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“TRADE AND FREIGHT: FROM SOIL TO CONSUMER”

Maltepe University and Logistics Association Publication

8^{th} International Logistics & Supply Chain Congress

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"TRADE AND FREIGHT: FROM SOIL TO CONSUMER"

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PREFACE

It is a great pleasure for us to host the 8th International Logistics and Supply Chain Congress, 2010, in Istanbul. The Congress is organized by Maltepe University, Logistics Association (LODER) and Zaragoza Logistics Center this year.

The International Logistics and Supply Chain Congress is being arranged in cooperation with a Turkish University, an International University and LODER every year. Hence we thank a lot to Robert Morris University (USA), Bahçeşehir University (TR), City University (GB), Dokuz Eylül University (TR), University of Paris 1-Sorbonne (FR), Galatasaray University (TR), Miskolc University (H), Belgrade University (SCG), Izmir University of Economics (TR), Okan University (TR) and Technical University of Berlin (GE), İstanbul Bilgi University (TR), Neu-Ulm University (GE), Yıldız Technical University (TR), Ahmet Yesevi University (KH), University of Economics in Katowice (PL) for their support in the previous years.

The main objective of the Congress is to bring together international experts from academic entities and practitioners from the industry, and to provide a platform for presenting and discussing recent developments on the relationship among the logistics, supply chain management and international value chains. 58 Papers from different countries were accepted and published in the proceedings.

Trade and logistics is the main building blocks of the bridge (supply chains) between the producer and the customer. Supply chain management and supply chain logistics management give us a wider perspective than logistics alone. Since the supply chain management is a new business management style, supply chain logistics management is the management of logistics activities along the supply chain. Managing supply chains involve two different chains: the primary chain of goods, and the secondary chain of the container. While goods are providing customer satisfaction, the container starts a reverse journey to meet other goods for new destinations. Former researches have traditionally been focused on the supply of goods; the secondary chain has been overlooked. For sustainability, we have to think more green; we have to consider reverse flows for the good and the package/container – whole or recycled.

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

In a recent research made by IBM, the key challenges of supply chain managers are the supply chain visibility, risk management, increasing customer demands, costs containment and globalization. In order to overcome those challenges we have to think smarter: more instrumented, more interconnected and more intelligent. By this way, scientific congresses are very useful as a reference for finding solutions for problems. We are sure that this congress will provide one of the corner stones in this basis with presentations, discussions and proceedings.

We would like to thank Maltepe University, Zaragoza Logistics Center, and LODER for their efforts in organizing this congress. The support of Keynote Speakers of the Congress, Alfons Antoni, President of ELA; Karl Klaseius, President of APICS; Santiago Kraiselburd, Executive Director of Zaragoza Logistics Center are acknowledged and kindly appreciated. We also would like to thank all the authors as well as the scientific and organization committee members and the reviewers for their enthusiasm, time and expertise.

We thank to Marma Congress Center and the congress organization company, Cnidus and the sponsors of congress for their contributions. Thanks to Güner Gürsoy and Mustafa Çağrı Gürbüz for their organizational support, and thanks to Hamit Vanlı, Levent Aksoy, Burak Küçük and Melda Bölek who did a lot of organizational works.

Finally, we would like to thank everyone who has contributed for making this congress a reality and a success. And special thanks to Kemal Köymen, Rector of Maltepe University, for his valuable support.

Muhammed BAMYACI Maltepe University Chair of the Congress	Mehmet Tanyaş President of LODER Co-Chair of the Congress

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SUPPLY CHAIN PERFORMANCE MEASUREMENT: A LITERATURE REVIEW

Gamze Arabelen[1], Okan Tuna[2]

Abstract *— In modern business environment, supply chain management, as an effective business philosophy, has become important among both the academics and practitioners. In recent years, with the evaluation of supply chain management, a great many articles dealing with the theory and practice of supply chain management have been published, but the topics of performance measurement and metrics do not receive adequate attention. The role of these measures and metrics in the success of an organization can not be underestimated because they provide the necessary assistance for performance improvement in terms of supply chain management. However, the process of choosing appropriate supply chain measures is difficult due to the complexity of these systems. The purpose of this paper is to review a sample of the literature relating to performance measurement and metrics in supply chain management. The paper context includes evaluating which procedures are currently used in practice and academic research to develop and analyze performance measures and to assess the general issues regarding performance measurement in supply chain integration.*

Keywords — Integration, Metrics, Performance Measurement, Supply Chain Management

INTRODUCTION

In today's competitive business environment, companies are striving to gain an appropriate percentage of the market share. Companies understand that the key to survival in a competitive market is to generate substantial profit by operating at the lowest possible cost. Despite the difficulties of identifying logistics costs, many organizations are surprised by their scale and start to look for savings from those costs [15].

In modern business environments, characterized by ever-increasing competition and economy globalization, manufacturers have been exploiting innovative technologies and strategies to achieve and sustain competitive advantage. As an effective business philosophy, supply chain management has become important among both the academics and practitioners community in the recent years.

Nowadays, more than ever, manufacturers face an increasing pressure of customer's requirements in product customization, quality improvement, and demand responsiveness. On the other hand they need to reduce production cost, shorten lead time, and lower inventory level to ensure profitability. In order to survive under these pressures, more and more enterprises are striving to develop long-term strategic partnerships with a few competent suppliers and collaborate with them in product development, inventory control, and non-core process outsourcing [6]. Moreover, various value-adding processes from material purchasing, production and assembly, to distribution and customer order delivery are integrated and synchronized to achieve the common goal of enhancing customer satisfaction. In this connection, the paradigm of modern business management has witnessed a significant change from competing as solely autonomous entities to competing as integrated supply chains [13].

Over the last decade of evolution of supply chain management, a steady stream of articles dealing with the theory and practice of supply chain management have been published, but the topic of performance measurement does not receive adequate consideration in supply chain management [5]- [10] -[12]. As an indispensable management tool, performance measurement provides the necessary assistance for performance improvement in pursuit of supply chain excellence.

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Supply chain management has been a major component of competitive strategy to enhance organizational productivity and profitability. By the late 1980's, outsourcing in US industries contributed to nearly 60% of the total product cost. In the UK, a survey showed that 40% of the UK's domestic product was spent on distribution and logistics related activities [2]. Such findings and developments present significant visible impact of distribution, purchasing, and supply management on company assets. Managers in many industries, especially those in manufacturing, are trying to better manage supply chains. Important methodologies like just-in-time, total quality management, lean production and Kaizen have been embraced. The concept of supply chain management (SCM), according to reference [19], represents the most advanced state in the evolutionary development of purchasing, procurement and other supply chain activities. At the operational level, this brings together functions that are as old as commerce itself – seeking goods, buying them, storing them and distributing them. At the strategic level, SCM is a relatively new and rapidly expanding discipline that is transforming the way that manufacturing and non-manufacturing operations meet the needs of their customers.

The intent of this literature review is to document and analyze literature relating to the need for supply chain performance measurement and basic criteria in determining the most appropriate performance measurement systems and metrics.

The main aim of the study is to evaluate which procedures are currently used in practice and academic research to develop and analyze performance measures, to assess the general issues regarding performance measurement and to understand basic criteria in determining the most appropriate performance measurement systems.

THE NEED FOR SUPPLY CHAIN PERFORMANCE MEASUREMENT

Research in this area evaluates how supply chain performance measures are currently selected and analyzed within organizations. They focus on classifying measures in different type of categories, where the modeling element is not always considered. In these researches, a large number of performance measures have been used to characterize manufacturing systems, production, distribution and inventory systems.

Traditionally, performance measurement is defined as the process of quantifying effectiveness and efficiency of action [17]. In other words, measuring performance means transferring the complex reality of performance into a sequence of limited symbols that can be communicated and reported under similar circumstances [14].

In modern business management, performance measurement assumes a far more significant role than quantification and accounting. Performance measurement can provide important feedback information to enable managers to monitor performance, reveal progress, enhance motivation and communication, and diagnose problems. In supply chain management, performance measurement can facilitate inter-understanding and integration among the supply chain members. It also provides insight to reveal the effectiveness of strategies and to identify success and potential opportunities. It makes an indispensable contribution to decision making in supply chain management, particularly in re-designing business goals and strategies, and re-engineering processes.

PERFORMANCE MEASUREMENT AND METRICS IN SUPPLY CHAIN MANAGEMENT

Some researchers have addressed performance measurement in supply chain management. Reference [4] categorizes performance measures in existing literature into two groups: qualitative and quantitative where customer satisfaction and responsiveness, flexibility, supplier performance, costs and others for supply chain modeling discussed.

Supply chain models have predominantly utilized two different performance measures [5]:

- Cost includes inventory costs and operating costs
- A combination of cost and customer responsiveness includes lead time, stock out probability and fill rate.

Although other performance measures such as

- customer satisfaction [7],
- information flow [18],

- supplier performance[8],

may be important characteristics of a supply chain, their use in supply chain models is challenging, since the qualitative nature of such measures makes them difficult to incorporate into quantitative models.

Single Supply Chain Performance Measures

The use of a single performance measure is attractive because of its simplicity. However, if a single measure is utilized, this measure adequately describes the performance. Reference [3] identified and evaluated various individual supply chain performance measures. The author emphasized that there are significant weaknesses in performance measures, based on such criteria as inclusiveness, universality, measurability, and consistency. But the most consistent weakness for these measures is inclusiveness. In order for a measure to be inclusive, it must measure all pertinent aspects of the supply chain.

Although cost as a resource measure is important, reference [16] identifies many shortcomings of relying on cost as the sole performance measure:

- a lack of relevance of cost categories
- costs distortions and
- inflexibility

Reference [16] emphasizes that the type of measures required for a manufacturing organization are directly related to the manufacturing strategy chosen by the company. The relationships with performance measures and strategic goals are as follows:

- The company may determine if its performance is meeting its strategic goals; and
- People in the organization will concentrate on what is measured; thus the performance measure will steer company direction.

Strategic goals involve key elements that include the measurement of resources, output and flexibility.

TABLE 1
Goals of performance Measure Types

Performance Measure Type	Goal	Purpose
Resources	High level of efficiency	Efficient resource management is critical to profitability.
Output	High level of customer service	Without acceptable output, customers will turn to other supply chains
Flexibility	Ability to respond to a changing environment	In an uncertain environment, supply chains must be able to respond to change

Source: ''Measuring Supply Chain Performance'', Benita M. Beamon, *''International Journal of Operations& Production Management''*, Vol.19 No:3 1999

Resource measures include inventory levels, personnel requirements, equipment utilization, energy usage and cost. Resources are generally measured in terms of the minimum requirements (quantity) or a composite efficiency measure. Resource measurement is an important part of the measurement system. Too few resources can negatively affect the output and the flexibility of the system, while the deployment of too many resources artificially increases the system's requirements.

One general goal of supply chain analysis is resource minimization. Although a minimum level of output is often specified, the effect of reducing resources on the flexibility of the supply chain is not often considered.

Output measures include customer responsiveness, quality and the quantity of final product produced. Many output performance measures are easily represented numerically, such as:

- number of items produced,

- time required to produce a particular item or set of items,
- number of on-time deliveries (orders).

Flexibility measures which are seldom used in supply chain analysis, can measure a system's ability to accommodate volume and schedule fluctuations from suppliers, manufacturers and customers [5].

Supply Chain Reference Model (SCOR Model)

The SCOR model was developed in the mid - 1990s by a cross industry consortium of over 70 companies in the USA called the Supply Chain Council. SCOR defines common supply chain management processes and matches these with best practice, benchmarked performance measures and use of software. The purpose is to provide a generic framework for measuring supply chain performance and identifying areas for improvement [1].

The model is based around four generic supply chain management functions of planning, purchasing, manufacturing and distribution.

The benefits of model reported in the literature include: the potential for ''strategic'' level improvements in supply chain management through the use of the benchmarking tools; provision of a common platform for communication between trading partners that does not require specialized training or expertise; identification of points of leverage in the supply chain enabling more effective allocation of resources; provision of clear standards, processes and performance measures for the management of a supply chain at the industry level; and the enabling of more rapid development of supply chain management software applications [20].

A New Framework for Supply Chain Performance Measurement

Reference [11] emphasizes that the evaluation of suppliers in the context of the supply chain (efficiency, flow, integration, responsiveness and customer satisfaction) involves measures important at the strategic, operational and tactical level [11].

The strategic, operational and tactical levels are the hierarchies in function, wherein policies and trade-offs can be distinguished and suitable control exerted [2].

- **The strategic level** measures influence the top level management decisions, very often reflecting investigation of broad based policies, corporate financial plans, competitiveness and level of adherence to organizational goals.
- **Tactical level** deals with resource allocation and measuring performance against targets to be met in order to achieve results specified at the strategic level.
- **Operational level** measurements and metrics require accurate data and assess the results of decisions of low level managers.

The metrics that are used in performance measurement and improvement should be those that truly capture the essence of organizational performance. A measurement system should facilitate the assignment of metrics to where they would be most appropriate. For effective performance measurement and improvement, measurement goals must represent organizational goals and metrics selected should reflect a balance between financial and non-financial measures that can be related to strategic, tactical and operational levels of decision making and control.

FINDINGS OF THE LITERATURE REVIEW

Supply chain management, analysis, and improvement is becoming increasingly important. The literature includes approaches to supply chain management in addition to supply chain models. The performance measures utilized in these models directly affects their real-world applicability. This research describes and evaluates the various types of performance measures that have been used in supply chain modeling, and discusses the applicability of these measures. Table 2 summarizes the supply chain models available in the literature and the corresponding measures used in the supply chain measurement literature.

TABLE 2

Advantages/ Disadvantages of Performance Measures Used in Supply Chain Modeling

Author(s)	**Performance Measure Type**	**Advantage(s)**	**Disadvantage(s)**
Cohen and Lee(1988) Cohen and Lee (1989) Cohen and Moon (1990) Pyke and Cohen (1993) Pyke and Cohen (1994) Tzafestas and Kapsiotis (1994) Lee and Feitzinger (1995)	<u>Cost</u> dimension relates to *inventory costs *operating costs *consumption of a variety resources, such as labor, capital, knowledge and facility	*Moreover, cost also involves the loss and scrap in material management and production *It indicates the effectiveness of business management and production productivity *The use of a single performance measure is attractive because of its simplicity	*It can be identified many shortcomings of traditional management accounting *The problems include a lack of relevance of the cost categories, cost distortions, and flexibility such as reports that are too valuable
Arntzen et al. (1995)	<u>Cost and Activity Time</u> is a strategic dimension *in assessing the management performance in pursuit of faster responsiveness and lower inventory level	*It is of critical concern to both internal and external customers.	*Not only enough for measuring all pertinent aspects of the supply chain *The most consistent weakness for these performance measures is inclusiveness
Ishii (1988) Wikner et al.(1991) Towill(1991) Towill et al. (1992) Newhart et al.(1993) Davis (1993) Christy and Grout (1994) Altiok and Ranjan (1995) Cook and Rogowski(1996)	<u>Cost and Customer Responsiveness</u> measures include *lead time *stock out probability and *fill rate	*The reduction in order cycle time leads to reduction in supply chain response time, and as such is an important performance measure and source of competitive advantage *It directly interacts with customer service in determining competitiveness	*Not only enough for measuring all pertinent aspects of the supply chain * Although these measures may be important characteristics of a supply chain, their use in supply chain models is challenging, since the qualitative nature of such measures makes them difficult to incorporate into quantitative

			models
Beamon (1999)	Resources, Output and Flexibility dimensions relates to *inventory levels *personnel requirements *equipment utilization *energy usage *quality of final product *quantity of final product produced *customer satisfaction	*Main goals of these measures are high level of efficiency *high level of customer service *ability to respond to a changing environment *In an uncertain environment, supply chains must be able to respond to change	* However, some performance measures such as customer satisfaction and product quality can be much more difficult to express numerically

Table 2 Continued

Christopher (1994)	Customer Satisfaction dimension relates to measure *customer services *requirements of customers in supply chain to assess the performance	*In a modern supply chain customers can reside next door or across the globe, and in either case they must b e well served. *For assessing supply chain performance exactly, supply chain metrics must centre on customer satisfaction	*As a supply chain performance metrics, customer satisfaction can be expressed difficultly *Only customer satisfaction dimension can not be inclusive for assessing whole supply chain performance
Davis (1993)	Supplier Performance their functions are *supply base management *material procurement and *inbound material management *the evaluation of suppliers in the context of the supply chain (efficiency, flow, integration, responsiveness and customer satisfaction) involves measures	*From suppliers through manufacturers to distributors and sales, the processes add value to the materials and products or provide services *Supplier partnership and strategic alliances refer to the co-operative and more exclusive relationships between organizations and their upstream suppliers and downstream	*The growth and development of supply chain management is not only driven by internal motives such as suppliers, but by a number of external factors such as increasing globalization, reduced barriers to international trade, improvements in information availability, and environmental concerns.

	important at the strategic, operational and tactical level	customers.	
Nicoll (1994)	<u>Information Flow</u> the role of information flow *is shifting from a general passive management enabler through databases, to a highly advanced process controller that can monitor activities and decide upon an appropriate route for information	*Modern information flow and technology through its power to provide timely, accurate, and reliable information, has led to a greater integration of modern supply chains than possible by any other means	*Inaccurate and untimely information flow and technology may lead to ‘’bullwhip effect’’ that is an example of a typical supply chain management outcome resulting form circumstances such as excessive inventories, low customer service levels, lost income and also increased transportation costs
Gunasekaran et al. (2004)	<u>Strategic, tactical and operational levels in supply chains</u> this framework mainly deals with *supplier, delivery, *customer service and inventory and logistics costs	*The strategic, operational and tactical levels are the hierarchies in function, wherein policies and trade – offs can be distinguished and suitable control exerted	*It can not be achieved an effective performance measurement and improvement, unless measurements goals must represent organizational goals related to strategic, tactical and operational levels of decision making

Source: Author

CONCLUSION

In recent years, organizational performance measurement and metrics in the success of an organization can not be overstated because they affect strategic, tactical and operational planning and control. Performance measurement and metrics have an important role to play in setting objectives, evaluating performance, and determining future courses of actions.

Performance measurement selection is a critical step in the design and evaluation of any system. Generally, the larger and more complex the system, the more challenging it becomes to measure effectively. While there is an ever-increasing number of supply chain models presented in the literature, there is very little available in supply chain performance measure selection. As such, many of the existing models use inappropriate or ineffective performance measures that are limited in scope (non-inclusive). This paper reveals the key issues in the existing performance metrics in the supply chain management context.

Performance measurement and metrics have an important role to play in setting objectives, evaluating performance, and determining future courses of actions. Until now, cost, activity time, customer responsiveness and flexibility have all been used by the researchers as supply chain performance measures either singly or jointly. The most consistent weakness for these performance measures was inclusiveness. In order for a measure to be inclusive, it must measure all pertinent aspects of the supply chain. The measures chosen must coincide with the organizational strategic goals. This measurement system can then allow study of the interactions among the measures or can at least ensure a minimum level of performance in different areas.

Additional research and practitioner-driven initiatives are needed in the area of supply chain performance measurement. Creative efforts are needed to design new measures and new programs for assessing the performance of the supply chain as a whole, as well as the performance of each organization that is a part of the supply chain.

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EVALUATION OF SUPPLY CHAIN GAMES: SMARTER SUPPLY CHAIN 2010

Sanem Şenonay [1] , Ömür Y.Saatçıoğlu [2], Okan Tuna [3]

Abstract – *The concept of management has undergone a considearble amount of change since 1950's. In the 2000's, has extended international activities of enterprise and resuşted with bringing trading partners together with the common goal of optimization and efficiency. Paralel with this change in management, a requirement for teaching this concept has also flourished and games have proven to be important tools to teach the dynamics of management and supply chain. In this research, INNOV 8 2.0, a game developed by ıbm, aiming to introduce supply chain management concepts is introduced. In the second step, a research is conducted to analyze the learning environment and the effects of INNOV 8 2.0 on learning objective. Undergraduate students, graduate students and the people from industry participated in the study. The research revealed that the game contributed to the learning process of participants.*

Keywords – Management Games, Supply Chain Management, INNOV 8 2.0,

INTRODUCTION

There have been numerous and important milestones in supply chain management. In the 1950s and 1960s, minimizing unit production cost with the mass production was the primary operations strategy and there was a little product or process flexibility. Technology and expertise sharing was not common and little emphasis have been placed on cooperative and strategic buyer-seller partnership. In the 1970s, Manufacturing Resource Planning was introduced. New materials management concepts were effective for improving performance of the company. In the intense competition of 1980s, companies began to use JIT and other management initiatives to improve manufacturing efficiency and cycle time. With the usage of JIT, manufacturers began to realize the potential benefit and importance of strategic and cooperative buyer-supplier relationship. In the 1990s, many manufacturers and retailers have embraced the concept of supply chain management to improve efficiency across the value chain (Tan, 2001).

Harwick (1997) emphasizes that supply chain management is a management philosophy which extends traditional internal activities focusing on inter-enterprise scope, bringing trading partners together with the common goal of optimization and efficiency. As Tan (2001) pointed, short-term objective in supply chain management is to increase productivity and reduce inventory and cycle time, while long-term strategic goal is to increase customer satisfaction, market share and profits for all members of the virtual organization. Hence, supply chain management is growing in popularity as a source of competitive advantage. The benefits associated with twin approach of SCM – which consists of integrating the supply chain and the application of lean manufacturing techniques- and its significant scope, including technological, organizational and attitudinal factors have been defined in literature. Some of these benefits are: a reduction in lead times, improved customer service, supply chain synergy, minimum total supply chain costs, less inventory and improved quality (Burgess, 1998).

SCM is a concept dependent on a process view; in other words, supply chain can be defined as "integration of business processes from end user through original suppliers that provides products, services and information that add value for customers" (Cooper et al 1997). BPR is a tool for rethinking of the organization's strategy as well as their supply chain strategies. The supply chain concept also forms a basis for strategic decision-making. BPR and SCM are enabling techniques within the overall context of the company (Burgess, 1998). Croom (et al 2000) performed a content review of existing literature on supply chain

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management in 6 categories which are defined as: Strategic management, Relationships/partners, logistics, best practices, marketing and organizational behavior.

As Nagajaran (et al 2006) discussed, the evolution of supply chain management has underlined two important facts: 1) a business process consists of several decentralized firms 2) operational decisions of these different entities impact each others' profit and thus the profit of the whole supply chain.

MANAGEMENT GAMES

Training has been an indispensable part of adaptation and change. The reasons which increase the demand for training are: globalization, new information technologies, new business processes and increasing competition. Competitive environment forces companies innovate. Furthermore, leadership, teaming, project management, effective strategy and good risk management are necessary skills that a person should have during innovation. These responsibilities require training managers and knowledge workers (Summers, 2004). Among many available strategies, gaming has been proven to be a tool that effectively enhances teaching and learning. Instructors can build a pleasant environment through games, whereas students can achieve a sense of victory through games, therefore, changes, challenges and fun can characterise the entire learning process, and this is why students like playing games. (Chang et al 2009).

Simulations are used in 3 types of education programs – learning how to use prepackaged information technology such as SAP and Windows Server; learning to control equipment and entire systems such as medical devices, oil drilling equipment, nuclear reactors and airplanes and soft-skills training such as leadership, teaming and preacticing concepts and skills used in strategic management, marketing, finance and project management programs (Summers, 2004).

Business simulation exercises are tools which participants can try strategies and apply their knowledge. By means of business simulation exercises participants can do different things, think longer term, see the big picture and understand the competitive landscape (Scherpereel, 2005). Gonen (et al 2009) emphasized that business simulation games allow executives to sharpen their decision-making skills, experiment with strategies they might fear using without a trial, train exceutives in areas where they require further training, correct bad habits, and gain insights into many areas of the company's operations. Scherpereel (2005) and Gonen(et al 2009) also defined benefits of business simulation games as: practice in an environment without risk, increased creativity, decreased decision time, more focused competitive analysis, increased cross-functional understanding, and increased subject content knowledge.

The major desired outcomes of simulations typically can be sorted in three categories: (Anderson and Lawton , 2009):

a) Learning

- Teach students the terminology, concepts and principles of business in general or specific discipline
- Help students grasp the interrelationships among the various of business (marketing, finance, production, etc)
- Demonstrate the difficulty of executing business concepts that appera relatively simple.
- Enhance retention of knowledge.
- Enable students to transfer learning to the business world.

b) Attitudinal

- Improve student attitudes toward the discipline
- Provide a common experience for classroom discussion.
- Engage students in the learning process.

c) Behavioral

- Teach students to apply the concepts and principles of business to make effective decisions.
- Enable students to implement course concepts
- Improve students' ability to interact with their peers.
- Give students practice at making business decisions.
- Improve students' business decision skills.

Business simulations are more widely used in conjuction with strategic management cources than with courses in any another business discipline. Simulations for strategic management should a)involve simple rules, so that players will be able to learn quickly how to play the game and b)include smart algorithms that serve the function of subordinates who implement chosen strategies and advise top management (Thavikulwat and Pillutla, 2008).

Chang (et al 2009) defined four specific principles that the game should have:

a) **Challenges (Principle 1):** The contents of the game need to be challenging in order to arouse students' curiosity.
b) **Competition (Principle 2):** So that students' motivation remains high, either individual students or groups need to compete with each other.
c) **Cooperation (Principle 3):** The design of the game should help studnets to develop a sense " of work as a team and win as a team".
d) **Authentic tasks (Principle 4):** The game should incorporate authentic, real-world cases, instead of textbook-like materials.

As Nikitakos and Sirris (2008) classified, games can be designed in different categories.

1) At the event level or Lesson level, a game may be designed to facilitate one or more specific instructional event within an instructional unit. A relatively simple game, like adventure (quiz, puzzle) or table top games for example, may be designed to present learners with a scenario engaging their interest and asking them to explore related concepts through a series of readings and activities in order to facilitate recall of factual content or to promote active involvement and discussion.

