program with frequency distribution and one of the main statistical analyses of "dependent samples t-test" have been used. This empirical study has shown that according to the Logistics Performance Index, there is a significant difference between the overall scores and subscores of the OECD countries and the other countries at index.

Keywords: Logistics Management, Logistics Performance Index (LPI), OECD Countries

1. Introduction

The LPI consists therefore of both qualitative and quantitative measures and helps build profiles of logistics friendliness for these countries. It measures performance along the logistics supply chain within a country and offers two different perspectives: international and domestic.

The LPI is based on a worldwide survey of operators on the ground (global freight forwarders and express carriers), providing feedback on the logistics “friendliness” of the countries in which they operate and those with which they trade. They combine in-depth knowledge of the countries in which they operate with informed qualitative assessments of other countries where they trade and experience of global logistics environment. Feedback from operators is supplemented with quantitative data on the performance of key components of the logistics chain in the country of work (Germany Trade and Invest - GTAI, 2016).

The international score uses six key dimensions to benchmark countries' performance and also displays the derived overall LPI index. The scorecard allows comparisons with the world (with the

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option to display world's best performer) and with the region or income group (with the option to display the region’s or income group's best performer) on the six indicators and the overall LPI.

The logistics performance index (LPI) is the weighted average of the country scores on the six key dimensions (Arvis and others, 2010, p. 4):

1) Efficiency of the clearance process (speed, simplicity and predictability of formalities) by border control agencies, including customs;
2) Quality of trade and transport related infrastructure (ports, railroads, roads, information technology);
3) Ease of arranging competitively priced shipments;
4) Competence and quality of logistics services (transport operators, customs brokers);
5) Ability to track and trace consignments;
6) Timeliness of shipments in reaching destination within the scheduled or expected delivery time.

The international LPI is a summary indicator of logistics sector performance, combining data on six core performance components into a single aggregate measure. Some respondents did not provide information for all six components, so interpolation is used to fill in missing values. The missing values are replaced with the country mean response for each question, adjusted by the respondent’s average deviation from the country mean in the answered questions.

The six core components are:

1. The efficiency of customs and border clearance, rated from “very low” (1) to “very high” (5) in Word Bank Logistics Performance Index survey.
2. The quality of trade and transport infastructure, rated from “very low” (1) to “very high” (5) in Word Bank Logistics Performance Index survey.
3. The ease of arranging competitively priced shipments, rated from “very difficult” (1) to “very easy” (5) in Word Bank Logistics Performance Index survey.
4. The competence and quality of logistics services, rated from “very low” (1) to “very high” (5) in Word Bank Logistics Performance Index survey.
5. The ability to track and trace consignments, rated from “very low” (1) to “very high” (5) in Word Bank Logistics Performance Index survey.
6. The frequency with which shipments reach consignees within scheduled or expected delivery times, rated from “hardly ever” (1) to “nearly always” (5) in Word Bank Logistics Performance Index survey (Arvis and others, 2010, p. 51-52).

2. Aim of The Study

The main purpose of this study is to analyze according to the Logistics Performance Index, it examines whether there is a statistically significant difference between the OECD countries and the overall scores and subscores of the other indigenous (other) countries. There are 34 OECD countries in the world, so these OECD countries are drawing the economical shape of the world and they are giving direction to the world. The mission of the Organisation for Economic Co-operation and Development (OECD) is to promote policies that will improve the economic and social well-being of people around the world. The OECD provides a forum in which governments can work together to share experiences and seek solutions to common problems. They work with governments to understand what drives economic, social and environmental change. They measure productivity and global flows of trade and investment. They analyse and compare data to predict future trends. Also, they set international standards on a wide range of things, from agriculture and tax to the safety of chemicals. That is why reasons OECD countries were selected in the research (OECD, 2016).

According to the LPI 2014 report, the logistic scores of the remaining 126 countries were compared with statistical methods according to the LPI general score and six basic subscores of 34 OECD member countries. This research is an inferential statistical study and the findings are interpreted.