2) At the unit level, a game incorporates all of the events and activities necessary to achieve a specified set of goals and objectives associated with an instructional lesson or unit.

3) At the course level, one game is played throughout an entire course, tying together all the units, lessons and events associated with the course. Business strategy simulation games are best suited in this case.

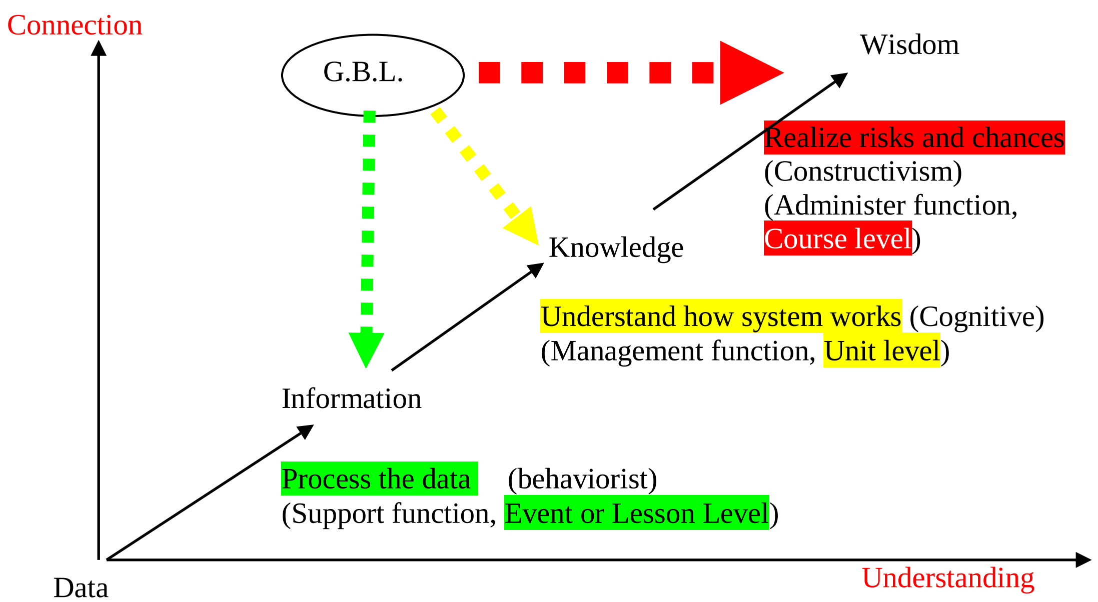

FIGURE 1
Game Based Learning for all Educational Levels

Source: Nikitakos and Sirris (2008)

As shown in Figure 1, games process data at the Lesson Level and players get information. At the Unit Level, players understand how system works and gain knowledge. At the course level, players realize risks and chances.

REVIEW OF LOGISTICS AND SUPPLY CHAIN GAMES

In recent years, games have been proven to be an effective tool in supplementing traditional teaching methods. Games are a goal-directed, challenging, and competitive activity that is conducted within a framework of agreed rules to provide a playful learning environment. The use of games enhances the richness of learning and improves learning efficiency; games can provide experience in the application of theory and concepts as well as improve a student's capacity to think. An additional goal is educating students in new methods of aggressive learning, which enables them to combine theory and practice to construct new concepts that are learned from course content in the classroom. Therefore, more and more instructors use the method of game playing to construct classroom situations so as to enhance the learning motivation of the students. Especially, instructors in production management, logistics management, and other decision sciences courses adopt game-assisted teaching tools to simulate real enterprise situations so as to let students prepare for their professional careers.

The first (and best known) supply chain game game is the Beer Game, which was originally developed by the Massachusetts Institute of Technology (MIT) in the 1960s. The aim of the Beer Game is to reveal how people's decision patterns in production, logistics, and customer chains sometimes produce unexpected and undesired results. The game was first played on a board like a card game and later was transferred to a computerized environment. Several other games were developed after the Beer Game to challenge students' reactions and to develop their management skills. Several web-based games have now been developed and have been adopted not only in the classroom to facilitate learning, but also in other circumstances to stimulate research by bringing international competition and collaboration among students, instructors, and researchers. Table 2 shows several well-known web-based games in production and logistics management (Chang, 2009; 1242).

TABLE 2
Logistics Games in the World

Name of the game	Description	Decision Scope	Developer
Columbia Beer Game	Beer production and distribution in a multi-stage distribution channel	Act as manufacturer, distributor, wholesaler or retailer to determine production/order quantities (similar to MIT beer game but with stochastic customer demand)	Columbia University
Hulia Game http://www.hulia.haifa.ac.il/Eng/hulia.html	Beer production and distribution in a multi-stage distribution channel	Act as manufacturer, distributor, wholesaler, or retailer to determine production or order quantities	The University of Haifa, Israel (2000)
Little.eld Technology http://www.little.eld.responsive.net	Manufacturing simulation in made-to-order assembler of electronic systems	Act as a manufacturer to determine utilization, queuing, scheduling, and inventory	Stanford University, USA (1996)
Match Game	Match distribution game. It covers SCM aspects: shortage gaming, location selection, synchronization of parts flow, and demand uncertainty	Act as a retailer(2), a wholesaler, a distributor, and a factory to determine production and order quantities to decrease the costs and increase the customer service level	Kazaz& Moskowitz Loyola University, Chicago& Purdue University (1999)
MERIT Simulation Game (**M**anagement, **E**nterprise, **R**isk, **I**nnovation& **T**eamwork)	Computer simulation game that enables participants, grouped into a team, the opportunity to experience managing their own fictional construction company	Act as a managing director, marketing& tendering, financial, overhead, personnel and construction manager to determine about marketing, risk managing, estimating, bidding, finance, personnel and construction	Loughborough University, UK

Name of the game	Description	Decision Scope	Developer
MIT Beer Game http://www.beergame.mit.edu/	Beer production and distribution in a multi-stage distribution channel	Act as manufacturer, distributor, wholesaler, or retailer to determine production or ordering quantities	Massachusetts Institute of Technology, USA (1988)
Simple Game (**SIM**ulation of **P**roduction and **L**ogistics **E**nvironment)	Production and logistics simulation game which has manufacturer and supply chain mode, it can be played by individually or team	Act as a supplier, manufacturer, and retailer to determine about inventory management, capacity management, production planning, forecasting, and cooperation and competition within a supply chain	National Chiao Tung University, Taiwan
Supply Chain Game http://www.factory.isye.gatech.edu/research/	Production and distribution simulation in automobile industry, including manufacturers, transporters, and suppliers	Act as decision-maker in a competitive supply chain framework, such as a supplier or assembler	Georgia Institute of Technology
Supplying Hoop Dreams	Hoop distribution game	Act as a retailer(2), distributor, factory, supplier(2) to decrease costs and to increase customer service level	Kazaz& Moskowitz Loyola University, Chicago& Purdue University (1999)
The Logi-Game http://www.moltho.dk	Simulation game of material owns in a distribution channel for bicycle industry	Act as manufacturer, wholesaler, or retailer to make manufacturing and inventory decisions	Technical University of Denmark
Trading Agent Competition http://www.sics.se/tac	Online bidding on multiple markets Simultaneously	Act as an agent to manufacture PCs, win customer orders, and procure components	Swedish Institute of Computer Science (2003)

Source: This table compared from Chang, Chen, Yang and Chao, 2009; 1242. Tuna, 2009; 94. Wall and Ahmed, 2006; 1387. http://www.damas.ift.ulaval.ca, http://www.sba.luc.edu, 09.04.2010.

METHODOLOGY OF THE STUDY

A field study has been implemented in order to evaluate a online supply chain game. Considering this fact, it's decided to use INNOV8 2.0 scenarios. INNOV8 2.0 scenarios Smarter Traffic, Smarter Customer Service and Smarter Supply Chain) have the same purpose of aiming to direct players; to think smarter, to react quickly, and most importantly to be innovative.

Smarter supply chain scenario has been selected for this Project. Smarter Supply Chain evaluates a traditional supply chain model, balance supply and demand and reduce environmental impact. It is intended to streamline transportation lines, keep needed items in stock, and greatly reduces greenhouse emissions by using real-time data. This scenario's main subject is illustrated with this information: ''Whether it's reallocating resources on the fly, or re-stocking store shelves to keep up with demand, effective supply chain management is essential to the success or failure of a business. In this scenario, you will use BPM and new technologies, such as RFID, to change the way supply chains are managed. By using real-time data, you can streamline transportation lines, keep needed items in stock, and greatly reduces greenhouse emissions (www.ibm.com/innov8).

Smarter Supply Chain is composed of five parts:

1. To renovate and improve existing supply chain management process of After Inc.
2. To coordinate excess inventory due to the impending storm. (HURRICANE)
3. To make discounts to all customers. (SAFETY RECALL)
4. To restructure supply chain management process with RFID Technology.
5. To make special discounts to Lawn and Garden customers only. (SAFETY RECALL WITH RFID)

Objectives of the Study

The objective of the study is to investigate the effects of the SMARTER SUPPLY CHAIN GAME in learning. Specific objectives of the study can be stated as follows;

- To investigate the effectiveness of the game in terms of learning objectives.
- To investigate the effectiveness of the game in terms of learning environment.
- To explore the profile of respondents.

Sampling and Data Collection

Smarter Supply Chain game has been implemented to 53 participants (both from the industry and universities). A structured questionnaire has been used in order to collect the before mentioned objectives. All questionnaires have been collected in one day through a series of application of the Smarter Supply Chain Game. On eof the authors has been dedicated to instruct the players before the game, to observe them and to collect the data. Discussions have been made after the end of each game session, however those qualitative findings have not been used in this paper.

Findings of the Study

Majority of the respondents represent (62,3 %) the graduate students. However, on the other hand, significant number of individuals (17%) from the industry has been attracted for the application (See Table 3.)

TABLE 3
Demographics of Respondents

	Frequency	%
Profile of the Respondents		
Undergraduate Student	11	20,8
Graduate Student	33	62,3
Industry	9	17

Majority of the participants state that duration of the game is normal (75,5 %). On the other hand majority of them find the game realistic (81,1 %) and would like to play the game one more time (%69,8). This illustrates the positive impact of the game on the participants.

TABLE 4
General Perception of the Game

	Frequency	%
Duration of the game is;		
Too Long	1	1,9
Long	2	3,8
Normal	40	75,5
Short	9	17,0
Too Short	1	1,9
Did you find the stages of the game enough?		
Yes	42	79,2
No	11	20,8
Did you find the game realistic in terms of logistics?		
Yes	43	81,1
No	10	18,9
If you play the game alone, will you be more successful?		
Yes	14	26,4
No	39	73,6
Would you like to play this game again?		
Yes	37	69,8
No	16	30,2

Smarter supply chain game has a strong impact on teaching the supply chain management process. Participants state that "game has enabled me to learn all stages are connected with each other in SCM process" (mean=4,29) and "game has enabled me to learn SCM" (mean=4,19). On the other hand, teaching capacity of the game in terms of SOA(Service Oriented Architecture) seems a little bit lower than the other factors (Mean=3,70). (See Table 4)

TABLE 4
Effectiveness of the Game in Terms of Learning Objectives

Statements Related to Learning Objectives	Mean* (n=53)	Standard Deviation
Game has enabled me to learn the logic of business process management.	3,89	1,013
Game has enabled me to learn the importance of BPM.	3,87	1,001
Game has enabled me to learn the logic of SOA.	3,79	1,063
Game has enabled me to learn the importance of SOA.	3,70	1,011
Game has enabled me to learn the logic of RFID Technology.	3,74	1,022
Game has enabled me to learn the importance and logic of using KPI.	4,08	0,829
Game has helped me to understand the importance of quick and correct decisions in SCM.	4,15	0,864
Game has enabled me to learn all stages are connected with each other in SCM process.	4,26	0,944
Game has enabled me to learn the importance of information sharing in SCM.	4,06	1,134
Game has enabled me to learn SCM.	4,19	1,020

**1= I strongly disagree 5=I strongly agree*

Majority of the respondents perceive the game learning environment positive. “Game develops skill of producing a solution for encountered risk (mean=4,02) and “game has a complementary feature with experiential learning (mean=4,38)” have the highest scores in terms of mean. On the other hand, “game provides professional life experience (mean=3,47)” has the lowest score (See Table 5).

TABLE 5
Effectiveness of the Game in Terms of Learning Environment

Statements Related to Learning Environment	**Mean* (n=53)**	**Standard Deviation**
1. Game has a positive impact on the learning process.	4,28	0,885
2. Game encourages teamwork.	4,26	0,923
3. Game provides a motivation in a learning process.	4,32	0,850
4. Game is useful to convert theory to practice.	4,15	0,818
5. Game enables students to learn more about prior lessons and practice about these issues.	3,87	1,110
6. Game with feedback features is useful for analyzing outcomes of game.	3,96	0,898
7. Game provides a permanent knowledge.	4,02	1,009
8. Game has a positive impact to create responsibility.	3,89	0,954
9. Game is useful in analytical thinking and decision-making process.	4,34	0,783
10. Game has a complementary feature with experiential learning.	4,38	0,765
11. Game develops a variety of skills, techniques, and strategies.	4,09	0,966
12. Game developed my communication skills.	3,47	1,154
13. Game is required for preparation for working life.	3,83	1,172
14. Game provides professional life experience.	3,47	1,085
15. Information that I have gained from game will be useful in my real life.	3,72	1,133
16. Game develops skill of producing a solution for encountered risk.	4,02	1,047

**1= I strongly disagree 5=I strongly agree*

General evaluation of the game is very high having a score of 4,09 (mean). (See Table 6).

TABLE 6
General Evaluation of the Game

General Evaluation	**Mean* (n=53)**	**Standard Deviation**
General evaluation	4,09	0,815

CONCLUSION

Management games are of critical importance in terms of teaching real life scenarios to the learners. Chang (et al 2009) emphasized that, there are many simulation games in the business-administration and production-management fields, and it has been proved that these games are effective teaching aids since they enhance teaching and students’ learning interest. As Summers (2004) emphasized, business simulation support research into learning and various aspects of management, including decision support, strategy making, group behaviour, organizational learning and change and leadership. Management games are also important tools to change decision making perspective. As far as the supply chain and logistics management is considered, the importance of the games increase due to the applied nature of this discipline. Interactive nature of simulations make them ideal for learning.

In our paper, we have attempted to illustrate how effective a supply chain game can be used in teaching. A sample has been selected in order to apply an online game (smarter supply chain) and perceptions of those participants have been collected through structured questionnaire.

Findings reveal that, application of such games on the learners (both from industry and universities) has a strong positive impact on both learning environment and learning objectives. In addition to that, participants find such games very motivating and stimulating in their learning process. In other words, this game created change in the participants.

However, usage of such games in logistics and supply chain management curriculum is very low in Turkey. Dokuz Eylul University Maritime Faculty use such tools in a structured way (logistics laboratory).

We propose that other institutions in Turkey should also increase the usage of such tools in order to enhance their learning objectives and environment.

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STRATEGIES FOR FUTURE COMPETITIVE SUPPLY CHAINS: THE EMERGENCE OF SUPPLY CHAIN LEADERSHIP CAPABILITY

Amir M. Sharif[1], *Zahir Irani*[2]

Abstract *— Competition and co-operation within globalised markets and economies, involves a high degree of complexity and concurrency where supply chain management is concerned. The effective and efficient application of strategies, techniques, tools and best practice within and across production and service-oriented sectors, is a vital component within supply chain management. Against this backdrop, what are the current and future challenges and trends from an operational perspective within the area? Furthermore, how can supply chain management strategies pre-empt or at least mirror the changing nature of business in a truly global sense? This paper presents a strategic framework for aligning trends in operations and supply chain management, and identifies the emergence of supply chain leadership capability as a fundamental pillar of supply chain management.*

Keywords — Supply Chain Management, Supply Chain Leadership, Personal Values, Framework

INTRODUCTION - LEADERSHIP IN SUPPLY CHAIN MANAGEMENT

Organisations are increasingly being interweavem through intra-and inter-organisational supply chains – this transition from being homogenic to polygenic illustrates that individual businesses do not merely contend as exclusive self-governing entities that operate in inolation, but act as an interacting web of supply chains (Stock *et al.* [1]; Burgess *et al.* [2]; Robinson and Malhotra [3]; Lambert and Cooper [4]). Moreover, as 'virtual' organisations progress, business and management leaders need to take a holistic approach and consider the whole supply chain as a single conglomerate (McAdam and McCormack [5]). Greater attention is now being offered to craft appropriate leadership styles that are responsible for sustaining supply chains and, managing their performance and improvement (Li *et al.* [6]; Robinson and Malhotra [3]; Mentzer *et al.* [7]). Others accentuate that leadership drives the overall system of the supply chain that results in improved financial results and customer satisfaction (Ou *et al.* [8]; Kuei *et al.* [9]). While some advocates of the supply chain discipline are exceptionally dubious vis-à-vis this alliance, nevertheless, inter and intra-organisational decision processes may certainly benefit from the participation of proficient leadership in managing the supply chain. This seems principally to be the case regarding large-scale investments in supply chain systems where the jeopardy of failure is particularly high if not implemented appropriately. These arguments are supported by several other researchers who report effective leadership as a significant impetus for directing and managing while achieving impactful supply chain management performance (van Hoek *et al.* [10]; Kuei *et al.* [9]). Moreover, a number of academic researchers have also regarded administration and management allegiance, or leadership, as the most significant influential driver for successful transformation (McAdam and McCormack [5]; Lambert and Cooper [4]).

On the other hand, Robinson and Malhotra [3] also assert that within supply chains, top management must guide and direct not only individual company efforts, but also encourage participation and cultivate quality measurement and performance among all channel members. Moreover, this also indicates that a focal supply chain is categorised by the existence of an affiliate who is the 'instinctive' leader, e.g. due to his financial power or exceptional knowledge of products and processes (Stadtler [11]). Researchers claim through their empirical findings that as supply chain management facilitates administration of processes across distinct departments, this result in significantly improving an organisation's competitiveness (Li *et al.* [6]; Robinson and Malhotra [3]). Whereas, McAdam and McCormack [5] accentuate that the establishment of programs and

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tactics to manage and monitor supply chain quality is an underlying stride en route for augmenting the competitiveness and market leadership of supply chains.

Researchers also signify here that overseeing the supply chain connotes administrating crosswise long-established operational areas in an organisation and managing communications external to the organisation with stakeholders i.e. customers and suppliers (Li *et al.* [6] and Lummus and Vokurka [12]). These earlier conceptions advocate that a successful supply chain management strategic prophecy is established on the basis of effective management leadership, which creates and converses the business strategic vision of supply chain management (Stock *et al.* [1]; Stadtler [11]).

Lummus and Vokurka [12] assert that the rationale for the above conceptions (i.e. significance of leadership in supply chain management) can be attributed to three essential viewpoints: Firstly, as organisations have become more focused, they tend to be more specific while exploring suppliers for procuring cost-effective though quality products. This move towards procurement of quality products befits crucial for organisations to administer the entire system of supply chain to optimise overall organisational performance. Secondly, it is highly acknowledged that there is amplified national and global competition and amidst such transformations, customer's nature and purchasing behavioural patterns have significantly changed. Moreover, the vigorous disposition of marketplace has made the long-established inventory maintaining practices (i.e. organisations attempted to solve the dissemination problem through maintaining inventory at diverse locations all through the supply chain) a precarious and potentially unsuccessful conglomerate. Thirdly, the shift in accentuation to the supply chain is because of the realisation by most organisations that maximising performance of one department (including its related functions) may lead to below optimal performance for the whole organisation. For these reasons, proficiently managing the supply chain has become critical for most organisations. Thus, the aforementioned research confirms the fact that the success of supply chain management is directly associated to the presence of constructive leadership that also invigorates supportive behaviour within the organisation, moreover, coordinating and overseeing the whole supply chain (Melnyk et al. [13]; Mentzer et al. [7]). It would therefore be judicious to confer greater consideration to research on further exploring the role of leadership (e.g. those that specifically manage and lead a supply chain) particularly given the recent transformational business and management activities that have surrounded the many organisations. It is within this context that this paper progresses and seeks to provide the identification of supply chain leadership capability via the notion of personal values; and thenceforth to further identify those supply chain leadership values pertinent to Turkish supply chain directors and managers.

IDENTIFYING SUPPLY CHAIN LEADERSHIP CAPABILITY: PERSONAL VALUES

Noting the above, the authors now wish to extend these notions of leadership towards that of identifying how specifically, supply chain leadership itself can be supported and developed as a mantra for improvement and as part of a strategic goal. With this in mind, focus is now given to those aspects of management or leadership behaviour and practice upon which this might be based: which lie ultimately with the realisation of and adherence to personal and organisational values.

Principles, ethics or in the context of this literature analysis 'values' play an imperative role in understanding the behaviour of human resources at workplace given that senior management is seen to appraise events and respond accordingly using values as their criteria (Lenartowicz and Johnson [14]). There are many conceptions with regards to values theorised in the normative literature such as Askun *et al.* [15] reporting that values are at the mainstay of our philosophy, dogma, and at the most perceptible characteristic of human beings, behaviour. Becker and McClintock [16] support that values are deemed as normative benchmarks to adjudicate and to opt for amongst proxy approaches of behaviour. As per Rokeach [17], values are enduring viewpoints that instigate established ideologies to steer individuals' right through their lives. According to a more stable definition proposed by Posner *et al.* [18] (p. 22), 'Value of a given social group is any entity (object, behaviour, situation) on which that group places a high worth or importance and, values can be personal, professional, organisational, or societal'. Chow [19] highlighted that values are in all likelihood to reflect the manager's ethos. He also stated that while comparing values of different cultures, factors related to environment such as political, legal and economic systems are sought to be taken into consideration.

With regards to comparative cross-cultures studies conducted in the preceding years (Askun *et al.* [15]; Tan [20]), it is noticed that amongst these research investigation three important approaches have transpired in value research – the convergence e.g. advocates of this theory assert that managers of dissimilar cultures will exhibit analogous managerial values as countries transit from developing to developed economies (Child [21]); whilst divergence benefactors argue against by stating that culture and ethos are profoundly ingrained in individuals and will be retained despite of economic principles (Ricks *et al.* [22]), whereas, supporters of crossvergence theories allege that there is a possibility that comprehensive occurrence of convergence or divergence is not inevitable as there is continuum amid the polar limits of convergence and divergence (Tan [23]). These research findings illustrates some contradictory conceptions regarding the values, such as, according to Lenartowicz and Johnson [14] amongst these theorised conceptions, crossvergence theory is deemed to hold firm on its theoretical constructs. Nevertheless, other researchers also argue that cultural differences are even now considered extremely fundamental (Ali and Amirshahi [24]). It can be further argued in the context of industrialisation, transformations in business environments and worldwide fiscal catastrophe and no matter what their effects are, managerial values have a significant impact on the operational activities of the organisations. Sylvie *et al.* [25] also support that managers' values strongly influence managerial practices in an organisational environment.

A number of research studies have examined managerial values across industries and organisations also positing demographic determinants such as age, service duration and didactic achievement, in concert with individual skills, expertise, attitudes and individuality aspects as strategic paramount variables in determining managerial values (Mellahi and Guermat [26]; Wallace *et al.* [27]). Other researchers such as Posner [28] argue that a thoughtful realisation of managers' fundamental individual values augments the understanding of their beliefs, attitudes, and behaviours. Posner [28] also reports on the assertion that the 'direction and strength of corporate establishments and their managers cannot be effusively comprehended without gaining adequate knowledge vis-à-vis the values and visions of the individuals who manage it', is perhaps evident today. Thus, it can be said that managerial values demonstrate a certain point of reference that can be exhibited in a work environment and signify how the work is ought to be accomplished (Mellahi and Guermat [26], Garavan *et al.* [29]). It is also reported that managerial values diverge from one territory culture to another, thus, agreed to the disparity in managerial values, managers are sought to befit understanding of intercultural interactions, ethnic and social sensitivity, effectual intercultural performance and cultural management influences (Garavan *et al.* [29]).

For the purposes of this research, the authors have identified the importance of personal values within the wider context of decision-making and organisational fit (Posner and Schmidt [30]). As such this henceforth provides the basis for developing a supply chain leadership (SCL) approach within the context of this paper. The concept of personal values and personal value systems has been described as "an enduring organization of beliefs," that are "general plans employed to resolve conflicts and to make decisions." (Rokeach [17]). Likewise Ravlin and Meglino [31] have identified that values affect the ". . . organization of behavioral choices or the formulation of alternative courses of action" – a point which has already been echoed and noted as being as of importance within supply chain operations previously.

Furthermore, in order to understand how these personal – and therefore organisationally bound – values can be evaluated and defined, the usage of personal value frameworks is likewise important to note. Many personal values frameworks and instruments exist. These vary from Morris' [32] 'Ways to Live' - which involve relationships between "Operative", "Conceived" and "Object" values); Kilmann's 'Insight Test', KIT– which involve rating 18 values ranging from "ambition" and "logic" through to "cheerfulness", "courage", "imagination" and "independence" (Kilmann [33]); through to the "Personal Value System" of England, PVS – which involve rating 66 values across 5 components of "Business Organisation Goals", "Personal Goals", "Ideas associated with People", "Groups of People" and "Ideas about general topics" (England [34,35]); and McClelland's "Personal Values Questionnaire", PVQ – which involve relationships between "Achievement", "Affiliation" and "Power" (McClelland [36]; Langens [37]). Principally the authors wish to make the distinction between these and associated personality-based evaluations such as noted by Biber *et al.* [38]. Specifically, England's PVS studies developed and presented the concept of personal values for organisational and individual analysis in order to identify key determinants of personal attitudes and behaviours. These studies focussed primarily on US but then later international companies. Later, the work of McClelland looked at the concept of human motivation within the workplace in order to further distinguish between behaviour and motives along implicit (individual) as well as explicit (social) lines, developing into the PVQ instrument (McClelland [36]; Langens [37]).

It is on this basis that the research conducted by the authors has been based in order to develop a framework for supply chain leadership from primary data collected using McLelland's PVQ tool.

IDENTIFYING SUPPLY CHAIN LEADERSHIP THROUGH THE PVQ

Given the points raised so far the authors now present primary data collected from a small sample (n=13) of Turkish supply chain directors in order to synthesise and identify personal values within the supply chain context, noting the relevance of doing so as part of understanding the wider implications of these factors within management research as identified by Payne [39]. This study was conducted in Istanbul in Turkey within a facilitated workshop setting with supply chain managers and directors from a variety of sectors including retail consumer goods, industrial products, pharmaceutical, automotive, chemical and related process industries.

The research involved applying the PVQ tool by McClelland (thus noting the scales of "Achievement", "Affiliation" and "Power") as part of a wider management development initiative – but pertinent too and concomitant with the focus on supply chain management and leadership capability. The choice of the particular PVQ instrument was based upon previous successful usage by the researchers and the ease of use, simplicity, ease of administration and rapid insight via analysis of the results that can be gleaned. Thus, the usage of the 3 ordinal scales across 30 questions from McClelland [36] as opposed to using the lengthy 5 component, 66 sub-scale instrument of England [34,35], was therefore also of prime consideration. It was also deemed appropriate to use this in order to explain the so-called "conscious drivers of behavior" within the supply chain management context as discussed at the beginning of this paper. Thus in order to align personal values with those that are associated with achieving tasks to a standard (achievement); maintaining close, friendly relationships (affiliation); or impact on others (power). Hence the PVQ was also chosen as an instrument in order to elucidate and consider the implications of these criteria for Supply Chain Leadership (SCL) as described earlier.

In this case, the instrument consists of a two stage process of completion. In the first stage, respondents were requested to complete a series of 30 qualitative questions which are based upon a series of value statements such as "How important are close, friendly co-operative relations with others at work?" through to "Having the opportunity to exercise control over an organisation or group". Each qualitative question must be then graded using a 5 point Likert scale where 0 denotes "Not important to me" and 5 denotes "Extermely important to me". Each question likewise is specifically broken down across "Affiliation", "Achievement" and "Power" components, and a total for each of these per question is divided by 10.

In the second stage, respondents were then asked to plot their results for Achievement, Affiliation and Power themselves (as part of the PVQ instrument) to generate their personal values profile. This profile was then explained to respondents in terms of the meanings attributed as part of the instrument. Table 1 shows this in further detail.

TABLE 1.
PVQ instrument definitions for Achievement, Affiliation and Power

Component	Meaning	Low Values	High Values
Achievement	The belief that it is important to meet, or exceed, a standard of excellence.	Require successful outcome, <=50%, low risk situations	Require successful outcome, >50%, high risk situations
Affiliation	The belief that establishing and maintaining close, friendly relationships is important	Value distance interactions more (e.g. Email, telephone)	Value personal interactions more (e.g. Face to face meetings)
Power	The power that having an impact matters	Values personal power, wants to direct others	Values institutional power, collective organisation

Analysis of the McLelland PVQ results: the Turkish SCM case

The results of this PVQ instrument as administered to the sample of Turkish SCM leaders is now given and explained with the results shown in Figure 1 and Table 2 for the given sample size. That is to say that when noting the explanation of high and low values for achievement, the participants value and recognize a high level of excellence and may exhibit a higher level of risk taking in order to achieve success (mean of 4.42 across the sample).

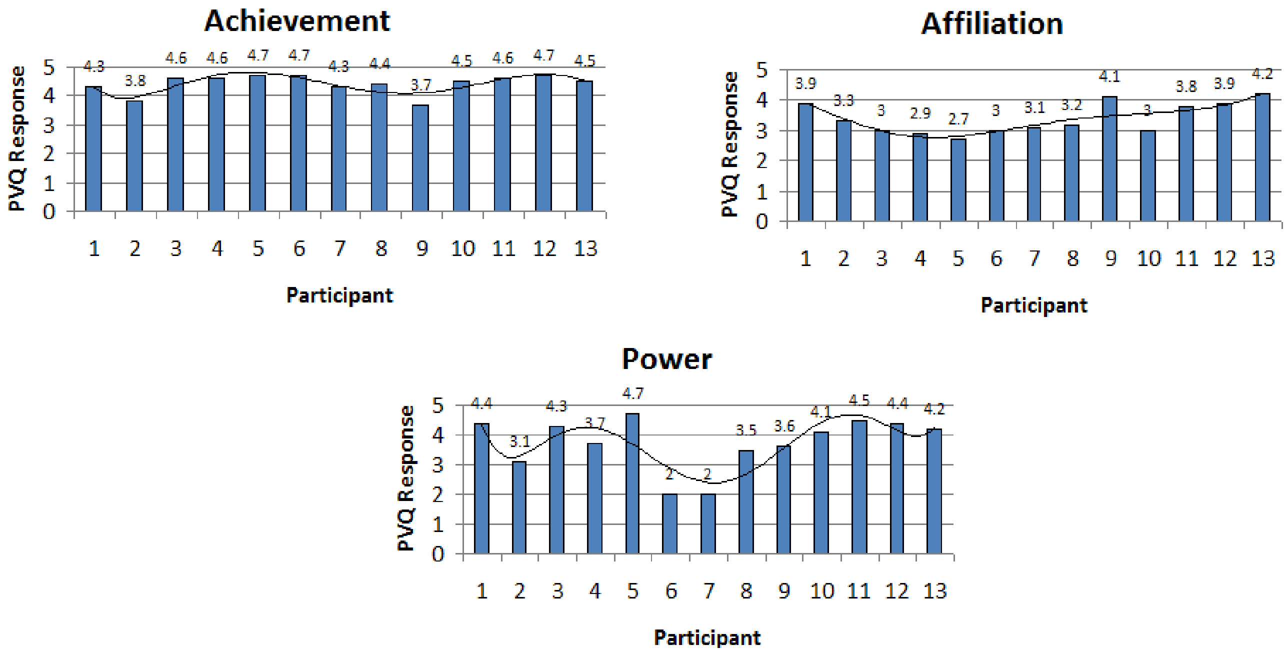


FIGURE 1.
Individual PVQ results for Turkish SCM directors

Likewise the mean response for power of 3.7, whilst being only marginally above the average of the scale from 1-5, also shows that most of the respondents value the “power” of the organization that they work for rather than their own internalized or self-directed power (with the exception of participants 6 and 7 who have below average power scores, denoting that they value they own personalized power (potentially hinting at greater leadership drive and capability). Similarly the mean affiliation responses were also reasonably high (3.39) denoting that the sample population value personal interactions greatly – an important constituent for supply chain management and operations. The additional descriptive statistics for the population in Table 2 show and uphold the fact that there was increasing variance and deviation in responses across the sample population in relation to affiliation and power (standard deviations of 0.51 and 0.89 and variances of 0.26 and 0.80 respectively). The distributions of responses for each of the PVQ components are overall fairly “peaked” (for achievement and power) – thus skewed towards higher values; but reasonably “flat” for affiliation, skewed towards lower values. Thus denoting that for this population, achievement and power were valued as relating to high standards of excellence and utilizing the full power of each individual’s organization, respectively, in terms of their own supply chain management roles.

TABLE 2.
Descriptive statistics for PVQ results

Achievement		Affiliation		Power	
Mean	4.42	Mean	3.39	Mean	3.73
Median	4.50	Median	3.20	Median	4.10
Mode	4.60	Mode	3.00	Mode	4.40
Standard Deviation	0.33	Standard Deviation	0.51	Standard Deviation	0.89
Sample Variance	0.11	Sample Variance	0.26	Sample Variance	0.80
Kurtosis	1.30	Kurtosis	-1.51	Kurtosis	0.39
Skewness	-1.46	Skewness	0.40	Skewness	-1.15
Minimum	3.70	Minimum	2.70	Minimum	2.00
Maximum	4.70	Maximum	4.20	Maximum	4.70
Largest	4.70	Largest	4.20	Largest	4.70
Smallest	3.70	Smallest	2.70	Smallest	2.00
Confidence Level (95.0%)	0.20	Confidence Level (95.0%)	0.31	Confidence Leve l(95.0%)	0.54

Figure 2 shows the overall, aggregated results for the sample as a result, also denoting the average plotted as the dashed line (shown as "Avg") in the legend below. Again, this visually shows how and where individuals are recognizing their personal values especially when noting the context of the facilitation of the response data as part of a supply chain management and leadership development workshop. This shows a clear clustering of above average responses to achievement, and to a certain extent affiliation, but a wider spread of value interpretations for how individuals may approach their usage of and interpretation of power (and hence a potential mixture of transactional leadership style – high values; and transformational leader style – low values).

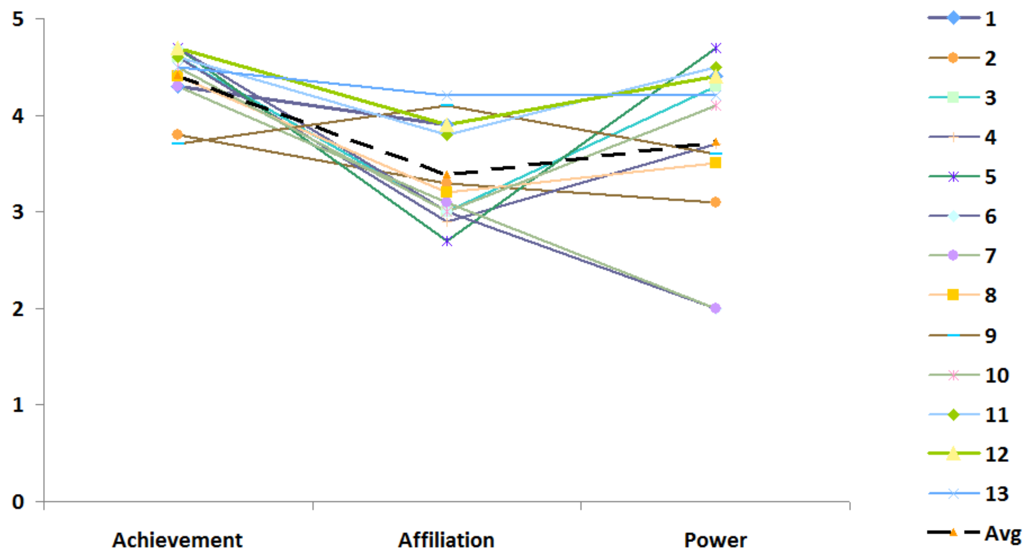


FIGURE 2.
Aggregated PVQ results for Turkish SCM directors

However, it is interesting to note that affiliation and achievement are negatively correlated for this group with a value of -0.343 (hence as personal interactions increase, a lower level of risk or success is required), as shown in Table 3. This possibly indicates either a cultural or socially bound attachment to having trust-based relationships which facilitate achievement although the covariance results in Table 4 show that this is only slight (-0.053). Similarly, there is loose coupling in these terms across the achievement-power (0.069) and affiliation-power (0.119) scales.

TABLE 3.
Correlation for PVQ results

	Achievement	Affiliation	Power
Achievement	1.000		
Affiliation	-0.343	1.000	
Power	0.256	0.281	1.000

TABLE 4.
Covariance for PVQ results

	Achievement	Affiliation	Power
Achievement	0.098		
Affiliation	-0.053	0.242	
Power	0.069	0.119	0.736

Certainly the study by Altintas [40] shows that where Turkish managers are concerned, there are strong preferences for equity, the power of social relationships, reciprocation of favours, authority, loyalty, risk taking, and influence amongst others. This is certainly borne out by our PVQ results as well – noting the importance of these factors as a part of successful supply chain management strategies (as denoted by Lambert and Cooper in their work too). Noting the work of Danandjaja [41] in relation to the administration of England's PVQ scale, successful managers / leaders were noted to have higher value concentrations around components of affiliation ("My subordinates", "My company", "Organisational efficiency"), than those around purely power or achievement scales ("industry leadership", "prestige", "employees").

In contrast, Orpen [42] notes that for South African managers, there is a greater tendency to gravitate towards a more US-centric approach of high levels of achievement and power ("productivity", "aggressiveness", "success", "competition"). The Turkish results reported here, fall somewhere between the two, although as Westwood and Posner [43] clearly indicate there will always be cross-cultural differences which will effect value systems in organisations – although a universal or global value ethos will provide similarities rather than differences. In this respect, such results would have to be benchmarked and aligned to country specific and therefore cultural factors also especially where multi-country supply chain partners and operations would be concerned.

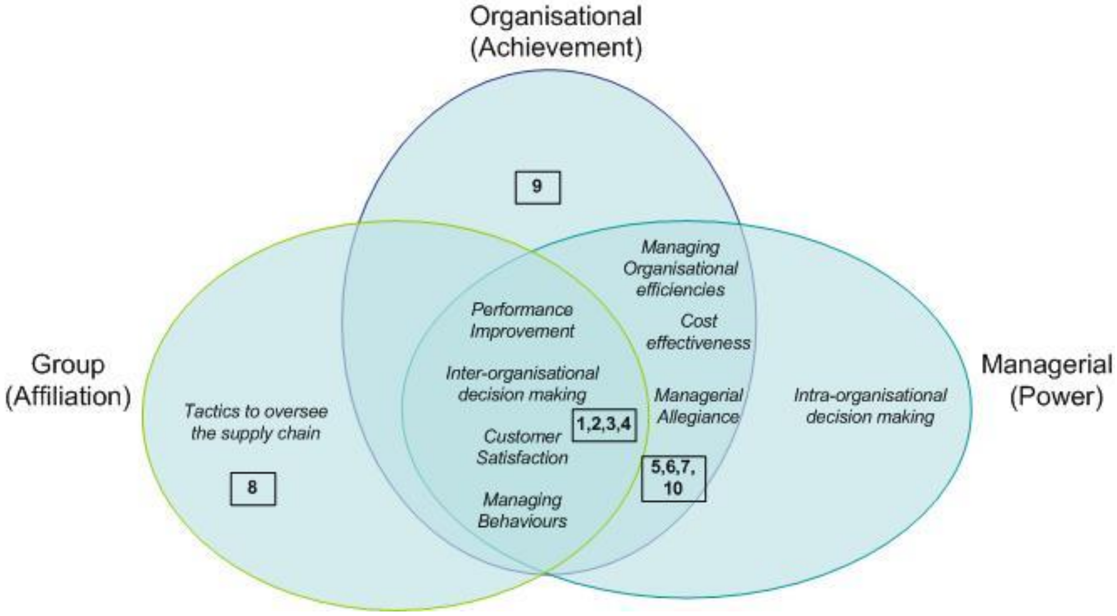
Finally, a comparison with the longitudinal 30 year study by Oliver [44] using England's PVQ scales highlights a number of interesting points. Productivity and efficiency (ostensibly achievement-related) still are seen as key drivers of success for organisations, with profit maximisation and leadership following shortly afterwards. Ambition, ability, skill and cooperation, customers, "my company", employees, self and subordinates – which is suggested by the authors to relate to the affiliation component of PVQ – are then also seen as important. Competition, change, risk and compromise – thus those which relate to the power component of PVQ – are subsequently chief drivers of success also. Overall, these results using the McLelland PVQ compare very well with England's PVQ in these terms and serve to highlight the importance of these concepts: even more so when considering the drive to improve supply chain operations as noted in the literature in the earlier part of this paper.

DEVELOPMENT OF A SUPPLY CHAIN LEADERSHIP FRAMEWORK

Against this backdrop, the authors now present a conceptual framework which synthesises and integrates both the supply chain literature on management and leadership as well as identifying those components of value-based approaches to management. The authors feel this integration is important and pertinent, as whilst the literature as well as practice within the field regularly (and rightly) advocates the usage of effective management capability there is a lack of viewpoints and perspectives which identify how such approaches can be developed based upon the individual who is charged with supply chain responsibilities. These responsibilties are ostensibly based upon a generalised view of personal values across Organisational, Group and Managerial (individual) boundaries, as noted above by both England and McClelland via PVQ constructs.

As such Figure 3 shows a combined perspective on this, as part of developing a view on supply chain leadership (SCL) as opposed to supply chain management (SCM) based upon the literature in the first part of the paper.

FIGURE 3.
Conceptual framework of supply chain leadership components



This framework not only upholds and supports the generic notions of SCM in terms of providing products/services across a tier of network suppliers and providers in the most effective and efficient manner, but also therefore places an emphasis on how those individuals who are tasked with supporting these operations need to include and involve the wider organisation, groups as well as their own capabilities to be successful. Hence, the framework provides a clustered intersection and grouping of the pertinent components from the literature surveyed above and highlights the strong inter-relationship between organisational (achievement), group (affiliation) and power (managerial)-based values. In this regard, the authors feel that the concept of SCL is not an overarching paradigm in itself, but is a vital underpinning to SCM (thus enhancing the traditional view of transformational leadership driving transactional management).

Furthermore the authors propose that by identifying these factors the PVQ data can be overlaid as shown in Figure 3 (the numbered items) to identify those supply chain leaders within and across organisations. This has been achieved by identifying which respondents have high achievement, affiliation, power scores (thus clustered in the middle of the diagram); high achievement-power (clustered to the right, “Organisational-Managerial”); and / or a particular individually strong score (in either of the the three components – in this case, affiliation thus “Group”). Hence in these terms the authors suggest that supply chain leadership capability should adopt and integrate the given instances of high achievement values and low power values, noting the effects of having a balance between all three personal value components in order to ensure performance, decision making, customer satisfaction and management behaviours are developed for supply chain effectiveness.

CONCLUSIONS

Leadership remains a critical aspect of business and management, where an inspirational figurehead sets the strategic direction of the organization for other to follow and deliver against. Whilst this has traditionally been seen at a senior management level priority, typically a Managing Director, Chief Executive Officer etc, there is increasingly a need to motivate and inspire others, at a business unit or process level to direct them to greater accomplishments. Applying effective leadership within a supply chain context is now considered critical given the complexity of organizational management, put simply, businesses are complex. The authors of this paper have conducted primary empirical research to identify those constructs that support the creation of a framework that culminates supply chain leadership components. In doing so, those data sampled have supported the creation of a framework that identifies the following building blocks that are classifies as *Organizational* (Achievement), *Managerial* (Power) and *Group* (Affiliation) and thus, essential leadership traits, where leaders are required to carry out:

- Performance improvements
- Inter-organisational decision making
- [Delivering] Customer satisfaction
- Manage behaviors
- [Creating] Managerial allegiances
- Manage organizational efficiencies
- [Delivering] cost efficiencies
- Tactics to oversee the supply chain

The emergent framework offers those seeking to create a leadership capacity within a supply chain context a clearer understanding of the leadership challenges that lie ahead. However, to provide a more scalable insight, the research will need to increase its sample population thus allowing more generic outcomes to emerge and therefore generalizable conclusions. Whilst such an extension of this research could develop numerous strands, into *discovery*, *theory building* or *testing*, what remains clear is that the authors would instinctively gravitate towards exploring cultural differences between participants from discrete sample populations and thus, extend beyond the Turkish context. This is considered to lead to much richer insight that extends beyond a supply chain context and in itself will open up and promote multidisciplinary research opportunities.

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TAXONOMY OF COLLABORATION IN SUPPLY CHAIN MANAGEMENT

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Abstract— *Integrity, trust building and collaboration among the Supply Chain players are the main themes for a successful Supply Chain Management (SCM) application and mostly appeared in the literature. The changing nature of competitiveness shifted power from firms to supply chains as a whole, making SCM and especially collaboration vital for gaining and sustaining competitive advantage. Coupled with all the advances in Information Technology (IT), e-collaboration became the key concept in facilitating both firm and supply chain performance. This article provides a critical look at the intersection of supply chain management and collaboration topics. After introducing the importance and benefits of collaboration and role of IT, this article focuses on the taxonomy of the collaboration models and frameworks provided in the SCM literature. Scope, strengths, weaknesses and limitations of the current modeling and framework development efforts are also discussed comparatively. The study reveals that intersection of supply chain and collaboration interaction topics needs to be improved in the literature and successful implication of collaboration frameworks ensures and contributes to the success of SCM models.*

Keywords— *collaboration, modeling, supply chain*

INTRODUCTION

Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities, including the coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers [1]. Reflecting the dynamic and global nature of today's economy, there has been increased expectations on visibility, velocity, accessibility and connectivity on supply chain partners, causing the supply chains to become more lengthy and complex [2,3]. With all these increased pressures, since the early 1990s there has been a growing understanding that supply chain management should be built around the integration of trading partners [4]. In the modern world where competition is no longer between the organisations but between supply chains, coordination and collaboration become the key to effectiveness, agility and competitiveness of the supply chains [5,6].

With all the opportunities offered by the Internet-based information systems, it is well-proven and established that IT improves both intra- and inter-organizational coordination [2, 7, 8, 9]. By making possible the sharing of large amounts of information, IT has enabled real- time collaboration and integration between supply chain partners; and the Internet became the information technology which has the most profound impact on business integration and collaboration [10, 11]. As such, the use of IT has changed the nature of business from intra- to inter- enterprise and IT became one of the most critical enablers for integrity [4, 9, 12, 13] as well as necessity [14]. By providing various levels of integrity ranging from restricted electronic data

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interchange (EDI) usage to seamless coupling of enterprise-wide systems among supply chain partners, advances in IT led to the concepts of *'e-supply chain'* and *'e-collaboration'*.

Collaboration in the context of supply chain is an amorphous meta concept that has been interpreted in many different ways by both organizations and individuals, academic definitions focusing on the business-to-business (B2B) internet-based technologies while practical definitions having a wider scope [15].

Reference [8] investigates various studies on supply chain coordination and mention the following definitions for supply chain coordination:

- Collaborative working for joint planning, joint product development, mutual exchange of information and integrated information systems, cross coordination on several levels in the companies on the network, long term cooperation and fair sharing of risks and benefits,
- Two or more independent companies working jointly to plan to execute supply chain operations with greater success than when acting in isolation,
- A win/win arrangement that is likely to provide improved business success for both parties.
- A strategic response to the challenges that arise from the dependencies.

The continuum of 'competition→ cooperation→ collaboration→ coalescence' is defined in terms of degrees of objective alignment among the supply chain partners and 'collaboration' is considered as the third stage along this continuum in [16].

The typical collaboration modes involve demand-side collaboration, supply-side collaboration and overall synchronization [17]. Beyond simple e-buy and e-sell activities, the collaboration concept involves integration and sharing of process, design and resources [15], as well as transparency and sharing of information among the supply chain members [18]. This transparency and sharing of information involve all the processes and resources of the value chain, including:

- product design & development,
- demand estimation,
- inventory& production planning,
- fulfillment & delivery planning,

and extending to joint problem solving & decision making, joint financial planning & risk sharing. Within this broad perspective, the level of supply chain integration or collaboration should be determined by business needs related to supplier development, strategic sourcing, outsourcing, customer compliance, product development, supply chain efficiency and responsiveness [5]. This wide scope of the concept is also emphasized in [8], mentioning the various perspectives of supply chain coordination in literature as follows:

- resource sharing,
- risk and reward sharing,
- responsibility,
- holistic view of coordination,
- workflow and resource,
- dependency,
- mutuality,
- joint promotional activities,
- joint forecasting,
- joint decision-making,
- benefit sharing.

Adoption of collaboration is mainly driven by the increased need of information sharing & visibility along the supply chain, efficient communication in a distributed network, cost reduction, increased opportunities on partnership, flexibility, adoptability [15] and increased desire to improve coordination [19]. The idea is to integrate the value creation processes with a total end-customer driven orientation and improving competitiveness through a coordinated effort in a lean environment [20].

Benefits accruing from effective collaboration include: elimination of excess inventory, reduction of lead times, increased sales, improved customer service, efficient product development efforts, low manufacturing costs, increased flexibility to cope with high demand uncertainty, increased customer retention, and revenue enhancements [8], as well as elimination of the bullwhip effect by linking the inventory and replenishment decisions, reduction of inventory levels up to 50% without compromising service levels, better utilization of production capacity and transport resources [19]. Literature also supports that lack of coordination may result in poor performance of supply chain, such as increased costs of stock out, expediting, transshipment, advertising and sale preparation, excess inventory obsolescence and disposal [8].

Literature consistently supports the idea that integration between firms improves firm's operational and business performance [10, 21]. Despite the clear relation between integration and performance, Vaart and Donk [22] highlight the excessive variation in the way different authors try to capture supply chain integration, lack of clarity of definitions and constructs used in measurement, as well as level of analysis in their critical review of survey-based studies focusing on the relationship between integration and performance. The study stresses that it is important to acquire a better understanding of the interactions or relationships between these factors. The idea that the supply chain coordination is still in the development stage is also supported in [8] .

As such, the rest of the article will focus on the supply chain collaboration modeling and framework development efforts in literature, organized as follows: Section 2 treats the main approaches, models and frameworks for supply chain collaboration, providing a taxonomy and comparatively discussing the strengths and weaknesses of each. Section 3 will provide discussion and further research.

APPROACHES, MODELS AND FRAMEWORKS FOR COLLABORATION

Literature contains various models, strategies and initiatives, representing various degrees of collaboration, starting with the initial approaches of quick response (QR), efficient consumer response (ECR), continuous replenishment policy (CRP), vendor managed inventory (VMI) and leading to collaborative planning, forecasting and replenishment (CPFR) [12, 23, 24].

Besides these approaches, there exists framework development efforts [24] to extend CPFR , as well as various maturity models based on collaboration/integrity levels; and operations reference models defining standardized supply chain processes and metrics as the base of collaboration. This section will discuss all of these efforts in detail.

Initial Approaches (QR, ECR, CRP and VMI)

Quick response, efficient customer response, continuous replenishment policy and vendor managed inventory appear as four main initial approaches for providing supply chain collaboration. Although the distinctions between these strategies are not obvious, the main differences arise from decision point of sales forecasting and order generation, inventory ownership, as well as skills and responsibilities of the vendor.