However, after determining the basic hypothesis and sub hypotheses about the research, it is aimed to interpret these hypotheses with statistical test methods and models.

3. Data and Methodology / Empirical Findings

In this part, it has been tried to determine whether the LPI scores of the 34 OECD countries in the Logistics Performance Index are compared with the scores of the remaining 126 countries and whether there is a meaningful difference between them. Analysis of the obtained data was done with PASW Statistics 18 SPSS package program. Then the relationships of the basic components in the LPI are measured by "factor analysis". In the interpretive statistical analysis, hypotheses were tested using the independent sample "t" test.

3.1. Hypotheses of Research

In this section, the basic hypothesis of the research and the sub hypotheses of the research are detailed below.

The dependent groups t test hypothesis can be expressed in two different ways (Sipahi and others, 2010, p. 134-139). These are;

Basic hypothesis:

H_0: There is a significant difference between the LPI general scores of OECD countries and the LPI general scores of other indigenous countries.

H_1: There is no significant difference between the LPI general scores of OECD countries and the LPI general scores of other indigenous countries.

Sub hypotheses:

H_{0a}: There is a significant difference between the LPI customs subscores of OECD countries and the LPI customs subscores of other indigenous countries.

H_{1a}: There is no significant difference between the LPI customs subscores of OECD countries and the LPI customs subscores of other indigenous countries.

H_{0b}: There is a significant difference between the LPI infrastructure subscores of OECD countries and the LPI infrastructure subscores of other indigenous countries.

H_{1b}: There is no significant difference between the LPI infrastructure subscores of OECD countries and the LPI infrastructure subscores of other indigenous countries.

H_{0c}: There is a significant difference between OECD countries' subscores on the ease of setting LPI shipments and the subscores on ease of setting LPI shipments of other indigenous countries.

H_{1c}: There is no significant difference between OECD countries' subscores on the ease of setting LPI shipments and the subscores on ease of setting LPI shipments of other indigenous countries.

H_{0d}: There is a significant difference between OECD countries' qualification and capableness of logistics services with the other countries' qualification and capableness of logistics services subscores of Logistics Performance Index.

H_{1d}: There is no significant difference between OECD countries' qualification and capableness of logistics services with the other countries' qualification and capableness of logistics services subscores of Logistics Performance Index.

H_{0e}: There is a significant difference between the LPI monitoring and traceability subscores of OECD countries and the LPI monitoring and traceability subscores of other indicated countries.

H_{1e}: There is no significant difference between the LPI monitoring and traceability subscores of OECD countries and the LPI monitoring and traceability subscores of other indicated countries.

H_{0f}: There is a significant difference between the LPI timeliness subscores of OECD countries and the LPI timeliness subscores of other indigenous countries.

H_{1f}: There is no significant difference between the LPI timeliness subscores of OECD countries and the LPI timeliness subscores of other indigenous countries.

3.2. Factor Analysis

Factor analysis is one of the most widely used multivariate statistical techniques, making a large number of interrelated variables small, meaningful, and independent of each other (Kleinbaum and others, 1998, p. 601).

The KMO (Kaiser-Meyer-Olkin) value shows how well the factor analysis is in place. Where this ratio is between 0,5 and 1 the suitability of the analysis is accepted, but it is generally considered acceptable by researchers when this ratio is above the 0,7 limit (Altunisik and others, 2005).

3.2.1. Factor Analysis for OECD Countries

At the beginning of the factor analysis, it was examined whether the factors were suitable for analysis by looking at the proportional common causal variance of the data. In fact, the proportional coefficient of common causality indicates the strength and the quality of the factors. From Table 1, "OECD_F1"customs subscore factor for the first group OECD countries, "OECD_F2" infrastructure subscore factor, "OECD_F3" ease of setting of shipments subscore factor, "OECD_F4" logistics services competence and quality subscore factor, "OECD_F5" tracking and traceability subscore factor and "OECD_F6" refers to the timeliness subscore factor.