Among these strategies, QR delegates only the forecasting responsibility to the vendor and the retailer makes decisions to generate orders. This strategy appears as a modified version of just-in-time replenishment strategy. ECR appears as a demand-driven, pull type of material movement aimed at providing a responsive, customer-driven system allowing distributors and suppliers to work together in order to maximize consumer satisfaction and minimize cost. As such, it appears similar to quick response in using pull type of movement trying to provide continuous, quick and efficient inventory flow. CRP involves contractual, mutual alliance and vendor is involved in demand forecasting and inventory control. VMI represents the level at which vendor has the largest set of responsibilities, making the vendor the primary decision maker for demand forecasting, inventory control and retail management. Thus, in VMI there is a high level of power for the supplier, but QR gives more power to the retailer. Study in [24] classifies QR as 'low' and VMI as 'high' degrees of partnership.

A comparative summary table is given below in terms of order generation, inventory ownership and vendor skills, as adopted from [24]:

TABLE 1
Comparison table for QR, ECR, CRP and VMI, Adopted from [24]

	Order generation	Inventory Ownership	Vendor skills
QR	Retailer- managed	Retailer	Demand forecasting
ECR	Joint, pull type	Vendor	Joint demand forecasting, inventory control and retail management.
CRP	Contractually agreed levels, continuous	Either party	Demand forecasting and inventory control.
VMI	Vendor-managed	Vendor	Demand forecasting, inventory control and retail management.

Besides order generation decision, inventory ownership and vendor skills, the following three main dimensions are also mentioned in [24] for the purposes of comparison:

- the organizational scope of management: internal logistics/supply chain/ supply chain network
- the degree of operational activity :execution/planning/strategic choices
- the decision-making frequency: periodical/real time

From the above discussion, it is evident that the distinctions among these approaches are blurred and that all of them mainly focus on efficiencies and collaboration related with order replenishment and inventory planning. As such, the scope of collaboration in this class of approaches appear as restricted mainly to inventory management, although the scope of responsibility changes. Since they do not contain standardized process definitions, collaboration mechanisms or measurement, metric & benchmarking tools, they can be classified as ‘approach’ or ‘philosophy’ to replenishment and inventory planning, rather than being models or frameworks for collaboration.

CPFR (Collaborative Planning, Forecasting and Replenishment) Model

Representing a still ‘higher’ degree of partnership, the Voluntary Inter-industry Commerce Standards (VICS) Association developed the CPFR® [25] initiative in the late 1990’s. As a business practice combining the intelligence of multiple trading partners in the planning and fulfillment of customer demand, CPFR links sales and marketing best practices to supply chain planning and execution processes to increase availability while reducing inventory, transportation and logistics costs. The model defines four Collaborative Activities to improve their performance:

- **Strategy & Planning:** Establish the ground rules for the collaborative relationship, determining the product mix and placement, and develop event plans for the period.
- **Demand & Supply Management:** Project consumer (point-of-sale) demand, as well as order and shipment requirements over the planning horizon.
- **Execution:** Place orders, prepare and deliver shipments, receive and stock products on retail shelves, record sales transactions and make payments.
- **Analysis:** Monitor planning and execution activities for exception conditions. Aggregate results, and calculate key performance metrics. Share insights and adjust plans for continuously improved results.

CPFR provides the breakdown given in Figure 1 for each activity and contains the nine steps given in Figure 2.

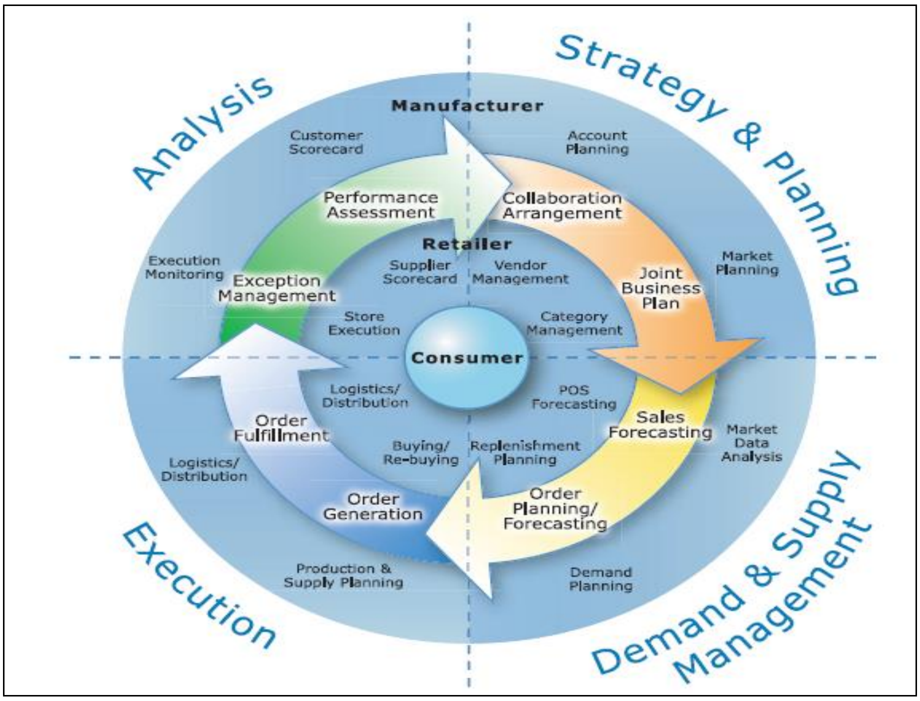

FIGURE 1
CPFR model [24]

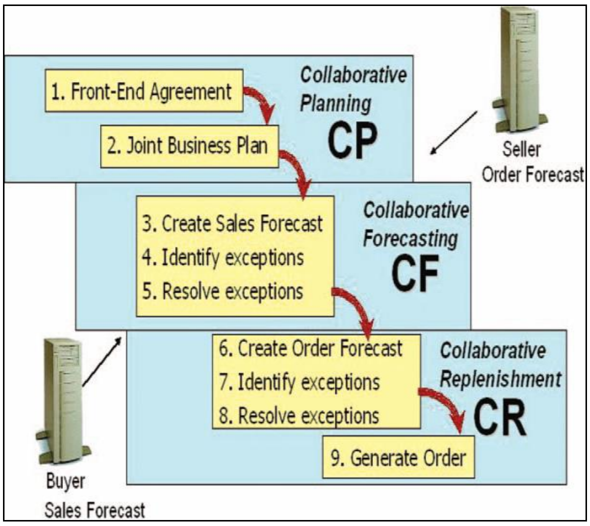

FIGURE 2
Steps of CPFR [25]

Starting from strategy, CPFR covers demand & supply management, enables performance assessment and exception management. It is always superimposed on an existing demand planning and replenishment process. As such, CPFR both enhances and is compatible with conventional ordering processes & vendor-managed (VMI). The distinguishing factor in these alternatives is who takes the lead in three collaboration tasks: sales forecasting, order planning/forecasting, and order generation. When compared with vendor-powered VMI model, CPFR requires agreement and collaboration of the vendor and supplier sides [25].

The model contains predetermined scenarios for four different trading relationships: **Retail Event Collaboration** (for highly promoted channels or categories), **DC (Distribution Channel) Replenishment Collaboration** (for goods replenished through distribution centers), **store-level collaboration** (for direct store delivery or retail DC-to-store distribution) and Collaborative Assortment Planning (for apparel and seasonal goods) [25]. Among them, DC replenishment collaboration is a CPFR scenario that enhances continuous replenishment programs such as co-managed inventory or vendor-managed inventory (VMI).

As a model that enables real-time sharing of information among partners, CPFR model is mentioned in literature as providing significant benefits and performance-related improvements. CPFR is emphasized to provide greater visibility to improve replenishment accuracy, out-of-stock reduction, overstock reduction, alignment of production capacity to meet customer demand, increased efficiency of the flow of product between trading partners; as well as product flow benefits including optimized order quantities minimizing the operations costs of picking, loading and unloading (vics.org 2004). By referring to previous research, study in [12] confirms that CPFR was able to improve the supply chain performance by responsiveness intensification, product availability, inventory and associated cost reduction and revenue growth. The typical benefits of CPFR are mentioned as increased profitability, reduced inventory, shortened cycle time, more efficient transportation and decrease of shortages. Based on previous literature, study in [26] emphasizes the fact that adaptation of higher levels of collaboration among members of a supply chain creates greater benefits for the supply chain, as large amounts of information available with CPFR are being effectively used to minimize the uncertainty along the supply chain. The comparative simulation-based study given in [12] also provide strong support on the performance- related improvements provided by increased level of collaboration. Their study compares four scenarios having different collaborative alternatives against the non-collaborative scenario in terms of average service level, average fulfillment rate, average order cycle time and total system cost, revealing that shared information on sales, inventory and capacity provide significant improvements in terms of the performance measures defined.

With all these proven benefits, CPFR involves stronger linkage of business planning, forecasting and replenishment through deeper information sharing [12] when compared with previously mentioned strategic approaches. Main difference between CPFR and other collaborative arrangements is that under CPFR, both parties are informed of exceptions, which generate the collaborative activities aimed at resolving these exceptions via an exception engine pointing out discrepancies [23]. As such, when compared with the models mentioned in 2.1, CPFR represents a tighter and higher form of collaboration.

Despite all these benefits and much wider scope of collaboration, the following limitations can be identified for the CPFR model:

1) The model represents an approach which is still material management and logistics oriented and lacks various stages of the supply chain, such as product design and development collaboration, human resources and after-sales support.

2) Although the model contains customer and supplier scorecards, it does not provide a customer-centric or supplier centric approach. As such, customer relationship management (CRM) and supplier relationship management (SRM) are not at the heart of the model.

3) The model does not contain any further standardized process definitions beyond the activity breakdown depicted in Figure 1, and stages defined in Figure 2. As such, it does not provide a process reference model as a structural base of collaboration.

4) The model does not provide measurement and metrics definitions at different levels of hierarchy. As such, the model does not enable performance measurement and benchmarking.

5) The model does not define the dimensions of collaboration and object items to be shared during collaboration. As such, inputs and outputs for each collaboration step are not defined.

6) The model does not involve the 'trust' aspect of the collaboration and does not mention trust-building mechanisms.

SCM Framework By Derrouiche et al. [24]

A newer collaborative supply chain framework is proposed in [24], which deserves detailed discussion in a separate subsection. This framework depicted in Figure 3 is based on five criteria: extent of the collaboration, objects involved in the collaboration, nature of the collaboration, decision level and frequency of decisions.

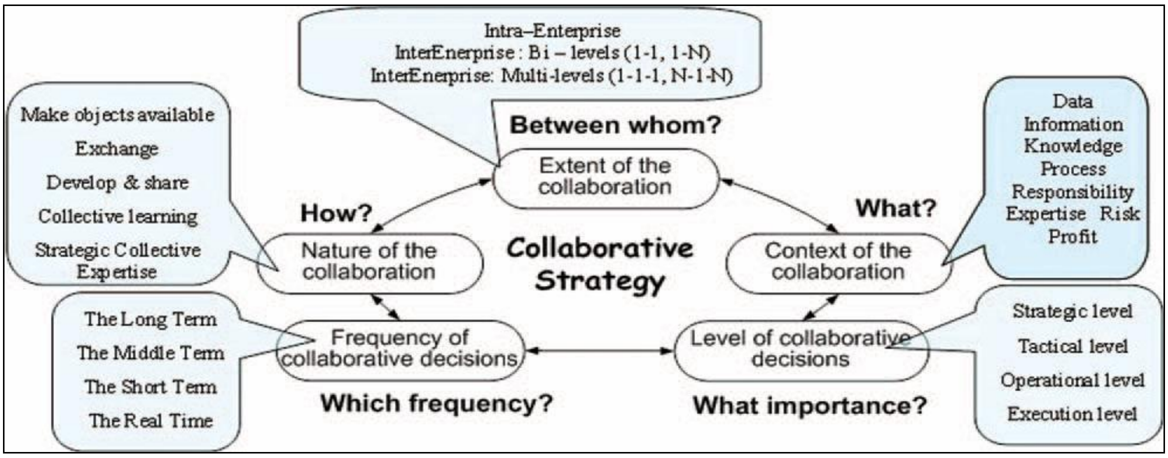

FIGURE 3
Framework by Derrouiche *et al.* [24]

The model contains four different time frames for the 'frequency' (long term/middle term/short term/real time) corresponding to four levels of 'decision' (strategic/ tactical/ operational/ executional). The nature of collaboration extends from 'making objects available' to 'collective expertise'; context of collaboration extends from 'data' to 'expertise' and 'profit'. The model handles both inter- and intra (both bi- and multi-level) collaboration. Using these dimensions, a 'collaborative cartography' is developed which represents ranges of collaboration. The cartography approach is depicted below:

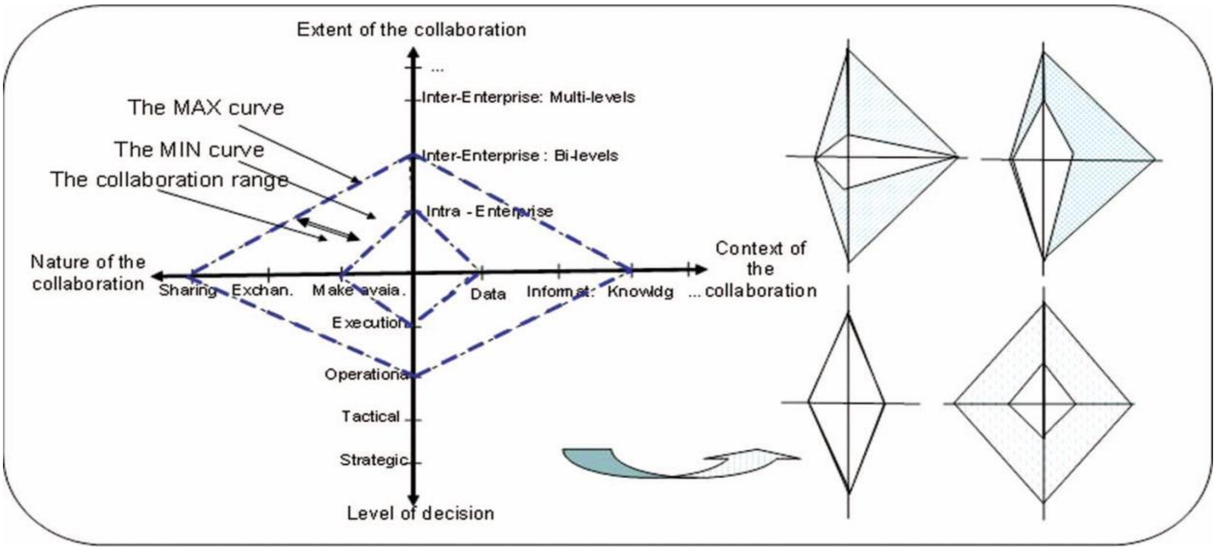

FIGURE 4
Cartographic tool [24]

The developed framework is then applied to CPFR model using an analysis grid tool and stages of CPFR model are matched to the dimensions of the framework. Thus, the framework is used to complement the CPFR model. This framework is a valuable contribution from the following aspects:

- It clarifies many dimensions, objects and nature of collaboration, alleviating the CPFR limitation item no. 5 mentioned in 2.2.
- It is applied to CPFR model. Therefore, it can be argued that this framework is compliant with CPFR, providing a complement to CPFR.
- It provides a practical, visual tool for determining the current collaborative positioning along various dimensions. This tool enables determining the relative positioning along various dimensions. As such, it can be argued that limitation item no. 4 mentioned in 2.2 is handled to a certain extent.
- It provides a basis for further UML modeling of a collaborative information system.

Although the CPFR limitation items 1, 2 and 3 still prevail, we believe that this framework provides a significant extension to CPFR model. It can be argued that if supplemented with sound, standardized process references, a much more comprehensive collaboration model can be obtained based on this framework.

Operations Reference Models: Supply Chain Operations Reference Model (SCOR), Design Chain Operations Reference Model (DCOR) & Customer Chain Operations Reference Model (CCOR*)*

SCOR model developed by Supply Chain Council provides a framework designed to link business process, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities [27]. The model is structured around SOURCE / MAKE / DELIVER / RETURN processes along with 'PLAN' and 'ENABLE' functionality for each process, as shown below:

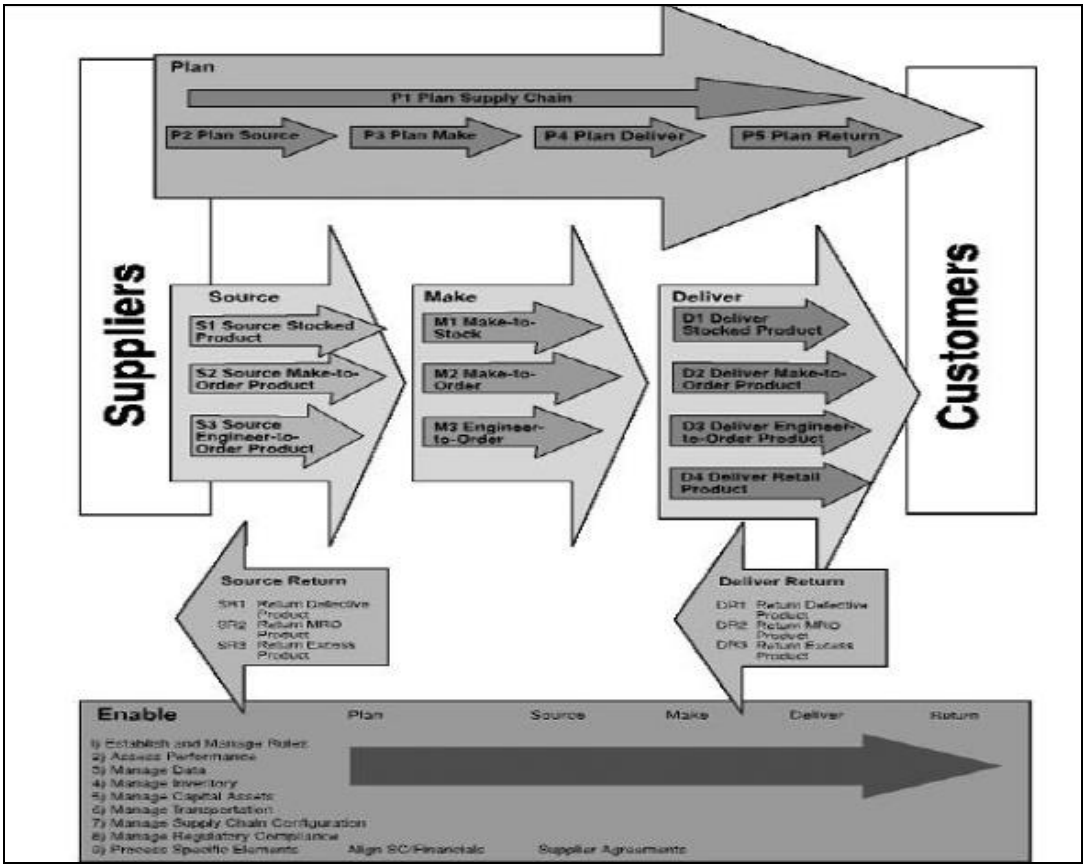

FIGURE 5
Basic SCOR structure [27]

SCOR model has the following basic properties:

- Provides a reference model for business process alignment.

- Has process orientation and builds on the concepts of process reengineering, performance measurement and logistics management.
- Includes structured building blocks, together with standard descriptions of processes, key performance indicators (KPI's), best practices and software functionalities needed associated with the best practices.
- Provides a configurable and cross-functional framework.

With all these critical properties, SCOR became the most commonly accepted/major framework [28, 29]. Especially the properties of having process building blocks and being measurement & metrics oriented make SCOR a strong structural foundation for supply chain standardization, communication and collaboration. As such, it can be considered as one of the critical models for supply chain collaboration.

Despite all these strengths, the following can be argued as the main limitations of SCOR, based on the gaps mentioned in [28] and the scope of the model:

1. Model does not address sales & marketing (demand generation), product development, research and development, and some elements of post-delivery customer support. The Model is silent also in the areas of human resources, training, and quality assurance.
2. SCOR can only represent the business flow between legal or geographical entities, not matrix-type organizations or the concept of 'virtual enterprise'.
3. SCOR is limited to representing one single supply chain, while most enterprises may be associated with multiple channels of markets or products.
4. For benchmarking purposes, KPI's of SCOR are not readily available in the targeted company, especially the cross-site information. This makes gap identification (between as-is and to-be status), comparing and clustering of the companies in terms of performance difficult. Unequal readiness of IT infrastructure, conflicts of management interests and presence of a multitude of non-weighted metrics again makes SCOR difficult and complicated to use as a practical benchmarking tool. Even when KPI analysis is available, intangible problems cannot be identified, such as cultural conflicts or coordination uncertainties.
5. Lacks the metrics for intangible assets, trust, collaboration and information productivity.
6. Order modification, activities of collaborative design and CRM are not taken care of.

To alleviate the scope limitations from product research & development and the customer viewpoints, DCOR [30] and CCOR [31] are developed, respectively. These two models are inspired by SCOR model and they exhibit consistent structures with SCOR model.

DCOR is structured around PLAN/ RESEARCH/ DESIGN /INTEGRATE/ AMEND processes, covering the cycle of new product design& development and design change management of existing products. Similarly, CCOR focuses on the customer side and it is structured around PLAN/ RELATE/ SELL/ CONTRACT/ ASSIST processes, integrating sales activities, contract management, account management and post-sales support.

As such, both DCOR and CCOR can be thought of as add-ons to SCOR model structure, adding the design and customer processes to SCOR and thus providing a wider scope. Ayers [1] mention these two models as 'sister models filling the gaps of SCOR'. However, these add-ons do not solve the other SCOR limitations (items no: 2 to 6) mentioned above. Thus, SCOR structure amended by CCOR and DCOR provides a very strong foundation for supply chain coordination in terms of processes and metrics definitions, but they are still far from solving the problems of metrics complexity, measuring degree of collaboration among supply chain partners and being a practical benchmarking tool. These operations reference models refer to CPFR model as 'best practice'.

Maturity Models Based on Integration/Collaboration

As well as the approaches and frameworks mentioned in 2.1 through 2.4, the literature contains various maturity models trying to classify and define various levels of integrity/collaboration and relating these stages to the maturity levels and performance of the supply chain partners. The following table summarizes five main maturity models:

TABLE 2

Comparison table for various maturity models

	Maturity levels	Description
Computer Sciences Corp. (CSC) Framework based on [32]	• Functional integration • Logistics integration • Inter-organizational processes integration • Collaborative Initiatives • Complete join/collaboration	Defines maturity levels in terms of **scope of integration/collaboration**, starting from functional integration and extending to complete join.
Business Orientation Maturity Model by Lockamy & Mc Cormack [33]	• Ad-hoc • Defined • Linked • Integrated • Extended	• A SCOR-based model • Starting with the ill-defined processes within an enterprise, the stages are defined in terms of degree and extend of collaboration for various processes. • Highest level of integrity corresponds to the ‘extended’ level (multi-firm networks are strongly coupled by trust& mutual dependency. • Developed as a common language for benchmarking purposes, this model is critical as being SCOR-compliant, providing a grade scale for classifying the company into one of these classes.
Capability Maturity model integration-CMMI [34]	• Initial • Managed • Defined • Quantitatively managed • Optimizing	Ability to include quantitative approaches is defined as a maturity level. Contains a set of best practices and roadmap.
Classification by Bendoly and Jacobs [35]	• Fundamentals • Cross-functional teams • Integrated enterprise • Extended supply chain • Supply chain communities	Defines a 5-stage evolution model extending to ‘supply chain communities’.
PMMM (Kerzner Project Management Maturity model) [1, 36]	• Common language • Common processes • Singular methodology • Benchmarking • Continuous improvement	5 stages are defined in terms of organizational awareness, management support, process discipline and motivation to ‘a project management’.

Among these maturity models, CSC framework prioritizes functional& logistics integration for inter-organizational collaboration and extends the degree of collaboration to ‘complete join’ stage. Business process orientation model given in [33] stands out as being SCOR-dependant and providing a grading and classification scheme for classifying the organization into predefined maturity stages. CMMI model contains mainly best practices and roadmap, whereas PMMM model has the focus on the ability of ‘project management’. Bendoly and Jacobs [35] try to describe the evolution and their classification can be considered again as a roadmap. PMMM model seeks for excellence in project management and aimed at providing common language, processes and singular methodology.

Ayers [1] also mention a 4-level of maturity classification extending from ‘no chain’ to ‘information networks’. This classification is based on supply chain types defined in [37], which differs by its ‘over classification’ of supply chain types into 16 classes and it contains inconsistencies in the naming of the supply chain types such as ‘micro chain’, ‘market dominance and blocking’, ‘speed to market’ and ‘innovation’.

Although different naming and terminology is present, in all of these maturity models we observe efforts of moving from functional and internally- focused structures to extended architectures that can communicate and collaborate beyond the enterprise. It is evident that clearly defined and integrated intra-enterprise process definitions are vital for being able to move to higher levels of integrity. It can easily be argued that standardizing, streamlining and coordinating the internal functions properly represents a critical stage of evolution [2]. As internal silos of functional information are broken down, enterprise-wide applications become efficiently in place. Only after this stage that external integrity considerations and collaboration with other supply chain partners can be in question. Thus, internal coordination and collaboration is a prerequisite for successful collaboration among supply chain partners. Literature fully supports this idea of ‘internal integrity first’ and detailed discussions of this idea can be found in [2]. Above- mentioned maturity models can be criticized from the following aspects:

- They lack the detailed and standardized process definitions. Among them, only model given in [33] utilizes the SCOR process definitions but the others do not provide any lower level process reference.
- They do not provide metrics and measurement tools that can measure ‘degree of collaboration’. As such, they are far from being a practical tool that can measure collaboration.
- They do not define the dimensions of collaboration and object items to be shared during collaboration. As such, inputs and outputs for each collaboration step are not defined.
- This class of models again lacks the ‘trust’ aspect and the human side of the collaboration issue.

DISCUSSION AND FURTHER RESEARCH

Detailed treatment of approaches, models and frameworks in Section 2 clearly reveals that literature still lacks consistent definitions, terminology and structures for collaboration modeling. This idea is also supported in [8]. Current literature seems to be fragmented in different lanes of ‘**various collaborative approaches’, ‘operation reference models’** and **‘maturity models**’. Approaches mentioned in 2.1 suggest only the philosophy for collaboration and does not touch upon the structure. CPFR model stands out as a major collaboration model but has several limitations, as mentioned in 2.2. Operation reference models have clearly defined, standardized process definitions and metrics structure to provide a structural foundation for collaboration, still having their own drawbacks. Maturity models intend to define evolution along various degrees of collaboration/integrity but they again lack the process and technology infrastructure.

On top of this fragmentation, drawbacks and limitations of current supply chain performance measurement systems are already well discussed and proven in supply chain performance measurement literature. Seeking for a balance of processes, struggling with complexity & inconsistency of metrics and failing to connect strategy and measurement, current supply chain literature is still in search of a holistic and consistent performance measurement system [14, 38, 39, 40]. As such, current approaches, reference models and maturity models do not appear to solve the performance management problems of today’s collaborative supply chains.

Gaps of coordination perspectives and conceptual models are also well-discussed in [8], emphasizing the following:

- need for handling different coordination mechanisms to deal with the complexities in managing the interdependencies like resource, knowledge&, information sharing, joint working, joint decision making, joint design and development of product, joint promotions, implementing information systems, designing risk-sharing contracts.
- need for quantifying and assessing the strength of coordination and developing a number of performance measures to capture the impact of coordination in a holistic manner.
- need for more empirical studies regarding the proper implementation of coordination mechanisms.

The authors also believe that soft aspects like effects of mutual trust and organizational structure on collaboration are also neglected in literature. Web-based architectural requirements, together with platform-independence and security issues are also major concerns on the way to obtain seamless e-collaboration among supply chain partners.

Thus, authors hold the opinion that literature still lacks a comprehensive, unified and consistent supply chain collaboration model which can:

- provide standardized process definitions, objects and infrastructures covering all the processes while handling complexities and interdependencies,
- quantify, measure and monitor ‘coordination’,
- provide planning, controlling, feedback and warning mechanisms covering all critical processes, thus enabling managerial control,
- provide a lean, practical and holistic measurement mechanism that alleviates the current drawbacks of supply chain performance measurement systems,
- allow benchmarking,
- incorporate best practices,
- does not ignore organizational and human aspects such as ‘trust-building’.

As such, the literature still appears immature in terms of modeling efforts and supply chain collaboration is still a fruitful area of research at which future research efforts can be directed.

This study revealed that the concept of ‘collaboration’, utilizing all the benefits of IT technology and having direct supply chain performance implications, is a critical ingredient of today’s supply chain management. Our effort to classify the supply chain models, frameworks and approaches that are either relevant or providing a foundation to the concept of ‘collaboration’ necessitated the coverage of maturity models or reference models as well as the initial approaches and CPFR. This clearly indicated the fragmented structure of current modeling efforts and the authors believe that strength of this taxonomy study lies in this joint treatment of models, frameworks and approaches.

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A MULTI OBJECTIVE OPTIMIZATION OF A GREEN SUPPLY CHAIN NETWORK USING FUZZY ANALYTIC HIERARCHY PROCESS

Turan Paksoy [1], Nimet Yapıcı Pehlivan [2], Eren Özceylan [3],

Abstract *— The global climate alteration has become one of the most important controversial issues in today, because of leading the environmental disasters. The greenhouse gas emissions (CO2, methane, etc.) and air pollution increase attention to develop and improve environmental strategies. The environmental sanctions are forcing enterprises to re-consider and re-design supply chain processes in a green way. This study develops a multi objective model to design a closed-loop supply chain (CLSC) network in a green frame. Our first and second objectives are minimizing the all transportation costs for forward and reverse logistics; third one is minimizing total CO2 emissions; fourth one is encouraging the customers to use recyclable materials as an environmental performance viewpoint. This research paper will aid the decision makers in compensating all aforementioned goals in SCM through the evaluation weights are determined using Fuzzy Analytic Hierarchy Process (FAHP) based model. The proposed linear programming model is tested via fulfilling a numerical example.*

Keywords — Closed-loop, fuzzy analytic hierarchy process, greenhouse gas emissions, green supply chain, multi objective optimization

INTRODUCTION

Supply chain and management is a business and academic term that has emerged in the last few years and is gaining in popularity quickly. Bowersox and Closs [1] defined the supply chain that the supply chain refers to all those activities associated with the transformation and flow of goods and services, including their attendant information flows, from the sources of materials to end users. All processes even the supply chains need certain capacities and resources. The most indications point out that the earth is changing from a world of abundant, fresh, cheap energy to a world of limited, expensive energy, drought and polluted. Aforetime whereas the most important thing was transportation or production costs, now the enterprises have to take into account environmental factors because of inadequate resources. A supply chain design problem comprises the decisions regarding the number and location of production facilities, the amount of capacity at each facility, the assignment of each market region to one or more locations, and supplier selection for sub-assemblies, components and materials [2]. The green supply chain (GrSC) design extends this definition by including:

(i) Waste of all processes,
(ii) Using efficient energy resources,
(iii) Greenhouse gas emissions,
(iv) Using capacities and resources efficiently,
(v) Considering legal environmental factors.

This is a fact that a supply chain network consists of industrial/distribution processes and needs transportation fuels to actualize these processes. We consider the greenhouse gas emission and recyclable products factor while designing the GrSC in our study. As seen in the Figure 1, these supply chain activities are significant sources (totally %30.8) of greenhouse gas emissions and air pollution, also creating harmful effects on living health and leading to global warming.

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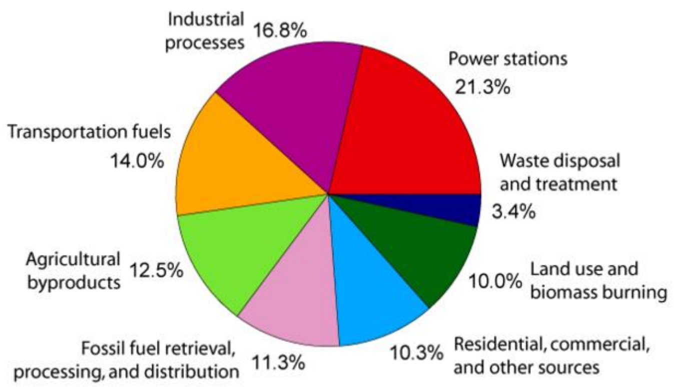

FIGURE 1
Greenhouse Gas Emissions by Sectors [3]

Actually, in an era with more environmental conscience on a global level (Kyoto, Social Responsibilities, Local Governments etc.), the enterprises and service providers could no longer reject indefinitely on the community of environmental costs and will be, in all probability, subjected to heavy environmental tax in next years [4]. These sanctions have raised the concerns on decreasing negative effects on green world. In this respect, many enterprises, including local or global supply chain networks have set strict targets to build a green structure.

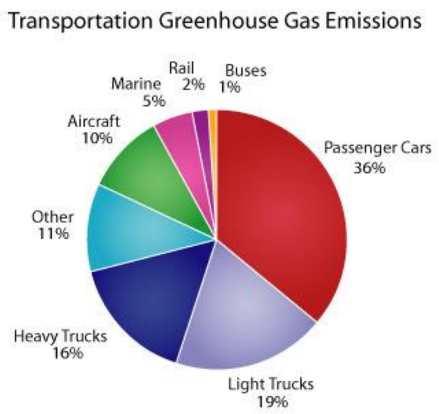

FIGURE 2
Transportation Greenhouse Gas Emissions [5]

Figure 2 shows that totally 35% ratio of transportation greenhouse gas emission is actualized via heavy and light trucks which are commonly used in the supply chain transportation. It is clear that the first job has to adjust the transportation gas emissions to change the extant network to green one. Choosing new models, diesel motors, intermodal transportation [4], alternative energy resources etc. would be solutions for harmful gas emissions. According to Figure 3, CO_2 is 72%, CH_4 is 18% and NO_3 is 9% of total gas emissions.

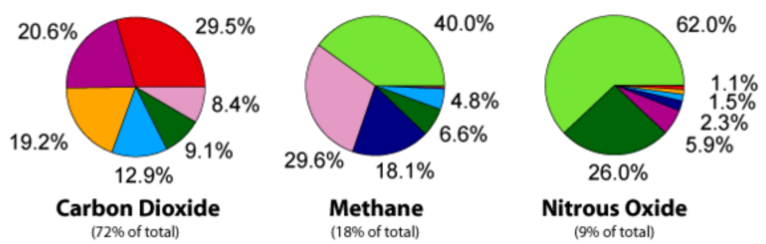

FIGURE 3
The Greenhouse Gas Emission Distribution [3]

Waste is another serious issue in supply chains besides the gas emissions. In response, recycling is drawing attention as it converts what was once seen as waste into useful materials. Thus, it improves SCM by helping to close the "material loop" of products from resource extraction, through production, use, and end of life.

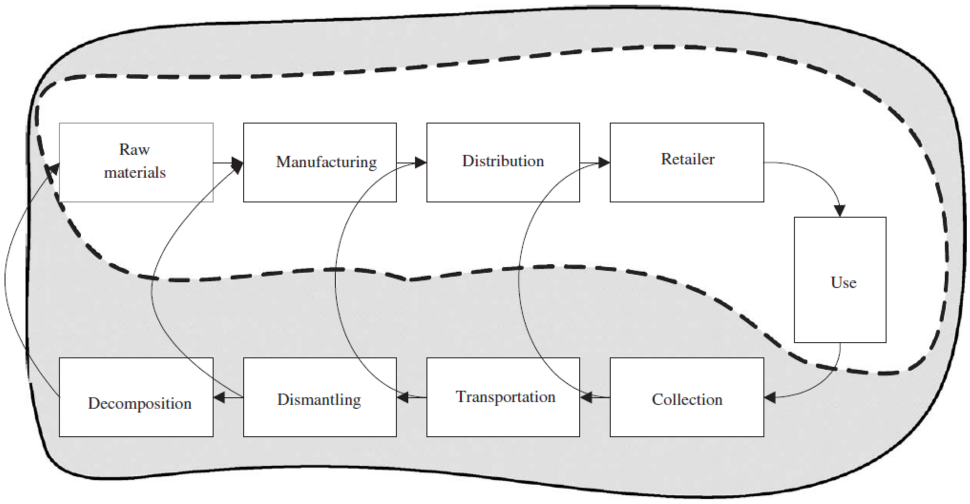

FIGURE 4
Recycling in a Supply Chain [6]

To further develop supply chains for recyclable and recycled materials, it will be necessary to improve recycling technologies, to allow recyclable materials to be reprocessed into recycled materials of sufficient quality that they can compete with virgin materials [7]. In response to increasing customers' demand for environmentally products enterprises and manufacturers of final products are exerting greater pressure on their suppliers to raise their environmental standards. The enterprises have been trying to develop products that are more energy efficient, less toxic and less hazardous to the environment. The concept of GrSC has been introduced and manufacturers are changing product designs to be greener. In order to change product design and to improve the recycled content of their products, enterprises must have recycled-materials and work with the recycled-parts suppliers. Therefore, the enterprises need to develop a closed loop relationships with suppliers of recycled materials and recycled parts (Figure 4).

In this study, we are motivated to study a GrSC network optimization problem where CO_2 gas emissions according to trucks options and recyclable products are considered to become a mirror of greenness. We determined a penalty cost to prevent more CO_2 gas emissions and encouraged the customers to use recyclable products via giving a small profit. Trucks' rental fees and purchasing costs of recyclable products can influence the environmental indicators in the model because of an existing a trade-off. With such a concern, we optimize the network also under transportation costs and capacity allocation constraints. Which of the aforementioned sub-aims is more important for the main goal and by how much? An FAHP model is used to solve this decision problem. The rest of the paper is organized as follows: In the next section a literature of green and CLSC and FAHP is given. In Section 3, we detail our proposed model with its' mathematical formulation. And then we conduct a numerical example to characterize the optimal solutions. Finally, the paper is ended with conclusions and suggestions for further researches.

LITERATURES REVIEW

In this section, we probe the literature and categorize studies into three. The first one is the GrSCs, the second one is the CLSCs in designing the networks and the third one is the Fuzzy Analytic Hierarchy Process.

The Green Supply Chain

There is a large of amount of literature on supply chain network design concerned with environmental issues through the GrSC networks. Graedel and Allenby [8] defined Industrial Ecology is the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. It is a systems view in which one seeks to optimize the total materials cycle from virgin material, to finished material, to component, to product, to obsolete product, and to ultimate disposal. GrSC management involves environmental criteria, or concerns, into organizational purchasing decision and long term relationships with suppliers. A GrSC aims at confining the wastes within the industrial system in order to conserve energy and prevent the dissipation of dangerous materials into the environment ([9], Figure 5). Beamon [10], described the current state of the natural environments, investigated the environmental factors, presented performance measures for the GrSCs and developed a general procedure towards achieving the GrSC.

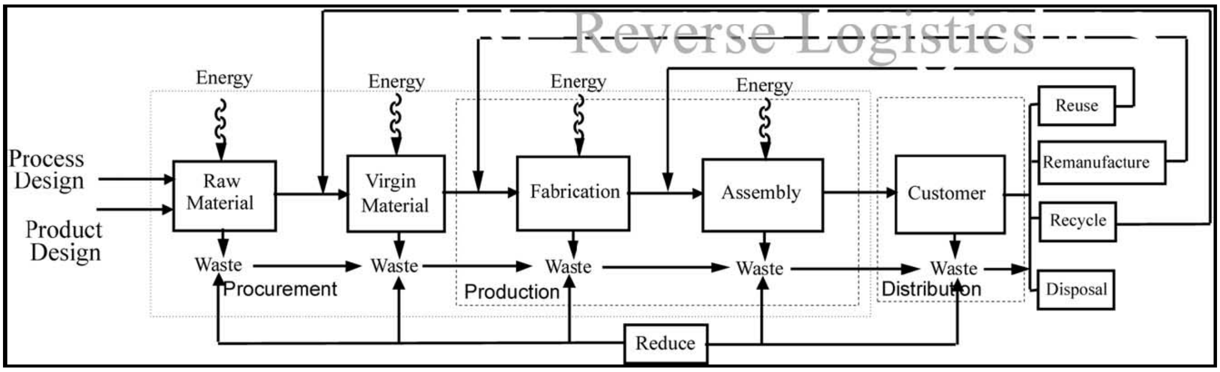

FIGURE 5
Functional Model of a GrSC [11]

Tsamboulas and Mikroudis [12] developed EFECT which is a generalized methodological framework for evaluating the impacts resulting from transportation projects with a specific orientation to environmental impacts. The innovative aspect of the methodological framework is the combination of Multi-Criteria Analysis (MCA) with Cost-Benefit Analysis (CBA) methods to come up with an overall assessment of transport initiatives impacts over different geographical regions and time periods. Sarkis [11] aimed to focus on the components and elements of GrSN management and how they serve as a foundation for the decision framework. For this, he explored the applicability of a dynamic non-linear decision model, defined as the ANP, for decision making within the GrSC. The decision support models for design of global supply chains, and assess the fit between the research literature in this area and the practical issues are handled in Meixell and Gargeya’s [2] study. Sheu et al. [13] presented an optimization-based model to deal with integrated logistics operational problems of GrSC management. In the proposed methodology, a linear multi-objective programming model is formulated that systematically optimizes the operations of both integrated logistics and corresponding used-product reverse logistics in a given GrSC. Kainuma and Tawara [6] extended the range of the supply chain to include re-use and recycling throughout the life cycle of products and services. Using their definition, they proposed the multiple attribute utility theory method assessing a supply chain considering this approach to be one of the GrSC methods. Anciaux and Yuan [4] proposed to show the issues for integrating the means of transport within the GrSC, as well as a decision-aiding model, which allows optimizing the solution choice of intermodal transport problems. Srivastava’ [14] paper took an integrated and fresh look into the area of GrSC management. The literature on GrSC management is covered exhaustively from its conceptualization, primarily taking a 'reverse logistics angle'. Using the rich body of available literature, including earlier reviews that had relatively limited perspectives, the literature on GrSC management is classified on the basis of the problem context in supply chain's major influential areas. Ferretti et al. [15] originated from an industrial case study in the field of the aluminum supply chain. The supply of molten metal represents a substantial benefit for the whole supply chain, because of the energy savings implicit in the method itself (i.e. both energy and time can be saved when melting the metal at the company furnaces). Moreover, the study integrated the concerns about transport pollution, addressing the topics of a GrSC problem and incorporating the environmental aspects in its analytical description. Beamon [16] described the challenges and opportunities facing the supply chain of the future and described sustainability and effects on supply chain design, management and integration. Traditional and GrSCs are compared and contrasted via focusing several important opportunities in GrSC management in depth, including those in manufacturing, bio-waste, construction, and packaging [9]. Chen and Sheu [17] demonstrated that a proper design of environmental-regulation pricing strategies is able to promote Extended Product Responsibility for GrSC firms in a competitive market. A differential game model comprising Vidale–Wolfe [18] equation has been established in light of sales competition and recycling dynamics as well as regulation related profit function.

The Closed-Loop Supply Chain

The general CLSC network investigated is illustrated in Figure 6. As can be seen in the network, these chain members can be classified into two groups [19]:

(1) Forward logistics chain members shown at the left side of Figure 6, including raw material suppliers, manufacturers, retailers and demand markets; (2) Reverse logistics chain members shown at the right side of Figure 6, including demand markets, recovery centers and manufacturers. Manufacturers and demand markets could be recognized as the nodes to combine the forward supply chain network and the reverse supply chain network together to form the CLSC network.

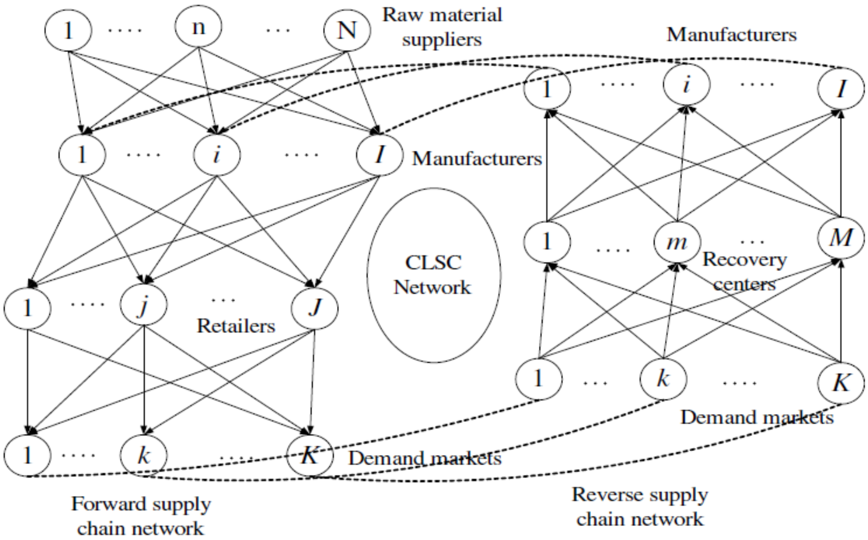

FIGURE 6
The CLSC Network [20]

Fleischman et al. [21] subdivided the field into three main areas, namely distribution planning, inventory control, and production planning. For each of these they discussed the implications of the emerging reuse efforts, review the mathematical models proposed in the literature, and point out the areas in need of further research. Fleischmann et al. [22] considered logistics network design in a reverse logistics context. They presented a generic facility location model and discussed differences with traditional logistics settings. Moreover, they used their model to analyze the impact of product return flows on logistics Networks and then they showed that the influence of product recovery is very much context dependent. Guide et al. [23] took a contingency approach to explore the factors that impact production planning and control for CLSCs that incorporate product recovery. A series of three cases are presented, and a framework developed that shows the common activities required for all remanufacturing operations. To build on the similarities and illustrate and integrate the differences in CLSCs, Hayes and Wheelwright's [24] product–process matrix is used as a foundation to examine the three cases representing Remanufacture-to-Stock (RMTS), Reassemble-to-Order (RATO), and Remanufacture-to-Order (RMTO).

The previous studies have addressed the problem of determining the number and location of initial collection points in a multiple time horizon, while determining the desirable holding time for consolidation of returned products into a large shipment. To fill the void in such a line of research, Min et al. [25] proposed a mixed-integer, nonlinear programming model and a genetic algorithm that can solve the reverse logistics problem involving both spatial and temporal consolidation of returned products. Zhu et al. [19] reported on results from a cross-sectional survey with manufacturers in four typical Chinese industries, i.e., power generating, chemical/petroleum, electrical/electronic and automobile; to evaluate their perceived GrSC management practices and relate them to closing the supply chain loop. Chung et al. [26] analyzed an inventory system with traditional forward-oriented material flow as well as a reverse material flow supply chain. In the reverse material flow, the used products are returned, remanufactured and shipped to the retailer for resale and then developed a CLSC inventory model and maximize the joint profits of the supplier, the manufacturer, the third-party recycle dealer and the retailer under contractual design. Kannan et al. [27] developed a multi echelon, multi period, multi product CLSC network model for product returns and the decisions are made regarding material procurement, production, distribution, recycling and disposal. The proposed heuristics based genetic algorithm (GA) is applied as a solution methodology to solve mixed integer linear programming model (MILP). Yang et al. [20] developed a model of a general CLSC network, which includes raw material suppliers, manufacturers, retailers, consumers and recovery centers. The objective of the paper is to formulate and optimize the equilibrium state of the network by using the theory of variation inequalities. In Wang and Hsu' [28] study, the integration of forward and reverse logistics was investigated, and a generalized closed-loop model for the logistics planning was proposed by formulating a cyclic logistics network problem into an integer linear programming model. Moreover, the decisions for selecting the places of manufactories, distribution centers, and dismantlers with the respective operation units were supported with the minimum cost. A revised spanning-tree based genetic algorithm was also developed by using determinant encoding representation for solving this NP model.

The Fuzzy Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) method was developed in the 1980s by Thomas L. Saaty [29]. AHP assumes that evaluation criteria can be completely expressed in a hierarchical structure. The data acquired from the decision-makers are pair-wise comparisons concerning the relative importance of each of the criteria, or the degree of preference of one factor to another with respect to each criterion. In the conventional AHP, the pair-wise comparison is made by using a ratio scale. Even though the discrete scale has the advantages of simplicity and ease of use, it does not take into account the uncertainty associated with the mapping of one's perception (or judgment) to a number [30]. In the FAHP approach, triangular fuzzy numbers are used for the preferences of one criterion over another and then by using the Chang's [31] extent analysis method, the synthetic extent value of the pair-wise comparison is calculated [30, 32]. Kahraman et al. [33] used the FAHP approach in the selection of the best facility location alternative by taking into account quantitative and qualitative criteria. Bozdağ et al. [34] have used the FAHP approach in the evaluation of cımputer integrated manufacturing alternatives by taking into account both intangible and tangible factors. Büyüközkan et al. [35] employed the FAHP method in selecting the most appropriate software development strategy. Kahraman et al. [36] used the FAHP process to evaluate and to compare the catering firms in Turkey. Tolga et al. [37] used the methods of FAHP and fuzzy replacement analysis in the operating system selection problem. Başlıgil [38] provided an analytical tool to select the best software providing the most customer satisfaction. Kong and Liu [39] aimed to find out the key factors that affect success in e-commerce using Fuzzy AHP. Kahraman et al. [32] proposed an integrated framework based on fuzzy QFD and a fuzzy optimization model to determine the product technical requirements to be considered in designing a product. The coefficients of the objective function are obtained from the approaches of Fuzzy analytic network and Fuzzy analytic hierarchy process. Bozbura et al. [40] have applied FAHP to improve the quality of prioritization of human capital measurement indicators under the fuzziness. Büyüközkan [41] proposed an analytic framework to provide practitioners a more effective and efficient model for prioritizing m-commerce requirements.

PROBLEM DEFINITION and MODELING

From the aforementioned concepts we described above, it is known that a CLSC network structure is necessary to design a GrSC. Regarding the traditional supply chains, CLSC and GrSC problems involved more complex, and need more efforts to control forward and reverse logistics simultaneously considering the environmental impacts. Mostly the cost is considered via enterprises to measure the effectiveness of the network. Besides the cost factor, the following conditions are handled in our model;

- CO_2 gas emission,
- Products which consist of different recyclable ratio raw materials,
- Opportunity prices to encourage customers using recyclable products,
- Penalty costs to prevent much CO_2 gas emission and etc.