Table 1: Communality for OECD Countries

	Starting	Communality
OECD_F1	1,000	0,730
OECD_F2	1,000	0,911
OEC_F3	1,000	0,629
OECD_F4	1,000	0,910
OECD_F5	1,000	0,659
OECD_F6	1,000	0,638

It is expected that the variance of the proportional common actor will be larger than 0,4 by the researchers. As a result of this measurement, it was observed that the six substances surveyed according to Table 1 were above 0,4 and the substances had sufficient proportional common variance for factor analysis.

Table 2: KMO ve Barlett's Test for OECD Countries

KMO ve Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0,826**
Bartlett's Test of Sphericity	Approx. Chi-Square	181,403
	df	15
	Sig.	0,000

According to Table 2, "KMO value" was found as 0,826 according to the data obtained from OECD countries as a result of KMO (Kaiser-Meyer-Olkin) and Bartlett's test. This value is considered to be a very good value, and factor analysis has been tested with the value of "Sig." being zero. Thus, for OECD countries it has been determined that these data are in accordance with the factor analysis.

Table 3: Cumulative Variance Ratio for OECD Countries

Cumulative Variance

Factor	Starting Basic Values			Error Sum of Squares		
	Total	Variance Percentage (%)	Cumulative Percentage (%)	Total	Variance Percentage (%)	Cumulative Percentage (%)
1	4,478	74,629	74,629	4,478	74,629	**74,629**
2	0,526	8,771	83,400			
3	0,451	7,511	90,911			
4	0,392	6,530	97,441			
5	0,081	1,344	98,785			
6	0,073	1,215	100,000			

According to Table 3, in the analysis of six substances in total, a total factor variance of these six substances has been reached. This total variance explains a rate of 74.629 % for our factor analysis. For factor analysis this value is acceptable.

From Figure 1, where the total variances are shown, only one of the six factors remains above 1 and follows a linear trend with a tendency to fall in the next factor step.

Figure 1: Cumulative Variance Chart for OECD Countries

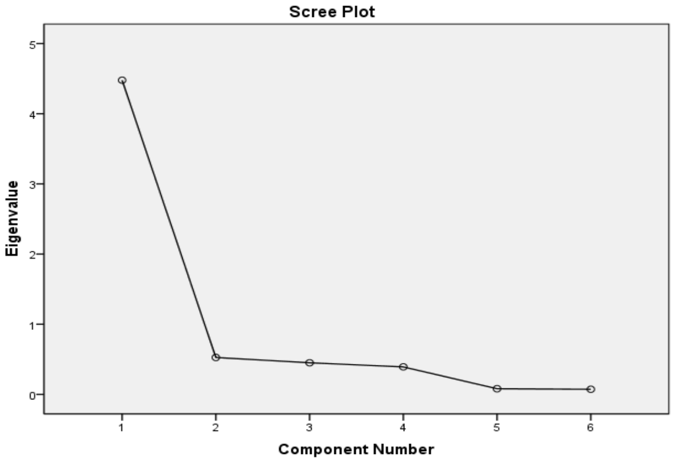

Table 4: Correlation Matrix for OECD Countries

Correlation	OECD_F1	OECD_F2	OECD_F3	OECD_F4	OECD_F5	OECD_F6
OECD_F1	**1,000**	0,852	0,637	0,835	0,509	0,553
OECD_F2	0,852	**1,000**	0,690	0,918	0,755	0,696
OECD_F3	0,637	0,690	**1,000**	0,655	0,566	0,590
OECD_F4	0,835	0,918	0,655	**1,000**	0,777	0,722
OECD_F5	0,509	0,755	0,566	0,777	**1,000**	0,598
OECD_F6	0,553	0,696	0,590	0,722	0,598	**1,000**

Lastly from Table 4, "Correlation Matrix" and the correlations of the factors with each other, that is, the relations between the factors are examined. If the correlation matrix value is over 0,3 the factors are related to each other. But if the correlation matrix value is below 0,3 we can say that the factors are independent of each other. If we make a tabular deduction in this direction, the correlations between the six factors are all over 0,3 so the relationship between the factors is strong.