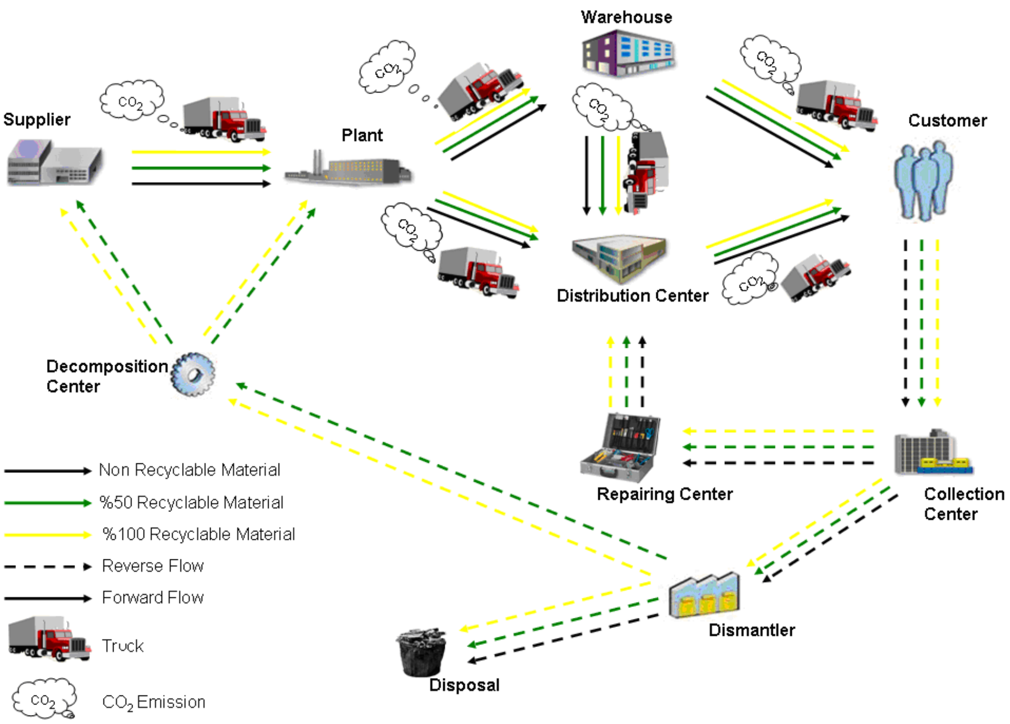

FIGURE 7
The Proposed CLSC Network across the GrSC

As can be seen in Figure 7, these chain members are classified into two groups: the first part is forward supply chain members, and the second part is used-product reverse supply chain members. Here a typical 5-layer forward supply chain is proposed in corresponding layers, including raw material supply, plants, warehouses, distribution centers, and end-customers respectively. Similarly, a 5-layer used-product reverse supply chain is specified, which includes collecting centers, repairing centers, dismantlers, decomposition centers, and final disposal locations of wastes, respectively. We considered that a decision maker would rent the trucks for only forward flow. Furthermore, the suppliers provide three different raw materials (into three different products) to plants via paying attention recyclable ratios of them. Considering the potential effects oriented from corresponding governmental regulations, the environmental protection administration and social responsibilities, the greenhouse gas emissions is tried to minimize owing to a penalty cost and encourage the customers to use recyclable products owing to a opportunity price. To specify the study scope and facilitate model formulation, assumptions are postulated below;

(a) The demand of each customer is certain and must be satisfied.
(b) The flow is only allowed to be transferred between two sequential echelons (except warehouse-customer)
(c) The capacities of all actors are limited and certain.
(d) The transportation, purchasing, penalty and opportunity costs are given.
(e) The CO_2 emissions, and all reverse part rates are given.
(f) The fuzzy pair-wise comparison matrix is given between each objective.

Because of the first three assumptions are also basic conditions for supply chain design, we shall consider them in our proposed model. The most important issue of designing CLSC is reverse rates. Wang and Hsu [28] pointed out that in the recovery systems; a common assumption is that the amounts of the returned products. The recovery amount is assumed to be a percentage of the customer demand in the model. Minimizing the total costs (transportation, purchasing, and penalty) is aimed while maximizing the amount of product which is recycled.

The fuzzy analytical hierarchy process (FAHP)

In this paper, we aimed to minimize the all total costs via providing the following sub-objectives;

(1) Minimizing the all transportation costs in forward logistic
(2) Minimizing the all transportation costs in reverse logistic
(3) Minimizing the all CO_2 emissions
(4) Minimizing the all raw material purchasing costs

The FAHP-based model is used to evaluate the objectives above together. In order to deal with the uncertainty and vagueness from the subjective perception and the experience of humans in the decision-making process, many FAHP methods are proposed by various authors. In the FAHP approach, triangular fuzzy numbers are used for the preferences of one criterion over another and then by using the Chang's [31] extent analysis method, the synthetic extent value of the pair-wise comparison is calculated. The extent analysis method is used to consider the extent of an object to be satisfied for the goal, that is, satisfied extent. In the method, the ''extent'' is quantified by using a fuzzy number. On the basis of the fuzzy values for the extent analysis of each object, a fuzzy synthetic degree value can be obtained, which is defined as follows [30, 32]. In this study, Chang's [31] extent analysis method on FAHP are handled due to its computational simplicity and effectiveness. The fuzzy comparison matrices of FAHP are shown in Table 1. In this approach, triangular fuzzy scale is used for the solving FAHP.

TABLE 1
Triangular Fuzzy Scale of Preferences

Saaty's scale	Definition	Fuzzy AHP scale: Triangular fuzzy scale	Fuzzy AHP scale: Triangular fuzzy reciprocal scale
1	Equally importance	(1,1,1)	(1,1,1)
3	Moderate importance of one over another	(2,3,4)	(1/4,1/3,1/2)
5	Essential or strong importance	(4,5,6)	(1/6,1/5,1/4)
7	Demonstrated importance	(6,7,8)	(1/8,1/7,1/6)
9	Extreme importance	(9,9,9)	(1/9,1/9,1/9)
2, 4, 6, 8	Intermediate values between two adjacent judgements	(1,2,3)	(1/3,1/2,1)
		(3,4,5)	(1/5,1/4,1/3)
		(5,6,7)	(1/7,1/6,1/5)
		(7,8,9)	(1/9,1/8,1/7)

Let $X = \{x_1, x_2, ..., x_n\}$ be an object set and $U = \{u_1, u_2, ..., u_m\}$ be a goal set. According to the method of Chang's extent analysis model, each object is taken and extent analysis for each goal g_i is performed. Therefore, m extent analysis values for each object can be obtained as $M_{g_i}^1, M_{g_i}^2, ..., M_{g_i}^m$, $i = 1,2,...,n$. All the $M_{g_i}^j$, $j = 1,2,...,m$ are triangular fuzzy numbers. The algorithm of the Chang's extent analysis model is as follows;

Step 1: The value of fuzzy synthetic extent with respect to the i th object is defined as

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \quad (1)$$

To obtain $\sum_{j=1}^{m} M_{g_i}^j$ perform the fuzzy addition operation of m extent analysis for a particular matrix such that

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \quad (2)$$

and to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1}$, perform the fuzzy addition operation of $M_{g_i}^j$, $j = 1,2,...,m$ values such that

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \quad (3)$$

and then compute the inverse of the vector in Eq.(3) such that

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (4)$$

The principles for the comparison of fuzzy numbers were introduced to derive the weight vectors of all elements for each level of hierarchy with the use of fuzzy synthetic values. To compare of the fuzzy numbers, following principles are used

Step 2: The degree of possibility of $M_2 \geq M_1$ is defined as

$$\begin{aligned} V(M_2 \geq M_1) &= \sup_{y \geq x}\left[\min\left(\mu_{M_1(x)}, \mu_{M_2(y)}\right)\right] \\ &= hgt\left(M_1 \cap M_2\right) \\ &= \mu_{M_2(d)} \\ &= \begin{cases} 1, & if \ \ m_2 \geq m_1 \\ 0, & l_1 \geq u_2 \\ \dfrac{(l_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \end{aligned} \quad (5)$$

Where; $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ and d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2} (see Fig.1). To compare M_1 and M_2, both $V(M_2 \geq M_1)$ and $V(M_1 \geq M_2)$ are needed.

Step 3: The degree of possibility for a fuzzy number to be greater than k fuzzy numbers M_i, $(i = 1,2,\ldots,k)$ can be defined by

$$V(M \geq M_1, M_2, \ldots, M_k) = \min V\left(M \geq M_i\right),\ i = 1,2,\ldots,k \quad (6)$$

Assume that,

$$d'(A_i) = \min V(S_i \geq S_k),\ \ k = 1,2,\ldots,n;\ k \neq i \quad (7)$$

Then the weight vector is given by

$$W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_n)\right)^T \quad (8)$$

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

Step 4: Via normalization, the normalized weight vectors are

$$W = \left(d(A_1), d(A_2), \ldots, d(A_n)\right)^T \quad (9)$$

Where; W is not a fuzzy number [30, 32]

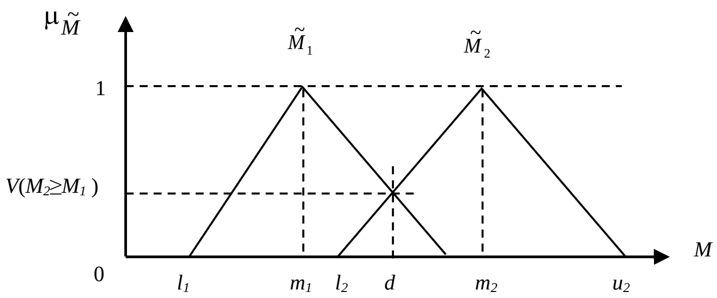

FIGURE 8
The Intersection Between $\tilde{M}_1$ and $\tilde{M}_2$

In Figure 9, we can see the main goal and the sub-factors to achieve this goal. Pair-wise comparison matrix of our model will be given in numerical example section.

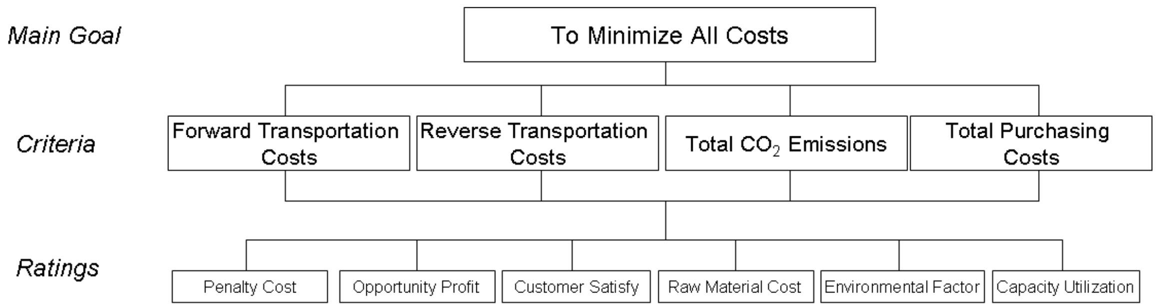

FIGURE 9
The FAHP-Hierarchy for Analyzing the Objectives of Proposed Supply Chain

Mathematical formulation of the model

Consider a supply chain network in Figure 7, in this section, based on six assumptions and the network structure; we shall propose a mathematical model to describe the goal of the paper. Definitions of variables and parameters in the green CLSC network are summarized below:

Indices;

I the number of suppliers with $i = 1, 2, ...I$

J the number of plants with $j = 1, 2, ...J$

K the number of distribution centers (DCs) with $k = 1, 2, ...K$

L the number of customers with $l = 1, 2, ...L$

M the number of collection centers with $m = 1, 2, ...M$

P the number of dismantlers with $p = 1, 2, ...P$

D the number of decomposition centers with $d = 1, 2, ...D$

T the number of trucks with $t = 1, 2, ...T$

R the number of raw/end material with $r = 1, 2, ...R$

Truck rental fee parameters;

H_t^{ij} the rental fee of truck t during the transportation supplier i and plant j

H_t^{jk} the rental fee of truck t during the transportation plant j and DC k

H_t^{j} the rental fee of truck t during the transportation plant j and warehouse

H_t^{k} the rental fee of truck t during the transportation warehouse and DC k

H_t^{l} the rental fee of truck t during the transportation warehouse and customer l

H_t^{kl} the rental fee of truck t during the transportation DC k and customer l

Transportation costs parameters after customers;

C_r^{lm} unit transportation cost of product r from customer l to collection center m

C_r^{m} unit transportation cost of product r from collection center m to repairing center

C_r^{k} unit transportation cost of product r from repairing center to DC k

C_r unit transportation cost of product r from repairing center to warehouse

C_r^{mp} unit transportation cost of product r from collection center m to dismantler p

C_r^{p} unit transportation cost of product r from dismantler p to disposal

C_r^{pd} unit transportation cost of product r from dismantler p to decomposition center d

C_r^{di} unit transportation cost of product r from decomposition center d to supplier i

C_r^{dj} unit transportation cost of product r from decomposition center d to plant j

Greenhouse gas emission parameters in forward logistic;

CO_2^{ijt} unit CO_2 emission of truck t during the transportation supplier i and plant j
CO_2^{jkt} unit CO_2 emission of truck t during the transportation plant j and DC k
CO_2^{jt} unit CO_2 emission of truck t during the transportation plant j and warehouse
CO_2^{kt} unit CO_2 emission of truck t during the transportation warehouse and DC k
CO_2^{lt} unit CO_2 emission of truck t during the transportation warehouse and customer l
CO_2^{klt} unit CO_2 emission of truck t during the transportation DC k and customer l

Incentives parameters for recycling;

P_r^i opportunity profit of supplier i because of choosing raw material r
P_r^j opportunity profit of plant j because of choosing material r
P_r opportunity profit of warehouse because of choosing material r
P_r^k opportunity profit of DC k because of choosing raw material r

Capacity parameters of facilities;

Ca_r^i capacity of raw material r at supplier i
Ca_r^j capacity of product r at plant j
Ca_r capacity of product r at warehouse
Ca_r^k capacity of product r at DC k
Ca_r^m capacity of product r at collection center m
Ca_r^{rc} capacity of product r at repairing center
Ca_r^p capacity of product r at dismantler p
Ca_r^d capacity of product r at decomposition center d

Truck' capacity parameters in forward logistic;

Ca_t^i transportation capacity of truck t departs from supplier i
Ca_t^j transportation capacity of truck t departs from plant j
Ca_t transportation capacity of truck t departs from warehouse
Ca_t^k transportation capacity of truck t departs from supplier i

The percentage rates parameters in reverse logistic;

$\alpha_{r\min/r\max}$ the minimum and maximum collection percentage rate from customers to collection centers for each product r
β_r the repairing percentage rate from collection centers to the repairing center for each product r
χ_r the transported repaired product percentage rate from the repairing center to DCs for each product r
δ_r the disposal rate from dismantlers to disposal for each product r
ε_r the decomposited product rate from decomposition centers to suppliers for each product r
De_r^l product r demand of customer l
P_r^i unit purchasing cost of raw material r from supplier i
$P_c^{CO_2}$ penalty cost for extra CO_2 emission

Forward logistic variables;

X_{rt}^{ij} transported raw material r via truck t from supplier i to plant j
Y_{rt}^{jk} transported product r via truck t from plant j to DC k

Z_{rt}^{j} transported product r via truck t from plant j to warehouse
Q_{rt}^{k} transported product r via truck t from warehouse to DC k
W_{rt}^{l} transported product r via truck t from warehouse to customer l
E_{rt}^{kl} transported product r via truck t from DC k to customer l
A_{r}^{i} total amount of raw material i purchased from supplier i

Reverse logistic variables;

K_{r}^{lm} transported product r from customer l to collection center m
T_{r}^{m} transported product r from collection center m to repairing center
U_{r}^{k} transported product r from repairing center to DC k
O_{r} transported product r from repairing center to warehouse
S_{r}^{mp} transported product r from collection center m to dismantler p
D_{r}^{p} transported product r from dismantler p to disposal
F_{r}^{pd} transported product r from dismantler p to decomposition center d
G_{r}^{di} transported product r from decomposition center d to supplier i
H_{r}^{dj} transported product r from decomposition center d to plant j

Given the aforementioned assumptions and definitions, now it is turn to describe the four objective functions (OBJF) below;

OBJF 1

$$\text{Min: } \sum_{i}\sum_{j}\sum_{r}\sum_{t} X_{rt}^{ij}\cdot H_{t}^{ij} + \sum_{j}\sum_{k}\sum_{r}\sum_{t} Y_{rt}^{jk}\cdot H_{t}^{jk} + \sum_{j}\sum_{r}\sum_{t} Z_{rt}^{j}\cdot H_{t}^{j} + \sum_{k}\sum_{r}\sum_{t} Q_{rt}^{k}\cdot H_{t}^{k} + \sum_{l}\sum_{r}\sum_{t} W_{rt}^{l}\cdot H_{t}^{l} + \sum_{k}\sum_{l}\sum_{r}\sum_{t} E_{rt}^{kl}\cdot H_{t}^{kl} \quad (10)$$

The first OBJF is to minimize the total cost of the transportation which actualize via different trucks (forward logistics), and the OBJF 1 represents this goal (10).

OBJF 2

$$\text{Min: } \sum_{l}\sum_{m}\sum_{r} K_{r}^{lm}\cdot C_{r}^{lm} + \sum_{m}\sum_{r} T_{r}^{m}\cdot C_{r}^{m} + \sum_{k}\sum_{r} U_{r}^{k}\cdot C_{r}^{k} + \sum_{r} O_{r}\cdot C_{r} + \sum_{m}\sum_{p}\sum_{r} S_{r}^{mp}\cdot C_{r}^{mp} + \sum_{p}\sum_{r} D_{r}^{p}\cdot C_{r}^{p} + \sum_{p}\sum_{d}\sum_{r} F_{r}^{pd}\cdot C_{r}^{pd} + \sum_{d}\sum_{i}\sum_{r} G_{r}^{di}\cdot C_{r}^{di} + \sum_{d}\sum_{j}\sum_{r} H_{r}^{dj}\cdot C_{r}^{dj} \quad (11)$$

The second OBJF is to minimize the total cost of transportation which are from customers (reverse logistics), and the OBJF 2 represents this goal (11).

OBJF 3

$$\text{Min: } P_{c}^{CO_2}\Big(\sum_{i}\sum_{j}\sum_{r}\sum_{t} X_{rt}^{ij}\cdot CO_2^{ijt} + \sum_{j}\sum_{k}\sum_{r}\sum_{t} Y_{rt}^{jk}\cdot CO_2^{jkt} + \sum_{j}\sum_{r}\sum_{t} Z_{rt}^{j}\cdot CO_2^{jt} + \sum_{k}\sum_{r}\sum_{t} Q_{rt}^{k}\cdot CO_2^{kt} + \sum_{l}\sum_{r}\sum_{t} W_{rt}^{l}\cdot CO_2^{lt} + \sum_{k}\sum_{l}\sum_{r}\sum_{t} E_{rt}^{kl}\cdot CO_2^{klt}\Big) \quad (12)$$

The third OBJF is representing the greenness of the model. By adding this OBJF, we aimed to minimize total CO_2 emissions which is produced by trucks on forward logistic. To dissuade the decision makers not to cause more CO_2 emissions, we determined a penalty cost based on an environmental legislation, the decision makers have to pay attention this issue due to not be punished.

OBJF 4

$$\text{Min: } \sum_{i}\sum_{r} A_{r}^{i} P_{r}^{i} - \sum_{k}\sum_{r} U_{r}^{k}\cdot P_{r}^{k} - \sum_{r} O_{r}\cdot P_{r} - \sum_{d}\sum_{i}\sum_{r} G_{r}^{di}\cdot P_{r}^{i} - \sum_{d}\sum_{j}\sum_{r} H_{r}^{dj}\cdot P_{r}^{j} \quad (13)$$

The fourth and last OBJF is formulated to encourage the customers to choose and use recyclable products. We encourage using recycling by minimizing the purchasing costs ($A_{r}^{i}\cdot P_{r}^{i}$) minus the total opportunity profits which is gained via using recyclable products. Let's think two different products, one of them is cheap but not recyclable, and the other is more expensive because of its recyclability. If the second one is chosen, we will not to purchase it again due to its recyclability and also the environmental responsibility will be accomplished. We determine the price difference, which is caused by the re-purchasing cost minus recyclable cost, as an opportunity profit.

Facility capacity constraints in forward logistic

$$\sum_j \sum_t X_{rt}^{ij} \le Ca_r^i, \qquad \forall_{i,r} \tag{14}$$

$$\sum_t Z_{rt}^j + \sum_k \sum_t Y_{rt}^{jk} \le Ca_r^j, \qquad \forall_{j,r} \tag{15}$$

$$\sum_t \sum_k Q_{rt}^k + \sum_l \sum_t W_{rt}^l \le Ca_r, \qquad \forall_r \tag{16}$$

$$\sum_l \sum_t E_{rt}^{kl} \le Ca_r^k, \qquad \forall_{k,r} \tag{17}$$

The constraints mainly contain two types: one is for limited capacities and the other is for the balance of the flow conversation in both of forward and reverse logistics. Equations (14), (15), (16) and (17) represent the limit of the capacity and provide not to exceed these capacities for suppliers, plants, warehouse and distribution centers for each products, respectively in forward logistic.

Facility capacity constraints in reverse logistic

$$T_r^m + \sum_p S_r^{mp} \le Ca_r^m, \qquad \forall_{m,r} \tag{18}$$

$$\sum_k U_r^k + O_r \le Ca_r^{rc}, \qquad \forall_r \tag{19}$$

$$D_r^p + \sum_d F_r^{pd} \le Ca_r^p, \qquad \forall_{p,r} \tag{20}$$

$$\sum_i G_r^{di} + \sum_j H_r^{dj} \le Ca_r^d, \qquad \forall_{d,r} \tag{21}$$

Equations (18), (19), (20) and (21) guarantee that collection centers, repairing center, dismantlers and decomposition centers could not exceed the given capacity limit for each products, respectively in reverse logistic.

The trucks capacity constraints in forward logistic

$$\sum_i \sum_j \sum_r X_{rt}^{ij} \le Ca_t^i, \qquad \forall_t \tag{22}$$

$$\sum_j \sum_k \sum_r Y_{rt}^{jk} + \sum_j \sum_r Z_{rt}^j \le Ca_t^j, \qquad \forall_t \tag{23}$$

$$\sum_k \sum_r Q_{rt}^k + \sum_l \sum_r W_{rt}^l \le Ca_t, \qquad \forall_t \tag{24}$$

$$\sum_k \sum_l \sum_r E_{rt}^{kl} \le Ca_t^k, \qquad \forall_t \tag{25}$$

Equations (22), (23), (24) and (25) show that the trucks could not move more than their capacity limits during departing from suppliers, plants, warehouse and DCs, respectively in forward logistic.

$$\sum_j \sum_t X_{rt}^{ij} = A_r^i, \qquad \forall_{i,r} \tag{26}$$

Equation (26) shows that the total amount of product r which is transported from supplier i to plants by truck t is equal the total amount of product r which is purchased from supplier i.

The equilibrium constraints in forward logistic

$$\sum_i \sum_t X_{rt}^{ij} = \sum_t Z_{rt}^j + \sum_k \sum_t Y_{rt}^{jk}, \qquad \forall_{j,r} \tag{27}$$

$$\sum_j \sum_t Z_{rt}^j = \sum_k \sum_t Q_{rt}^k + \sum_l \sum_t W_{rt}^l, \qquad \forall_r \tag{28}$$

$$\sum_j \sum_t Y_{rt}^{jk} + \sum_t Q_{rt}^k = \sum_l \sum_t E_{rt}^{kl}, \qquad \forall_{k,r} \tag{29}$$

$$\sum_t W_{rt}^l + \sum_k \sum_t E_{rt}^{kl} \ge De_r^l, \qquad \forall_{l,r} \tag{30}$$

Equations (27), (28) and (29) satisfy the law of the flow of each products conversation by in-flow equal to out-flow for plants, warehouse and DCs, respectively, in forward logistic. Constraint (30) is to satisfy the customer demand for each product.

The equilibrium constraints in reverse logistic

$$\alpha_{r\min}(\sum_t W^{l}_{rt} + \sum_k \sum_t E^{kl}_{rt}) \leq \sum_m K^{lm}_{r} \leq \alpha_{r\max}(\sum_t W^{l}_{rt} + \sum_k \sum_t E^{kl}_{rt}), \qquad \forall_{l,r} \tag{31}$$

$$\beta_r(\sum_l K^{lm}_{r}) = T^{m}_{r}, \qquad \forall_{m,r} \tag{32}$$

$$(1-\beta_r)(\sum_l K^{lm}_{r}) = \sum_p S^{mp}_{r}, \qquad \forall_{m,r:1,2} \tag{33}$$

$$\chi_r(\sum_m T^{m}_{r}) = \sum_k U^{k}_{r}, \qquad \forall_{r} \tag{34}$$

$$(1-\chi_r)(\sum_m T^{m}_{r}) = O_r, \qquad \forall_{r} \tag{35}$$

$$\delta_r(\sum_m S^{mp}_{r}) = D^{p}_{r}, \qquad \forall_{p,r:3} \tag{36}$$

$$(1-\delta_r)(\sum_m S^{mp}_{r}) = \sum_d F^{pd}_{r}, \qquad \forall_{p,r:1,2} \tag{37}$$

$$\varepsilon_r(\sum_p F^{pd}_{r}) = \sum_i G^{di}_{r}, \qquad \forall_{d,r:1,2} \tag{38}$$

$$(1-\varepsilon_r)(\sum_p F^{pd}_{r}) = \sum_j H^{dj}_{r}, \qquad \forall_{d,r:1,2} \tag{39}$$

Equation (31) describes the customer recovery relationship between the minimum and maximum recovery rate. Equations (32) and (33) provide the recycled product equilibrium from collection centers to repairing center and dismantlers, respectively. Equations (34) and (35) show the repaired product equilibrium from repairing center to DCs and warehouse, respectively. Equations (36) and (37) guarantee the recycled product equilibrium from dismantlers to disposal and decomposition centers, respectively. Equations (38) and (39) guarantee the recyclable product equilibrium from decomposition centers to suppliers and plants, respectively.

$$X^{ij}_{rt}, Y^{jk}_{rt}, Z^{j}_{rt}, Q^{k}_{rt}, W^{l}_{rt}, E^{kl}_{rt}, K^{lm}_{r}, T^{m}_{r}, U^{k}_{r}, O_r, S^{mp}_{r}, D^{p}_{r}, F^{pd}_{r}, G^{di}_{r}, H^{dj}_{r}, A^{i}_{r} \geq 0, \forall_{i,j,k,l,m,p,d,t,r} \tag{31}$$

Finally, equation (31) restrict that the variables are non-negative in our model.