3.2.2. Factor Analysis for Other Countries at The LPI

At the beginning of the factor analysis, it was examined wheher the factors were suitable for analysis by looking at the proportional common causal variance of the data. In fact, the proportional coefficient of common causality indicates the strength and the quality of the factors. From Table 5, "Others_F1"customs subscore factor for the second group OECD countries, "Others_F2" infrastructure subscore factor, "Others_F3" ease of setting of shipments subscore factor, "Others_F4" logistics services competence and quality subscore factor, "Others_F5" tracking and traceability subscore factor and "Others_F6" refers to the timeliness subscore factor.

Table 5: Communality for Other Countries

	Starting	Communality
Others_F1	1,000	0,793
Others_F2	1,000	0,895
Others_F3	1,000	0,819
Others_F4	1,000	0,911
Others_F5	1,000	0,871
Others_F6	1,000	0,775

It is expected that the variance of the proportional common actor will be larger than 0,4 by the researchers. As a result of this measurement, it was observed that the six substances surveyed according to Table 5 were above 0,4 and the substances had sufficient proportional common variance for factor analysis.

Table 6: KMO ve Barlett's Test for Other Countries

KMO ve Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0,916**
Bartlett's Test of Sphericity	Approx. Chi-Square	901,310
	df	15
	Sig.	0,000

According to Table 6, "KMO value" was found as 0,916 according to the data obtained from Other countries as a result of KMO (Kaiser-Meyer-Olkin) and Bartlett's test. This value is considered to be a very good value, and factor analysis has been tested with the value of "Sig." being zero. Thus, for Other countries it has been determined that these data are in accordance with the factor analysis.

According to Table 7, in the analysis of six substances in total, a total factor variance of these six substances has been reached. This total variance explains a rate of 84,417 % for our factor analysis. For factor analysis this value is acceptable.

From Figure 2, where the total variances are shown, only one of the six factors remains above 1 and follows a linear trend with a tendency to fall in the next factor step.

Table 7: Cumulative Variance Ratio for Other Countries

Cumulative Variance

Factor	Starting Basic Values			Error Sum of Squares		
	Total	Variance Percentage (%)	Cumulative Percentage (%)	Total	Variance Percentage (%)	Cumulative Percentage (%)
1	5,065	84,417	84,417	5,065	84,417	**84,417**
2	0,362	6,038	90,455			
3	0,216	3,595	94,050			
4	0,155	2,582	96,633			

Factor	Starting Basic Values			Error Sum of Squares		
	Total	Variance Percentage (%)	Cumulative Percentage (%)	Total	Variance Percentage (%)	Cumulative Percentage (%)
5	0,105	1,743	98,375			
6	0,097	1,625	100,000			

Figure 2: Cumulative Variance Chart for Other Countries

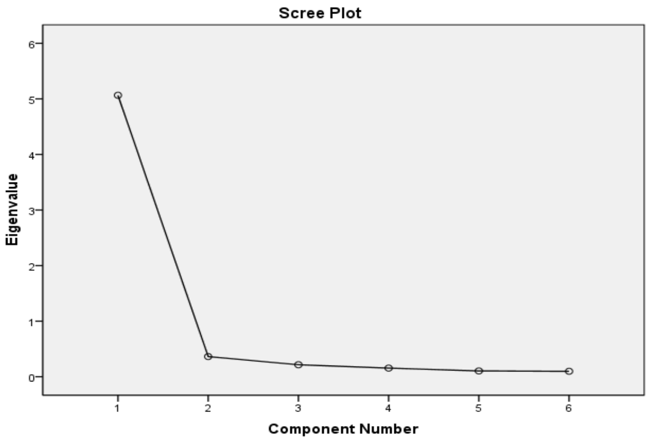

Table 8: Correlation Matrix for Other Countries

Correlation	Others_F1	Others_F2	Others_F3	Others_F4	Others_F5	Others_F6
Others_F1	**1,000**	0,872	0,778	0,828	0,770	0,661
Others_F2	0,872	**1,000**	0,819	0,882	0,851	0,786
Others_F3	0,778	0,819	**1,000**	0,828	0,806	0,759
Others_F4	0,828	0,882	0,828	**1,000**	0,888	0,828
Others_F5	0,770	0,851	0,806	0,888	**1,000**	0,824
Others_F6	0,661	0,786	0,759	0,828	0,824	**1,000**

Lastly from Table 8, "Correlation Matrix" and the correlations of the factors with each other, that is, the relations between the factors are examined. If the correlation matrix value is over 0,3 the factors are related to each other. But if the correlation matrix value is below 0,3 we can say that the factors are independent of each other. If we make a tabular deduction in this direction, the correlations between the six factors are all over 0,3 so the relationship between the factors is strong.

3.3. Analyzing The Hypotheses With ‘‘T’’ Test

The "t" test is a method of analysis thatis used to test the accuracy of this prediction when certain predictions are made on any subject (Gafuroglu, 2007, p. 98).

Dependent groups the "t" test is a one-way hypothesis and the H_0 hypothesis is accepted or rejected based on the *p* value calculated when acceptance or rejection is given. When H_0 is accepted, if $p > 0,05$ it is decided that the groups have different averages for the tested variable. When H_0 is rejected, it is decided that the averages for the tested *p* variable are the same as each other (Sipahi and others, 2010, p. 134-139).

3.3.1. LPI Overall Score

Table 9: Hypothesis Acceptance Status Based on LPI Overall Score

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Average	3,665882353	2,685907556

Variance	0,078218895	0,161911807
Observation	34	126
Cumulative Variance	0,144431642	
Average Difference	0	
df	158	
t Stat	13,34284597	
P(T<=t) one-tailed test	5,57629E-28	
t Critical one-tailed test	1,654554875	
P(T<=t) two-tailed test	1,11526E-27	
t Critical two-tailed test	1,975092073	

From Table 9, "Variable 1" refers to the findings of OECD countries while "Variable 2" refers to findings of other indigenous countries. There is an average difference of 0,979974797 between the average of the LPI overall scores of the OECD countries and the average of the overall scores of the other countries. There is a significant difference between them because they are far from each other.

In the "t" test, a significance level of 0.05 (5%) was accepted. When the variances of "Variable 1" and "Variable 2" are compared (0,078218895<0,1161911807). Since the variance of "Variable 1" is smaller, the averages are closer together and there is no widespread distribution around the mean. This situation increases the level of significance of "Variable 1". The variance of "Variable 2" is more widely distributed around the mean. Lastly, *p* value (t Stat) was calculated as 13,34284597. Because of this value is larger than the *t critical two-tailed value* (13,34284597>1,975092073), H_0 hypothesis is accepted. It is concluded that the LPI overall scores of OECD countries are different from the LPI overall scores of other indigenous countries.

3.3.2. LPI *Customs* Subscore

Table 10: Hypothesis Acceptance Status Based on LPI Customs Subscore

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Average	3,550757853	2,503280643
Variance	0,13511656	0,179671353
Observation	34	126
Cumulative Variance	0,170365605	
Average Difference	0	
df	158	
t Stat	13,13162169	

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
P(T<=t) one-tailed test	2,11503E-27	
t Critical one-tailed test	1,654554875	
P(T<=t) two-tailed test	4,23005E-27	
t Critical two-tailed test	1,975092073	

From Table 10, "Variable 1" refers to the findings of OECD countries while "Variable 2" refers to findings of other indigenous countries. There is an average difference of 1,04747721 between the average of the LPI customs subscores of the OECD countries and the average of the customs subscores of the other countries. There is a significant difference between them because they are far from each other.