A COMPUTATIONAL EXPERIMENT

General Information and Data

In this section, in order to evaluate the proposed model, we create an imaginary supply chain network based on a hypothetical data. We shall use a small example to illustrate the properties of the problem and the model. In the numerical example, we design a CLSC network which considers the environmental impacts. Consider the network in Figure 7. The network of the example contains two mainly part. The first part is forward logistic and consists of three suppliers, three plants, one warehouse, two DCs and five customers. Suppliers provide three kinds of raw materials which are 100% recyclable, 50% recyclable, non-recyclable raw materials, respectively. It is known that 100% recyclable products have to contain re-useable materials. But producing and using recyclable raw materials are expensive than the normal products because of standing the high technological processes and the 100% natural raw materials. So the decision maker faces a trade-off purchasing costs versus the recyclable rate. To present recyclable products to customers and consider greenness, the decision maker has to choose re-usable raw materials. Besides this environmental factor, we consider the greenhouse gas emissions in forward logistic. We assume that an outsourcing is used for only transportation. The 3PL firm presents three kinds of trucks for transporting which are 0-3 years, 4-7 years and 8-11 years old, respectively. Inherently, as aging the trucks, their rental fees will be cheaper. So, choosing always the oldest trucks are the best option but to consider greenness of the model, we pay the attention CO_2 emission of trucks. It is clear that as aging the trucks, their CO_2 emissions are also increased because of the engine differences. The added deterrent penalty cost ($P_c^{CO_2}$ = 0.05 \$/gr than more 2000 kg CO_2) in model puts the decision maker into another trade-off situation which is penalty cost versus CO_2 emissions (Tables 2, 3, 4).

TABLE 2

The Rental Costs ($/unit) of each Truck and the CO_2 Emissions (gr/unit) during the Transportation between Suppliers-Plants-Warehouse

	Suppliers									Plants		
	1			2			3			1	2	3
	Plants									Warehouse		
	1	2	3	1	2	3	1	2	3	1	1	1
Truck 1	3	2.5	3.2	2.8	2.6	3.1	3	2.5	3.3	1.5	1.4	1.8
Truck 2	2.2	2	1.9	2.3	2.1	1.7	1.9	1.8	1.6	1.2	1.1	1
Truck 3	1.5	1.7	1.3	2	1.5	1.6	1.45	1.76	1.8	0.9	0.7	0.6
	CO_2 Emission (gr/unit)											
Truck 1	0.9	0.9	1.1	1.2	1	0.8	0.7	1.1	1.2	1	0.9	1.1
Truck 2	1.3	1.5	1.6	1.4	1.2	1.4	1.3	1.7	1.4	1.3	1.2	1.5
Truck 3	1.7	1.8	1.9	1.6	1.5	1.7	1.5	1.7	1.9	2	1.3	1.7

TABLE 3

The Rental Costs ($/unit) of each Truck and the CO_2 Emissions (gr/unit) during the Transportation between Plants-DCs

	Plants					
	1		2		3	
	Distribution Centers					
	1	2	1	2	1	2
Truck 1	2.6	2.4	2.7	2.4	2.5	2.8
Truck 2	2.1	2	1.9	2.1	2.3	2.1
Truck 3	1.7	1.6	1.9	1.7	1.8	1.5
	CO_2 Emission (gr/unit)					
Truck 1	0.8	0.7	0.9	1	0.7	0.8
Truck 2	1.4	1.3	1.6	1.5	1.2	1.4
Truck 3	1.8	1.9	2	1.6	1.8	1.9

TABLE 4

The Rental Costs ($/unit) of each Truck and the CO_2 Emissions (gr/unit) during the Transportation between Warehouse-DCs-Customers

								DC									
	Warehouse							1					2				
	DC		Customers					Customers									
	1	2	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Truck 1	1.7	1.6	2.4	2.3	2.2	2.1	2.1	2.1	2.2	2.4	2.4	2.1	2	2.2	2.1	2.2	2.1
Truck 2	1.4	1.4	2.2	1.8	1.6	1.9	1.7	1.9	1.6	1.9	1.7	1.9	1.8	2.1	2.1	2.2	1.9
Truck 3	1.2	1.3	1.9	1.8	1.7	1.9	1.6	2	1.7	1.8	1.7	1.9	2.1	1.7	1.6	1.6	1.8
	CO_2 Emission (gr/unit)																
Truck 1	0.7	0.7	1.1	1.2	1	0.8	0.7	1.1	1.2	1	0.9	1.1	0.8	0.9	1.1	1.2	1
Truck 2	1.1	1.2	1.6	1.4	1.2	1.4	1.3	1.7	1.4	1.3	1.2	1.5	1.4	1.5	1.3	1.6	1.7
Truck 3	1.4	1.5	1.9	1.6	1.5	1.7	1.5	1.7	1.9	2	1.3	1.7	1.7	1.8	1.9	1.8	1.9

The plants purchase raw materials in three kinds mentioned above from the suppliers. The plants, warehouse and DCs triangular has a flexible structure. After the production in plants, the end-products flow can be actualize to warehouse and also DCs. The warehouse sends the end-products to customers directly, and also it can be happen by DCs. The capacity limits of suppliers, plants, warehouse, DCs and trucks are given in Tables 5 and 6.

TABLE 5

The Material Capacities of Suppliers-Plants-Warehouse-Distribution Centers (unit)

	Suppliers			Plants			Warehouse	Distribution Center	
Material	1	2	3	1	2	3	1	1	2
%100 Recyc.	10000	9000	11000	9500	11500	12500	22000	12000	11000
%50 Recyc.	11000	10000	12000	10500	11500	11500	19000	10000	9000
Non Recyc.	12000	11000	13000	11500	10500	12500	18000	11000	11000

TABLE 6

The transportation capacities of each truck between Suppliers-Plants-Warehouse-DCs (unit)

Trucks	Suppliers	Plants	Warehouse	Distribution Centers
Truck 1	32000	35000	22000	18000
Truck 2	34000	37000	21000	17000
Truck 3	31000	34000	23000	19000

The second part is reversing logistic and it contains two collection centers, two dismantlers, one repairing center, one disposal and two decomposition centers. The collection centers are responsible for collecting the used-products from customers.

- Minimum and maximum collection rates of collection centers are assumed to be $\alpha_{r\min}$ = %30 and $\alpha_{r\max}$ =%60.
- According the decisions in collection centers, the products which need just repairing, are sent to repairing center (β_r = %40).
- After the repairing in repairing center, products could be sent to warehouse and also DCs (χ_r = %70, %30).
- The rest of the products in collection centers are transported to dismantlers (1-β_r =%60).
- After the dismantling processes, half of the secondary and total of the tertiary products are disposal ($\delta_{r:2,3}$ = %50, %100).
- Full of the primary and the rest of the secondary products are transported to decomposition centers. According to decomposition situations, some of them are sent to suppliers (ε_r =%70) and the rest of them to plants (1-ε_r =%30).

All transportation in reverse logistic is actualized by the decision makers. Tables 7, 8 and 9 give the unit transportation costs between reverse facilities.

TABLE 7
The Unit Transportation Costs between Customers-Collection Centers-Dismantlers-Rep. Centers ($)

	Customers										**Collection Centers**					
	1		**2**		**3**		**4**		**5**		**1**	**2**	**1**		**2**	
	Collection Centers										**Repairing Center**		**Dismantlers**			
Material	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**1**	**2**	**1**	**2**
%100 Recyc.	1.2	1.3	1.2	1.4	1.2	1.3	1.2	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.3	1.2
%50 Recyc.	1.2	1.3	1.2	1.4	1.2	1.3	1.2	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.3	1.2
Non Recyc.	1.2	1.3	1.2	1.4	1.2	1.3	1.2	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.3	1.2

TABLE 8
The Unit Transportation Costs between Repairing C.-Warehouse-DCs-Dismantlers-Disposal-Decomposition Centers ($)

	Repairing Center			**Dismantlers**					
	1			**1**	**2**	**1**		**2**	
	Warehouse	**DCs**		**Disposal**		**Decomposition Centers**			
Material	**1**	**1**	**2**	**1**		**1**	**2**	**1**	**2**
%100 Recyc.	1.2	1.1	1.4	1.2	1.3	1.4	1.3	1.5	1.2
%50 Recyc.	1.2	1.1	1.4	1.2	1.3	1.4	1.3	1.5	1.2
Non Recyc.	1.2	1.1	1.4	1.2	1.3	1.4	1.3	1.5	1.2

TABLE 9
The Unit Transportation Costs between Decomposition Centers-Suppliers-Plants ($)

	Decomposition Centers											
	1			**2**			**1**			**2**		
	Suppliers						**Plants**					
Material	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
%100 Recyc.	1.1	1	0.9	1.2	1.1	0.9	1.1	1.2	1	1	1.1	1.2
%50 Recyc.	1.1	1	0.9	1.2	1.1	0.9	1.1	1.2	1	1	1.1	1.2
Non Recyc.	1.1	1	0.9	1.2	1.1	0.9	1.1	1.2	1	1	1.1	1.2

All flow decisions in reverse logistic are calculated via considering the capacity information and customer demands in Table 10.

TABLE 10

The Material Capacities of Collection Centers-Repairing Center-Dismantlers-Decomposition Center (unit) and the Demands of each Customer (unit)

	Collection Centers		Repairing Center	Dismantlers		Decomposition Centers		Customers				
Material	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**4**	**5**
%100 Recyc.	6000	5400	4200	4000	4500	4600	4600	6000	4000	7000	5000	6000
%50 Recyc.	5000	5500	4100	4500	4800	4800	4800	6700	5700	6700	5700	7700
Non Recyc.	4500	4500	4050	4600	4000	4700	4700	5900	5900	6900	4900	5900

We mentioned the encouraging factors at the beginning of paper. Using recyclable raw materials are better than re-purchasing these raw materials with a high cost. We determined an opportunity profit gained choosing recyclable raw materials and products (Table 11).

TABLE 11

Gained the Net Profit of Suppliers-Plants-Warehouse-DCs due to Recycling each Material ($) and Raw Material Purchasing Costs ($/unit)

	Suppliers			Plants			Warehouse	DCs	
Material	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**1**	**2**
%100 Recyc.	3.5	3.2	3.6	4	4.1	4.2	3.7	3.9	4.1
%50 Recyc.	2.7	2.5	2.9	2.9	3.1	2.7	2.5	2.8	2.9
Non Recyc.	-	-	-	-	-	-	1.9	1.8	1.9
				Purchasing costs ($/unit)					
%100 Recyc.	6	6.2	5.8	-	-	-	-	-	-
%50 Recyc.	3.2	3.5	3	-	-	-	-	-	-
Non Recyc.	2.3	2	2.1	-	-	-	-	-	-

The Outputs of the Illustrative Example

In the illustrative example, the fuzzy pair-wise comparison matrix and its priority vector (Table 12) are obtained by using the FAHP method according to the decision maker's priorities.

TABLE 12

The Fuzzy Pair-wise Comparison Matrix of the Example

Objectives	**A**	**B**	**C**	**D**	**Priority vector (W_G)**
Minimizing Forward Logistic Costs (A)	(1,1,1)	(2,3,4)	(1/5,1/4,1/3)	(2,3,4)	0.280445
Minimizing Reverse Logistic Costs (B)	1 / 2	(1,1,1)	(1,2,3)	(1,2,3)	0.258049
Minimizing Total CO_2 Emissions (C)	(4,5,6)	(1/3,1/2,1)	(1,1,1)	(1/3,1/2,1)	0.27256
Minimizing Purchasing Costs (D)	(1/4,1/3,1/2)	(1/3,1/2,1)	1 / 2	(1,1,1)	0.188946

From Table 12,

$S_A = (4.2, 6.25, 8.333) \otimes (14.783, 21.583, 29.833)^{-1} = (4.2, 6.25, 8.333) \otimes (1/29.833, 1/21.583, 1/14.783) = (0.140782, 0.289575, 0.563698)$

$S_B = (0.111732, 0.254826, 0.54115)$ $S_C = (0.156425, 0.277992, 0.54115)$ $S_D = (0.086592, 0.177606, 0.372041)$ are obtained. Using these vectors,

$V(S_A \geq S_B) = 1$, $V(S_A \geq S_C) = 1$, $V(S_A \geq S_D) = 1$;

$V(S_B \geq S_A) = 0.920139$, $V(S_B \geq S_C) = 0.943205$, $V(S_B \geq S_D) = 1$;

$V(S_C \geq S_A) = 0.971883$, $V(S_C \geq S_B) = 1$, $V(S_C \geq S_D) = 1$;

$V(S_D \geq S_A) = 0.673736$, $V(S_D \geq S_B) = 0.771219$, $V(S_D \geq S_C) = 0.682325$ are obtained. Thus the weight vector from Table 12 is calculated as $W_G = (0.280445, 0.258049, 0.27256, 0.188946)^T$.

In this example, with *I=3, J=5, K=2, L=5, M=2, P=2, D=2, T=3* and *R=3*, there are 445 variables, and 602 constraints. Using LINDO 6.1 with the most 1(s) elapsed time, we obtained the optimal solution as shown in Table 13. Calculated objective values are given in Table 12. All the experiments are conducted on a notebook with the Intel Core2 Duo 1.66 GHz and 2 GB RAM.

TABLE 13

The Optimal Solution of Numerical Example

Variable	Value	Variable	Value	Variable	Value	Variable	Value
$\mathbf{X}_{1211}$	8500	$\mathbf{Z}_{332}$	6900	$\mathbf{K}_{411}$	900	$\mathbf{D}_{12}$	525
$\mathbf{X}_{1221}$	11000	$\mathbf{W}_{212}$	400	$\mathbf{K}_{412}$	1280	$\mathbf{D}_{13}$	1310
$\mathbf{X}_{1231}$	5500	$\mathbf{W}_{213}$	3600	$\mathbf{K}_{413}$	660	$\mathbf{D}_{22}$	2400
$\mathbf{X}_{2213}$	3000	$\mathbf{W}_{233}$	300	$\mathbf{K}_{421}$	600	$\mathbf{D}_{23}$	4000
$\mathbf{X}_{2223}$	500	$\mathbf{W}_{312}$	7000	$\mathbf{K}_{422}$	430	$\mathbf{F}_{111}$	440
$\mathbf{X}_{2233}$	5000	$\mathbf{W}_{322}$	6700	$\mathbf{K}_{423}$	810	$\mathbf{F}_{121}$	100
$\mathbf{X}_{2312}$	5500	$\mathbf{W}_{332}$	6900	$\mathbf{K}_{521}$	1800	$\mathbf{F}_{122}$	525
$\mathbf{X}_{2322}$	9000	$\mathbf{W}_{411}$	5000	$\mathbf{K}_{522}$	2310	$\mathbf{F}_{221}$	4500
$\mathbf{X}_{2332}$	6000	$\mathbf{W}_{421}$	4600	$\mathbf{K}_{523}$	1770	$\mathbf{F}_{222}$	2400
$\mathbf{X}_{3113}$	6500	$\mathbf{W}_{431}$	4900	$\mathbf{T}_{11}$	2400	$\mathbf{G}_{131}$	308
$\mathbf{X}_{3123}$	9500	$\mathbf{W}_{513}$	6000	$\mathbf{T}_{12}$	2000	$\mathbf{G}_{231}$	3220
$\mathbf{X}_{3133}$	6500	$\mathbf{W}_{521}$	7500	$\mathbf{T}_{13}$	1800	$\mathbf{G}_{232}$	2048
$\mathbf{X}_{3312}$	4500	$\mathbf{W}_{523}$	200	$\mathbf{T}_{21}$	960	$\mathbf{H}_{131}$	132
$\mathbf{X}_{3322}$	2500	$\mathbf{W}_{533}$	5900	$\mathbf{T}_{22}$	1900	$\mathbf{H}_{211}$	1380
$\mathbf{X}_{3332}$	6500	$\mathbf{E}_{1222}$	5700	$\mathbf{T}_{23}$	1740	$\mathbf{H}_{222}$	876
$\mathbf{Y}_{1211}$	6000	$\mathbf{E}_{1232}$	5600	$\mathbf{S}_{111}$	540	$\mathbf{A}_{11}$	8500
$\mathbf{Y}_{1221}$	6700	$\mathbf{E}_{1422}$	1100	$\mathbf{S}_{113}$	1310	$\mathbf{A}_{12}$	11000
$\mathbf{Y}_{1231}$	5900	$\mathbf{E}_{2111}$	5400	$\mathbf{S}_{121}$	3060	$\mathbf{A}_{13}$	5500
$\mathbf{Y}_{3121}$	6800	$\mathbf{E}_{2112}$	600	$\mathbf{S}_{122}$	3000	$\mathbf{A}_{21}$	8500
$\mathbf{Y}_{3131}$	5600	$\mathbf{E}_{2121}$	6700	$\mathbf{S}_{123}$	1390	$\mathbf{A}_{22}$	9500
$\mathbf{Z}_{112}$	500	$\mathbf{E}_{2131}$	5900	$\mathbf{S}_{212}$	1050	$\mathbf{A}_{23}$	11000
$\mathbf{Z}_{121}$	700	$\mathbf{K}_{111}$	1800	$\mathbf{S}_{221}$	1440	$\mathbf{A}_{31}$	11000
$\mathbf{Z}_{122}$	2100	$\mathbf{K}_{122}$	2010	$\mathbf{S}_{222}$	1800	$\mathbf{A}_{32}$	12000
$\mathbf{Z}_{131}$	600	$\mathbf{K}_{123}$	1770	$\mathbf{S}_{223}$	2610	$\mathbf{A}_{33}$	13000
$\mathbf{Z}_{212}$	11500	$\mathbf{K}_{211}$	1200	$\mathbf{O}_{1}$	1008		
$\mathbf{Z}_{223}$	11500	$\mathbf{K}_{212}$	1710	$\mathbf{O}_{2}$	1170		
$\mathbf{Z}_{231}$	2700	$\mathbf{K}_{213}$	1770	$\mathbf{O}_{3}$	1062		
$\mathbf{Z}_{233}$	7800	$\mathbf{K}_{311}$	2100	$\mathbf{U}_{11}$	2352		
$\mathbf{Z}_{313}$	10000	$\mathbf{K}_{312}$	2010	$\mathbf{U}_{12}$	2730		
$\mathbf{Z}_{323}$	4700	$\mathbf{K}_{313}$	2070	$\mathbf{U}_{13}$	2478		

TABLE 14

Calculated Objective Function Values According to FAHP

OBJF	Definition	Value
OBJF1	Minimization the total transportation cost in forward logistic	453985.00 $
OBJF2	Minimization the total transportation cost in reverse logistic	105613.70 $
OBJF3	Minimization the total CO_2 emission and the penalty cost	318540 gr – 200000gr= 118540 gr Penalty Cost: 118540*0.05= 5927 $
OBJF4	Minimization the total purchasing costs via maximization the total opportunity profit	Total purchasing costs: 333900.00 $ Total opportunity profit: 57382.80 $
	Total	842042.90 $

According to the results obtained by LINDO 6.1 package program via weighted rates objectives, the total cost is 842042.90 $ (Table 14). Total transportation cost in forward logistic is calculated 453985.00 $. This money is expended for transporting 90000 units product which are consist of 28000 unit %100 recyclable, 32500 unit %50 recyclable, and 29500 unit non-recyclable. All trucks emissions totally 318540 gr CO_2 gas during the all transportation in forward logistic. We determined a lower limit (2000 kg CO_2) for emissions, and a penalty cost for each gr CO_2 after this lower limit. So, the decision maker paid 5917 $ as the total penalty cost. To answer all customers demand, totally 90000 units of raw material is purchased from three suppliers via paying 333900.00 $. 27000 units of re-used products are collected from customers and sent to the collection centers. Because of preferring the recyclable raw materials, the decision maker gained 57382.80 $ via saving the re-purchasing costs.

CONCLUSION

In global supply chain management, companies have to consider green factors over a long period of time. Green supply chain management has emerged as a proactive approach for improving environmental performance of processes and products in accordance with the requirements of environmental regulations. Various approaches for implementing green supply chain management practices has been proposed and recognized in previous literatures [42].

Under dynamic business environments, the attributes and weights may change, becoming not necessarily crisp, but rather fuzzy in nature. Traditional multiple attribute decision-making methods may not solve the long-term performance measurement problems in fuzzy environments. There are various decision-making methods, among which FAHP technique has been developed as a useful and simple method to deal with decision-making problems. SCM emphasizes on the strategic decisions between different kinds of objectives and also the core of SC is a decision making problem. The making right decision is an important problem in SCM and is the key to successful SCM. We know that decision makers want to handle all objectives together. Naturally, all objectives' desired priorities also could be different. We believe that by using a class of technique we may solve the key and tough problems of different objectives in SC network. Thus we develop an FAHP methodology to deal with SC network problems under environmental factors. For further researches, the uncertainty embedded in demand, capacity and recovery rates should be handled to facilitate practical applications. The model's environmental and greenness factors can be enlarged via adding noise pollution, accident risk and time assessment factors etc. Also we will try to extend Fuzzy AHP method to intuistionistic fuzzy AHP method to make better decisions.

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THE ROLE OF CUSTOMER CHOICES IN GREEN SUPPLY CHAIN MANAGEMENT: AN EMPIRICAL STUDY IN SAKARYA REGION

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Abstract — *There are numerous studies that have revealed that the green practices would increase or decrease the competitive advantage of firms [1]. However, the general assumption is that the green initiatives results with a cost increase (at least at the beginning). Beyond the cost increase, green initiatives can lead the emergence of some changes in their ongoing structures. When the lack of information about green practices and its' results added, under normal conditions, an organization won't go green. However some factors enforce businesses to shift to the green supply chain management. Some of these factors can be listed as follows; state pressure (regulations), consumer pressure (demands), environmental organizations, rivals, competition, and supply chain members. In this study, our goal is to determine companies' existing customers' perceptions about green supply chain and how it results with "customer pressure" factor. Thus, we would like to measure if customers can or may enforce companies to be "green". In order to reach this goal, we use a questionnaire which was conducted with mid and upper level managers of small and midsize businesses in Sakarya region.*

Keywords —*Environmentalism, Green Supply Chain Management, Pressure Groups*

INTRODUCTION

The economic system was supporting the traditional supply chains which based on profit, efficiency and effectiveness until the twentieth century. But since the negative effects of the natural destruction begin to affect the daily life and even jeopardize the future of mankind, this rendered the existing economic system's success.

Today, some developments such as increasing quantity and activity of environmental organizations, increasing number of international symposiums and congresses on environment, and acceptation of sanctions by some of countries in order to protect environment prove how environmental issues getting important. Also firms and their customers increasingly becoming aware of environment issues and trying to minimize damage to environment or at least making effort in this direction. This trend effects the consumption behavior of producers and consumers.

Developments that mentioned above affect the supply chains and results with the addition of environmentalism (green) concept to traditional supply chain structure which is profit, efficiency and effectiveness oriented. So "green supply chain management" which considers environmental concerns has getting importance.

In this study our goal is to research the effects of customer choices on companies while they make decisions about green SCM.

PRESSURE GROUPS

The literature has mix results for green SCM. Some of it suggest that going green increase cost for companies and reduce their competitiveness, while some others suggest that although there is initial cost increase in the long run going green will positively affect company in financial forms.

Evidence can be marshaled to support either the view that pollution abatement is a cost burden on firms and is detrimental to competitiveness, or that reducing emissions increases efficiency and saves money, giving firms a cost advantage [2]. However we won't focus on which is right or wrong.

The interest point for this paper is the reality of green practices are seem as cost factors by most of firms. For example according to Lee [3], growing demands for corporations to protect the environment will increase the cost burden, and as a result companies will have less resources to increase productivity and may lose their

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competitiveness in the market. So generally companies are not voluntary to implement green practices if it is left to their own initiatives.

Objectives like increasing employment, exports and protecting industries of strategic importance have traditionally enjoyed a higher political priority than safeguarding the environment [4]. However some pressure groups force businesses to be more sensitive to environmental issues. According to Buyukozkan and Erkut [5] the most important factor that forces corporations to implement green practices is government. In this regard the role of state can be listed as regulatory, facilitator and customer. Another factor is the negative financial and legal consequences that firms have to be faced because of mismanagement in the mean of environmental issues.

Also Roarty [6] were listed pressure groups as follow; consumers, governments, investors and environmental organizations. We think that the pressure of supply chain members and pressure of rivals should be added on Roarty's list. Because especially global firms force their suppliers (and suppliers' suppliers) to be green. Also gainings of green firms encourage the rivals to be green.

Considering all of these factors together, pressure groups can be shown as follows;

FIGURE. 1
Pressure Groups

1- Consumers

Becoming clear of environmental hazards that threaten human species, like global warming, leads people to consider environmental effects of what they consume. This preferences of consumers affects the firms and therefore the supply chains.

Kotler [7] mentioned that traditionally companies were judged by customers according to quality of their products, quickness of solving customer problems and degree of fairness but today companies are measured according to (environmental) ethics.

Most of studies reveal that, today, people are more sensitive against environment. Beamon [8] indicates that there has been increasing public attention placed on the overall condition of the natural environment. This attention may be largely attributed to information provided by the media, through growing numbers of environmental and consumer interest groups. As a result of increasing customer expectations, companies have had to manage supply chains more effectively to meet customer expectations and improve their supply chains by taking into consideration of correct and fair use of natural resources in social responsibility idea.

Gerald and Lindsay Zaltman [9], in their book "marketing metaphors", suggest that, if human beings are not respectful to the mother nature, the consequences of this will be very harmful for them. According to same research results, many consumers and managers feel personal and/or corporate responsibility for themselves to trend environment friendly shopping and consuming behavior. Yavuz [10] mentioned that American companies which are aware of potential of environmental products market are trying to design environmental friendly products and improving environmental business processes. For instance, General Electric have been noticed that there is a potential in environment friendly car market and has announced that it would invest 1.5 billion dollars per year to this product line.