In the "t" test, a significance level of 0.05 (5%) was accepted. When the variances of "Variable 1" and "Variable 2" are compared (0,13511656<0,179671353). Since the variance of "Variable 1" is smaller, the averages are closer together and there is no widespread distribution around the mean. This situation increases the level of significance of "Variable 1". The variance of "Variable 2" is more widely distributed around the mean. Lastly, *p* value (t Stat) was calculated as 13,13162169. Because of this value is larger than the *t critical two-tailed value* (13,13162169>1,975092073), H_{0a} hypothesis is accepted. It is concluded that the LPI customs subscores of OECD countries are different from the LPI customs subscores of other indigenous countries.

3.3.3. LPI *Infrastructure* Subscore

Table 11: Hypothesis Acceptance Status Based on LPI Infrastructure Subscore

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Average	3,689333794	2,517208056
Variance	0,161883587	0,220937535
Observation	34	126
Cumulative Variance	0,208603483	
Average Difference	0	
df	158	
t Stat	13,27939119	
P(T<=t) one-tailed test	8,32175E-28	
t Critical one-tailed test	1,654554875	
P(T<=t) two-tailed test	1,66435E-27	
t Critical two-tailed test	1,975092073	

From Table 11, "Variable 1" refers to the findings of OECD countries while "Variable 2" refers to findings of other indigenous countries. There is an average difference of 1,172125738 between the average of the LPI infrastructure subscores of the OECD countries and the average of the infrastructure subscores of the other countries. There is a significant difference between them because they are far from each other.

In the "t" test, a significance level of 0.05 (5%) was accepted. When the variances of "Variable 1" and "Variable 2" are compared (0,161883587<0,220937535). Since the variance of "Variable 1" is smaller, the averages are closer together and there is no widespread distribution around the mean. This situation increases the level of significance of "Variable 1". The variance of "Variable 2" is more widely distributed around the mean. Lastly, *p* value (t Stat) was calculated as 13,27939119. Because of this value is larger than the *t critical two-tailed value* (13,27939119>1,975092073), H_{0b} hypothesis is accepted. It is concluded that the LPI infrastructure subscores of OECD countries are different from the LPI infrastructure subscores of other indigenous countries.

3.3.4. LPI *Convenience of Shipment Adjustment* Subscore

From Table 12, "Variable 1" refers to the findings of OECD countries while "Variable 2" refers to findings of other indigenous countries. There is an average difference of 0,730049503 between the average of the LPI convenience of shipment adjustment subscores of the OECD countries and the average of the convenience of shipment adjustment subscores of the other countries. There is a significant difference between them because they are far from each other.

Table 12: Hypothesis Acceptance Status Based on LPI Convenience of Shipment Adjustment Subscore

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Average	3,439237971	2,709188468
Variance	0,062009066	0,177139768
Observation	34	126
Cumulative Variance	0,153093482	
Average Difference	0	
df	158	
t Stat	9,654698096	
P(T<=t) one-tailed test	6,3423E-18	
t Critical one-tailed test	1,654554875	
P(T<=t) two-tailed test	1,26846E-17	
t Critical two-tailed test	1,975092073	

In the "t" test, a significance level of 0.05 (5%) was accepted. When the variances of "Variable 1" and "Variable 2" are compared (0,062009066<0,177139768). Since the variance of "Variable 1" is smaller, the averages are closer together and there is no widespread distribution around the mean. This situation increases the level of significance of "Variable 1". The variance of "Variable 2" is more widely distributed around the mean. Lastly, *p* value (t Stat) was calculated as 9,654698096. Because of this value is larger than the *t critical two-tailed value* (9,654698096>1,975092073), H_{0c} hypothesis is accepted. It is concluded that the LPI convenience of shipment adjustment subscores of OECD countries are different from the LPI convenience of shipment adjustment subscores of other indigenous countries.

3.3.5. LPI *Logistics Services Adequacy and Quality* Subscore

From Table 13, "Variable 1" refers to the findings of OECD countries while "Variable 2" refers to findings of other indigenous countries. There is an average difference of 1,046030364 between the average of the LPI logistics services adequacy and quality subscores of the OECD countries and the average of the logistics services adequacy and quality subscores of the other countries. There is a significant difference between them because they are far from each other.

Table 13: Hypothesis Acceptance Status Based on LPI Logistics Services Adequacy and Quality Subscore

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Average	3,67759388	2,631563516
Variance	0,09116274	0,174450452
Observation	34	126
Cumulative Variance	0,15705492	
Average Difference	0	
df	158	
t Stat	13,6578791	
P(T<=t) one-tailed test	7,6572E-29	
t Critical one-tailed test	1,65455488	
P(T<=t) two-tailed test	1,5314E-28	
t Critical two-tailed test	1,97509207	

In the "t" test, a significance level of 0.05 (5%) was accepted. When the variances of "Variable 1" and "Variable 2" are compared (0,09116274<0,174450452). Since the variance of "Variable 1" is smaller, the averages are closer together and there is no widespread distribution around the mean. This situation increases the level of significance of "Variable 1". The variance of "Variable 2" is more widely distributed around the mean. Lastly, *p* value (t Stat) was calculated as 13,6578791. Because of this value is larger than the *t critical two-tailed value* (13,6578791>1,975092073), H_{0d} hypothesis is accepted. It is concluded that the LPI logistics services adequacy and quality subscores of OECD countries are different from the LPI logistics services adequacy and quality subscores of other indigenous countries.

3.3.6. LPI *Ability to Track and Trace Consignments* Subscore

From Table 14, "Variable 1" refers to the findings of OECD countries while "Variable 2" refers to findings of other indigenous countries. There is an average difference of 0,966675201 between the average of the LPI ability to track and trace consignments subscores of the OECD countries and the average of the ability to track and trace consignments subscores of the other countries. There is a significant difference between them because they are far from each other.

In the "t" test, a significance level of 0.05 (5%) was accepted. When the variances of "Variable 1" and "Variable 2" are compared (0,118313949<0,19926271). Since the variance of "Variable 1" is smaller, the averages are closer together and there is no widespread distribution around the mean. This situation increases the level of significance of "Variable 1". The variance of "Variable 2" is more widely distributed around the mean. Lastly, *p* value (t Stat) was calculated as 11,71347246. Because of this value is larger than the *t critical two-tailed value* (11,71347246>1,975092073), H_{0e} hypothesis is accepted. It is concluded that the LPI ability to track and trace consignments subscores of OECD countries are different from the LPI ability to track and trace consignments subscores of other indigenous countries.

Table 14: Hypothesis Acceptance Status Based on LPI Ability to Track and Trace Consignments Subscore

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Average	3,660418471	2,69374327
Variance	0,118313949	0,19926271
Observation	34	126
Cumulative Variance	0,182355687	
Average Difference	0	
df	158	
t Stat	11,71347246	
P(T<=t) one-tailed test	1,65305E-23	
t Critical one-tailed test	1,654554875	
P(T<=t) two-tailed test	3,30609E-23	
t Critical two-tailed test	1,975092073	

3.3.7. LPI *Timeliness* Subscore

Table 15: Hypothesis Acceptance Status Based on LPI Timeliness Subscore

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Average	4,025275882	3,044703071

t-Test: Two Examples Assuming Equal Variances	*Variable 1*	*Variable 2*
Variance	0,088574583	0,209056485
Observation	34	126
Cumulative Variance	0,183892543	
Average Difference	0	
df	158	
t Stat	11,83211896	
P(T<=t) one-tailed test	7,81381E-24	
t Critical one-tailed test	1,654554875	
P(T<=t) two-tailed test	1,56276E-23	
t Critical two-tailed test	1,975092073	

From Table 15, "Variable 1" refers to the findings of OECD countries while "Variable 2" refers to findings of other indigenous countries. There is an average difference of 0,980572811 between the average of the LPI timeliness subscores of the OECD countries and the average of the timeliness subscores of the other countries. There is a significant difference between them because they are far from each other.

In the "t" test, a significance level of 0.05 (5%) was accepted. When the variances of "Variable 1" and "Variable 2" are compared (0,088574583<0,209056485). Since the variance of "Variable 1" is smaller, the averages are closer together and there is no widespread distribution around the mean. This situation increases the level of significance of "Variable 1". The variance of "Variable 2" is more widely distributed around the mean. Lastly, *p* value (t Stat) was calculated as 11,83211896. Because of this value is larger than the *t critical two-tailed value* (11,83211896>1,975092073), H_{0f} hypothesis is accepted. It is concluded that the LPI timeliness subscores of OECD countries are different from the LPI timeliness subscores of other indigenous countries.

3.4. The Acceptance Status of Hypotheses

At this part, the acceptance of hypothesis results in the context of the findings in the analysis is given collectively at the Table 16. Whether or not there are meaningful differences in the hypotheses ensures that the hypothesis is accepted or rejected.

Table 16: The Acceptance Status of Hypotheses

Hypothesis	**Observation**	**‘‘T’’ Stat**	**‘‘T’’ Critical Two-Tailed**	**Hypothesis Accepted / Rejected Status**
H_0	160	13,34284597	1,975092073	**Accepted**
H_{0a}	160	13,13162169	1,975092073	**Accepted**
H_{0b}	160	13,27939119	1,975092073	**Accepted**

H_{0c}	160	9,654698096	1,975092073	**Accepted**
H_{0d}	160	13,6578791	1,975092073	**Accepted**
H_{0e}	160	11,71347246	1,975092073	**Accepted**
H_{0f}	160	11,83211896	1,975092073	**Accepted**

Consequently, in our research, the hypothesis that the OECD countries and other indigenous countries' logistics performance indexes are analyzed in terms of overall scores and subscores is not accidental, and statistically significant difference was reached between them.

4. Conclusion

In recent years, the logistics industry has become a rapidly growing sector in the world and especially in Turkey. Especially when it comes to concepts such as production, export, import, marketing, it is not possible to mention the importance of logistics activities. Therefore, the logistics sector is extremely important for the survival of the country's economy. The stronger and more effective the relationship between the logistics sector and the industrial sector, the greater the share of logistics in economic growth.

Countries need to determine logistic development policies as well as economic development policies. In this context, the logistics performance index is the only widely known work in the literature that studies countries' logistics potentials and their infrastructures with a detailed study process. In addition, scores from the World Bank's Logistics Performance Index are closely followed by governments, policy makers, logistics professionals and experts all over the world. From this point of view, the analysis and findings obtained in the survey are very important indicators of the future of the world economy and the logistic sectors of the countries.

The main purpose of the survey is to compare 34 OECD countries with 126 other countries in terms of logistics activities, according to the Logistics Performance Index reports, which have scores of 160 countries in total. Firstly, six basic components belonging to LPI were analyzed by basic component analysis in the context of factor analysis. With using analysis of basic components, the significance levels of the factors used in determining the LPI overall score were determined and the suitability of the index for six factors was determined.

After basic component analysis, the LPI overall scores and subscores of OECD countries and other indigenous countries were analyzed by " t " test. Using the averages and variances of the data, the "t stat" and "t critical two-tailed" values were reached. Finally, the hypotheses presented to the research according to whether the "t stat" value is greater than the "t critical two-tailed" value are accepted or rejected.

After all these analyzes, findings and research hypotheses are accepted, a general evaluation is made below.

The high export volumes of OECD countries directly affect LPI general scores. We can detail the relationship between exports and logistics performance in the following way. In foreign trade, the logistics sector is an indispensable element. All finished products imported or exported are subject to logistics services. Therefore, it is known that there is a relation between foreign trade and logistics, especially transportation, and this relationship indirectly affects foreign trade. In other words, the intense livelihood of foreign trade in a country and the high foreign trade figures of the country necessitate that the logistic infrastructure, potential and logistic service providers of that country are strong. At this point, the export figures of developed OECD countries confirm the relationship between logistics and exports.

5. References

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