The research which had organized by Landor Associates over 1500 consumer in the United States and Britain provides general information about consumer trends. According to this research, just a few people interested in green issues in 2006. However, in 2007, there has been a dramatic change and most of participants were interested in green issues [11].

2- Government

The most deterministic factor within pressure group is government. Government, as a regulatory agency, may be force companies and ultimate consumers to different environmental regulations. Unlike the other factors, government doesn't leave freedom of choice to companies. For instance, a company would respond or ignore its customers' or non-governmental organizations' demands about environment. This company has a freedom of choice at this point. However if the source of demand is government, company has two options; make the required arrangements or face legal sanctions.

Government can prevent applications that harm environment by putting disincentive taxes. For example Irish Government applies 20 cent tax for each plastic bag. Also Ireland became the first country that reduce the usage of plastic bags. Similarly, Uganda applies high taxes to plastic bags. On the other hand, some countries like France, India, United States and Rwanda banned the usage of plastic bags [12].

Due to environmental pressures, governments may cease to operation of a sector in a country. As Ozihtiyar [13] indicated, some developed countries like France, Italy and Spain had avoided tannery operations and sector shifted Turkey. But sector faced with high environmental pressure also in Turkey. Therefore industry tries to adapt environmental conditions. As a result of this efforts, today 70% of goods produced by using environmentally sensitive methods. As it is seen, government pressure not affects just individual businesses but can force a whole industry to adapt environmental standards.

3- Supply Chain Members

Another factor that force companies to go green is supply chain members. Because, if a company wish to have a green image initially it should evaluate its' suppliers if they are green or not. Green outputs require green inputs. As Paulraj [14] mentioned, in order to meet challenges of energy conservation, pollution abatement, waste reduction, etc., firms should also consider their supplier's environmental performance. Likewise, some research show that some companies, especially those which are operating on global scale, do not only evaluate their primary suppliers but they evaluate supplier's supplier in terms of environmental criteria.

Green supply chain should be considered in holistic. So companies' suppliers must be compatible with the environment. Otherwise it won't be possible to talk about a well functioning green supply chain. In developed countries, suppliers' suppliers are also evaluated [15]. Larsen [16] indicated that environmental requirements are also influencing the choice of supplier and the ongoing supplier evaluation. In subsequent years, Lee [17] mentioned that a few studies on environmental support programs, which were mainly case studies, mentioned the importance of supply chain pressures and support of partners such as in the form of industry leaders and experts given to SMEs as drivers and facilitators in improving their environmental performance. Likewise influential corporations, such as Ikea, Starbucks, and Ben&Jerry's, set requirements for all their suppliers to comply with stricter environmental regulations including bleach-free-processes [18].

Companies that want to get "green" title should take into account all of its' components. Lee Scott's, CEO of Wal-Mart, considerations are important at this point:

> *"We recognized early on that we had to look at the entire value chain. If we had focused on just our own operations, we would have limited ourselves to 10 percent of our effect on the environment and eliminated 90 percent of opportunity that's out there." [19].*

Determining suppliers according to environmental standards will lead to a reduction in number of suppliers. Yang et al. [20] mentioned that one of the obstacle of gren supply chain management is elimination of supply chain flexibility because of the reduction in supplier quantity. In Wal-Mart case, Heying and Sanzero [21] suggest that with increased dependence on a limited number of selected suppliers, Wal-Mart also may face rising prices from the narrow supply base, especially in times of limited resources. Also, with fewer suppliers Wal-Mart may miss opportunities to create innovative products that customers may want but are not necessarily environmentally friendly.

Today, only a few companies require environmental certification from their suppliers, but in future many customers will expect that suppliers are environmentally certified or are seriously planning to become so [22]. However recent research show that companies are increasingly working with more environmental friendly suppliers and parting the ways with suppliers that is not able to meet environmental standards.

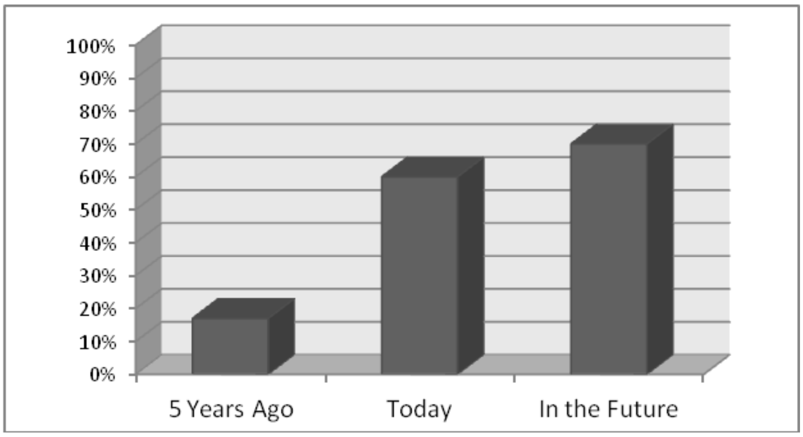

FIGURE. 2
Companies Deselecting Suppliers For Failing To Meet Sustainability Criteria [23]

4- Rivals

When international trade conditions are challenging and insecurity about the future widespread, going green may seem a particularly daunting move. But some of today's most successful organizations have made the decision to reshape themselves from the bottom up, improving their environmental profile and their public image, making financial savings and safeguarding against future environmental hazards [24]. Competitive advantages that competitors have already obtain or possible to obtain by implementing green approach, create pressure on companies not to be oblivious about green initiatives.

Rivals have bidirectional pressures on GSCM practices;

- *Gains that competitors obtained by application of GSCM,*
- *The need for differentiation from competitors.*

Some companies obtained large gains by GSCM applications. The developments that cause an increase in brand value in addition to cost savings push the rivals to do similar practices. According to a research results by Interbrand, Toyota's brand value has increased by 47 percent and reached 28 billion dollars by producing environmental friendly car, Prius [25]. Erbaşlar [26] mentioned that the most important reason to prefer green approaches is not to lose competitive position in the market.

Also Kotler [27] cited that companies operating in the same industry lost their diversity so there is no way for consumers to look civilization measurement of competing companies when making choices. Today, there is no significant differences between quality and prices so consumers prefer to buy from environment friendly companies.

5- Environmental Organizations

Another factor that forces companies to comply with the environmental standards are environmental organizations. Environmentalists, as individuals and organizations, have important contributions to reach current level of environmental protection policy. Especially national and international activities of non-governmental organizations have a big affect in this result [28].

The growing membership of environmental pressure groups reflects a more fundamental concern with environmental issues. Well organized pressure groups help to educate the public and raise the political profile of environmental issues [29]. In instance, today, Greenpeace has totally 2.8 million members in 101 countries. Also 3 million individuals supports Greenpeace financially, and 20.000 of them are from Turkey. Total turnover was 196,6 million euro in 2008.

EVALUATION OF PRESSURE FACTORS TOGETHER

There is no consensus about which pressure factor is more effective than the others but there is a consensus about customer and government factors are more effective than the others. Therefore discussions mostly focused on these two factors.

Zee [30] thinks that one of the most compelling arguments for a business to go green comes from customers. Surveys of customer attitudes to sustainability and the environment show a consistent and steady growth in the demand for the responsible products and green working practices.

On the other hand, Roarty [31] suggests that only government can provide the impetus to create a new framework for business decision making. He thinks that when a majority of consumers will only buy green products and actively boycott products which fail to meet high environmental standards, then the consumers become a potent force influencing commercial decisions.

Çepel [32] with a more environmental perspective, propounds that assuming of only government or industry will solve the environmental problems is a widespread wrong idea of a universal size. According to him, this attitude and thought is a dangerous illusion. And this illusion overshadowing the awareness of personal responsibility.

According to research of Murphy and Poist [33] within US and non-US firms, the most important reason for companies to be green is "compliance with government regulations". Other reasons can be listed in the following way; control environmental costs, societal expectations, minimize liability, profit opportunities and keep up with competitors.

According to another research, called "The State Of Green Supply Chain Management" by Lassar and Gonzales [34], researchers asked the participants "Please rank, in order of importance, the top 3 reasons your company is active with green/sustainability initiatives?" and the most important driver to be green is "corporate responsibility agenda". Also we can see that compliance with government/regulations is more deterministic than customer pressure. Figure 3 shows other results;

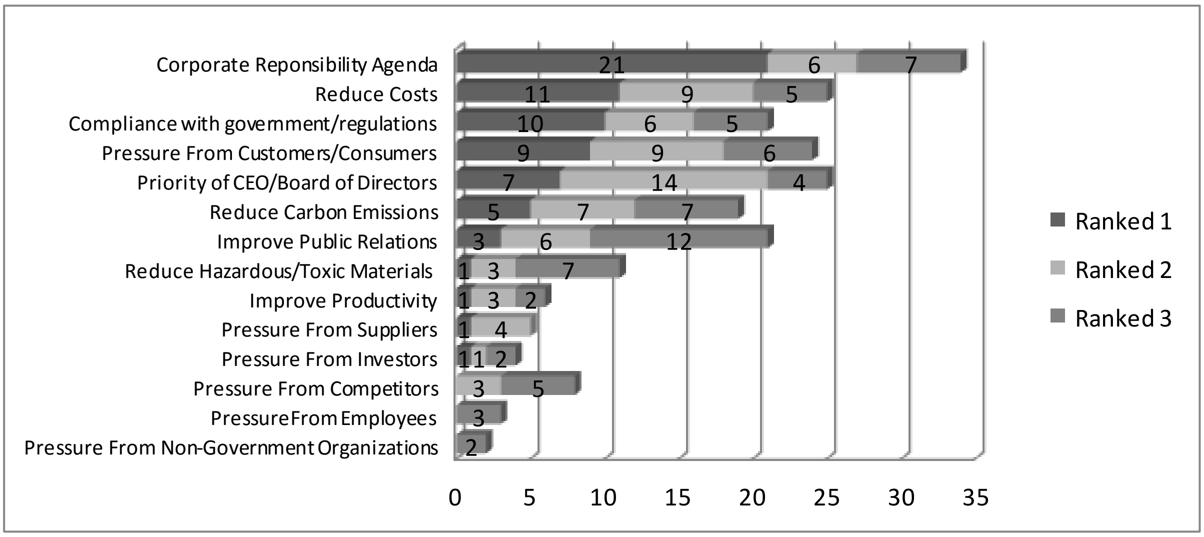

FIGURE. 3
Green Activity Key Drivers

Although research results indicate different factors, all of these pressure factors play complementary roles in the greening of the businesses. In generally, consumer and government pressures are overweight the others more. But there is no definite idea between these two factors. As Roarty [35] mentioned, the "push" of government has in some cases been overtaken by the "pull" of the market, as more and more consumers seek to purchase green products.

RESEARCH

In this research, our goal is to look at SMEs in Turkey and to determine which factors are playing important role for this companies to go green. The universe of the research is small and medium sized companies that perform in Sakarya region. Samples chosen from the firm list of Sakarya Chamber of Commerce and ve focused on companies which are located in industrial zones (101 of 577). A questionnaire was used in this research and we conducted them by two ways;

- Online questionnaire form prepared by using LimeSurvey program and the address link of questionnaire sent by e-mail to participants (10 questionnaire forms applied by this way).
- Questionnaires applied face to face with participants (91 questionnaire form filled by this way).

Totally 101 questionnaire form was collected. After this SPSS program was used to process the data.

DATA ANALYSIS

Our questionnaire has three parts.

First Part-Questions in this section include general information such as sector and size of firm and position of responder. According to answers, 19 of 101 participants are micro firms(less than 10 employee), 49 are small (between 10-49 employee) and 33 are medium (between 50-249) sized companies. Participants mainly operate in machinery (24,4%), automotive (18,6%) and metal (15,5%) industries. Responders are mainly president (26,1%), marketing (15,2%), purchasing (13%), and others.

Second Part-In the second part of the questionnaire focused on GSCM perceptions of participants'. 5 point likert scale was used. So, the expressions that we revealed and the percent values of summery of the answers are listed in Table 2.

TABLE 1
Expressions and Summery of Answers

Expressions	Disagree	Neutral	Agree
Green initiatives increase our costs significantly	15%	16%	69%
Being a green firm strengthen the brand image	6%	8%	86%
Being a green firm gives us competitive advantage	9%	9%	82%
Costs incurred for compelling with environmental standards affect our competitive advantage negatively	26%	16%	58%
Green initiatives are among our business priority	47%	19%	34%
Our company has current efforts to be green	45%	11%	44%
We use recycled materials in production process	24%	12%	64%
Our products are designed to be easy-biodegradable after using process	25%	23%	52%
We recycle some of our products after usage and evaluate them in production process again	30%	16%	54%

According to Table 2, most of firms (69%) think that green initiatives increase cost. On the other hand, they believe that being green will increase their brand value (86%). Also we can understand that companies are in a dilemma. They are agree on the rising competitive advantage (82%) by greening, however cost pressure changes their opinions. They think that the costs incurred to comply with environmental standards decrease their competitive advantage (58%). Although participant believe the competitive advantage of being green, it is not among their business priority (34%).

Next expressions trying to learn if they have sustainability concern during design, production and after use processes. 64% of participants use recycled materials in their production processes. Also %52 of them mentioned that they design products environmentally. Again, most of participants (%54) recycle the used products and evaluate them in production processes again.

Third Part-After learning about GSCM perceptions of participants, in this part, we aimed to learn if customers are a factor to force companies for green initiatives.

The first question of this part is "Which are the most important reasons for customers to prefer your company? Please rank, in order of importance, the top 3 reasons."

To assess this question, we multiply the ranked percentages with weighted scores (3-2-1). Then sum the 3 result and divide the total of weighted scores (3+2+1=6). For example, for "your prices" factor, (44*3)+(23*2)+(20*1)=198, 198/6=33. This score, 33, is the total score of "your prices" factor. After the implementing this process for all factors, the ranking occurred like the following way;

TABLE 2
Percentage of Rankings

	Ranked 1	Ranked 2	Ranked 3	SCORE
Your Prices	44%	23%	20%	33%
Service Quality	3%	17%	24%	11,17%
Product Quality	42%	35%	17%	35,5%
To be a Green Firm	0%	7%	7%	3,5%
Geographic Position	1%	7%	11%	4,67%
Certificates/Proficiency	8%	9%	21%	10,5%
References	1%	0%	0%	0,5%
JIT Delivery	1%	2%	0%	1,16%
Total	%100	%100	%100	100

According to this result, being environmental is not a determinant factor for customers. Customers mainly give importance to product quality and price

Secondly we gave several expressions to participants and asked them to choose one option. The results are listed in Table 3;

TABLE 3
Expressions and Answers

Expressions	Disagree	Neutral	Agree	N/A
Our customers have interest in green products	44%	15%	38%	3%
Our customers pay more for green products	55%	15%	27%	3%
Customers are demanding from our company to be green	58%	11%	29%	2%
Customers have been out of it because of not to adapt environmental standards.	78%	7%	11%	4%
Customers' pressure is compelling us to seek environmental standards.	61%	15%	21%	3%
Foreign customers are more sensitive than local customers about environmental issues.	58%	7%	30%	5%

In general, participant companies think that their customers do not have interest in green products (%44). If customers do not have interest in green products, it is not possible to pay more for these products. %55 of participants think that their customers won't pay more for green products. Also participants mentioned that their customers don't have a demand for green company. A critic examination for this research, is that customer pressure is not enough to force participants for green initiatives. Most of the firms (%61) doesn't feel customer pressure to be green.

Another and the last question in this section is "What are the reasons that push your company to be green? Please rank, in order of importance". After the assessing the results, the ranking occurred as shown below;

TABLE 4
Percentage of Rankings

	Ranked 1	Ranked 2	Ranked 3	Ranked 4	Ranked 5	SCOR
Customer Pressure	20,7%	49,4%	16,1%	11,5%	2,3%	24,98
Government Pressure	13,8%	28,7%	44,8%	8%	4,6%	22,58
Rival Pressure	0%	11,5%	18,4%	43,7%	25,3%	24,24
Environmental Organizations	0%	4,6%	8%	31%	57,5%	10,8
Environmental Awareness	65,5%	5,7%	12,6%	5,7%	10,3%	27,32
Total	100%	100%	100%	100%	100%	

RESULTS AND SUGGESTIONS

Although all of pressure factors play complementary roles in the greening of the businesses, some of them are more significant than others. Results show that participant companies do not think that customers are interested in green products. As a result of this, they are not willing to pay more for green products. Another important result is customers prefer companies for their product quality and prices initially. Greening of business is not a decisive factor for their choices. Also firms clearly stated that customer pressure is not compelling them to seek environmental standards. When all these results considered together, it is not hard to suggest that "customer choices don't play a deterministic role in green supply chain management".

When we ask to ranking the most important pushing factors to be green, after environmental awareness (or corporate responsibility), companies mostly choose "customer pressure" factor. It means, customer pressure is stronger than government, rivals and environmental organizations factors. So we can suggest that customer pressure is not a strong factor that pushes companies to be green, but it is relatively strongest factor when compare with others.

Starting point of GSCM should be the ultimate customers. When the price sensitivity of ultimate customers is high, producers try to eliminate cost factors and tend to choose the cheapest supplier, not the green one. So initial suppliers, for decreasing costs, tend to choose the cheapest supplier (secondary) and this goes up to end of the chain. So if ultimate customers are not environmental friendly, also supply chains will not. It means, “pull” of market is more important than “push” of government. But as can be seen from the results, although customer pressure is stronger than government, “pull” of market is too weak and not enough to prompt supply chains to be green. At this point government should take on a task about activating citizens to be environmental and prefer green products and firms.

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GREEN LOGISTICS: ANALYZING TRANSPORTATION AND ENVIRONMENT RELATIONS BY USING CANONICAL CORRELATION ANALYSIS

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Abstract — *Logistics is the integrated management of all the activities required to move products through the supply chain. For a typical product this supply chain extends from a raw material source through the production and distribution system to the point of consumption and the associated reverse logistics. The logistical activities comprise freight transport, storage, inventory management, materials handling and all the related information processing. The main objective of logistics is to co-ordinate these activities in a way that meets customer requirements at minimum cost. In the past this cost has been defined in purely monetary terms. As concern for the environment rises, companies must take more account of the external costs of logistics associated mainly with climate change, air pollution, noise, vibration and accidents. This paper aims to examine air pollution and transportation relations of countries by using EU data.*

Keywords — *Environment, Transportation, Air Pollution*

INTRODUCTION

Logistics is an important function of modern transport systems. Contemporary technological and spatial developments have improved the cost, efficiency and reliability of freight and passenger transport systems. Since the applications of logistics are generally positive for the efficiency of transport systems, it has been suggested that logistics are environmentally friendly, thus the concept of "gren logistics". It is argued that although logistics may be linked to less environmentally damaging transportation systems, they have created a set of paradoxes that may prove to be the contrary to what is believed.

In this study, we want to explore the variables which are affecting air pollution more. By finding this/these variable(s), this can be utilized while designing environmental policy for nations. Paper designed as follows. After introduction we mention on green logistics and canonical correlation. Then, apply the analysis to the selected variables and interpret the findings. Finally we discuss the results.

GREEN LOGISTICS

In common with many other areas of human endeavour, 'greenness' became a catchword in the transportation industry in the late 1980s and early 1990s. It grew out of the growing awareness of environmental problems, and in particular with well-publicised issues such as acid rain, CFCs and global warming. The World Commission on Environment and Development Report (1987), with its establishment of environmental sustainability as a goal for international action, gave green issues a significant boost in political and economic arenas. The transportation industry is a major contributor to environmental degradation through its modes, infrastructures and traffics [1, 2]. The developing field of logistics was seen by many as an opportunity for the transportation industry to present a more environmentally-friendly face. During the early 1990s there was an outpouring of studies, reports and opinion pieces suggesting how the environment could be incorporated in the logistics industry [3,4,5]. It was reported that the 1990s would be 'the decade of the environment' [6].

CANONICAL CORRELATION

The canonical correlation analysis [7,8] is the most general case of the general linear model. Correlation and regression analyses can be thought of as special cases of this approach [9]. Canonical correlation analysis

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is a method that can be used for the analysis of interdependence. The goal is to find two linear combinations of the original variables. One combination from the first set of variables and one combination from the second. Mostly canonical correlation is used for finding significant multivariate relationships between variable sets [10].

Canonical correlation analysis is explained as the optimization problem of maximizing the square of correlation between the score vector **t**, which is a linear combination of the explanatory variable **X**, and the response variable **y** [11].

Researchers shall be interested in measures of association between two groups of variables. The first group, of p variables, is presented by the *(px1)* random vector $\mathbf{X}^{(1)}$. The second group, of q variables, is represented by the *(qx1)* random vector $\mathbf{X}^{(2)}$.It is assumed that in the theoretical development, that $\mathbf{X}^{(1)}$ represents the smaller set, so that $p \leq q$.

For the random vectors $\mathbf{X}^{(1)}$ and $\mathbf{X}^{(2)}$, let

$$\begin{aligned} E(X^{(1)}) &= \mu_1;\ Cov(X^{(1)}) = \sum{}_{11} \\ E(X^{(2)}) &= \mu_2;\ Cov(X^{(2)}) = \sum{}_{22} \\ Cov(X^{(1)}, X^{(2)}) &= \sum{}_{12} = \sum{}_{21}' \end{aligned} \tag{1}$$

It will be convenient to consider $\mathbf{X}^{(1)}$ and $\mathbf{X}^{(2)}$ jointly, so by partitioning the covariance matrix it can be found that the random vector,

$$\underset{((p+q)x1)}{X} = \left[\frac{X^{(1)}}{X^{(2)}}\right] = \left[\begin{array}{c} X_1^{(1)} \\ X_2^{(1)} \\ \vdots \\ X_p^{1} \\ \hline X_1^{(2)} \\ X_2^{(2)} \\ \vdots \\ X_q^{2} \end{array}\right] \tag{2}$$

has mean vector

$$\underset{((p+q)x1)}{\mu} = E(X) = \left[\frac{E(X^{(1)})}{E(X^{(2)})}\right] = \left[\frac{\mu^{(1)}}{\mu^{(2)}}\right] \tag{3}$$

and covariance matrix

$$\begin{aligned} \underset{((p+q)x(p+q))}{\sum} &= E(X-\mu)(X-\mu)' \\ &= \left[\frac{E(X^{(1)}-\mu^{(1)})(X^{(1)}-\mu^{(1)})' \vdots E(X^{(1)}-\mu^{(1)})(X^{(2)}-\mu^{(2)})'}{E(X^{(2)}-\mu^{(2)})(X^{(1)}-\mu^{(1)})' \vdots E(X^{(2)}-\mu^{(2)})(X^{(2)}-\mu^{(2)})'}\right] \\ &= \left[\frac{\underset{(pxp)}{\sum_{11}} \vdots \underset{(pxq)}{\sum_{12}}}{\underset{(qxp)}{\sum_{21}} \vdots \underset{(qxq)}{\sum_{22}}}\right] \end{aligned} \tag{4}$$

The covariances between pairs of variables from different sets are contained in $\sum_{12}$ or equivalently $\sum_{21}$. That is, the *pq* elements of $\sum_{12}$ measure the association between the two sets. When p and q are relatively large, interpreting the elements of $\sum_{12}$ collectively is ordinarily hopeless.

Linear combinations provide simple summary measures of a set of variables. Set

$$\begin{aligned} U &= a'X^{(1)} \\ V &= b'X^{(2)} \end{aligned} \tag{5}$$

for some pair of coefficient vectors *a* and *b*. Then, using (5), it is obtained that,

$$Var(U) = a'Cov(X^{(1)})a = a'\sum_{11} a$$
$$Var(V) = b'Cov(X^{(2)})b = b'\sum_{22} b \qquad (6)$$
$$Cov(U,V) = a'Cov(X^{(1)}, X^{(2)})b = a'\sum_{12} b$$

It should be sought that coefficient vectors *a* and *b* such that

$$Corr(U,V) = \frac{a'\sum_{12} b}{\sqrt{a'\sum_{11} a}\sqrt{b'\sum_{22} b}} \qquad (7)$$

as large as possible [12,10,13,14,15].

Before interpreting canonical variates and the canonical correlations, one needs to determine if the canonical correlations are statistically significant. The null and alternative hypotheses for assessing the the statistical significance of the canonical correlations are

$$H_0 : C_1 = C_2 = \cdots = C_m = 0$$
$$H_a : C_1 \neq C_2 \neq \cdots \neq C_m \neq 0$$

The null hypothesis, which states that all the canonical correlations are equal to zero, implies that the correlation matrix containing the correlations among the *X* and *Y* variables is equal to zero, i.e. $\mathbf{R}_{xy}$ is the correlation matrix containing the correlations between the *X* and *Y* variables. One of test statistics, used for testing the hypothesis, is Wilks' Λ.

$$\Lambda = \prod_{i=1}^{m} (1 - C_i^{\,2})$$

The statistical significance of the Wilks' Λ can be tested by computing the following test statistic:

$$B = -\left[n - 1 - \frac{1}{2}(p + q + 1) \right] \ln \Lambda$$

which has an approximate χ^2 distribution with *pxq* degrees of freedom [16].

ANALYSIS RESULTS

In this section we use 5 environment and 5 transportation variables for analysis. These data gathered from Eurostat database. We will give in Table 1 brief explanation about these variables but researchers can find detailed information from the EUROSTAT website.

TABLE 1

Variables Used in the Analysis

Variables	Brief Explanation
Emissions of particulate matter by source sector: Transport (2006) (E1)	This indicator tracks trends in anthropogenic atmospheric emissions of primary particles, secondary particulate precursors (sulphur dioxide, nitrogen oxides and ammonia). Particulates and particulate precursor emissions are combined in terms of their particulate-forming potential and expressed in terms of particulate-forming equivalents.
Emissions of ozone precursors, by source sector; Transport (2006) (E2)	This indicator tracks trends in anthropogenic atmospheric emissions of ozone precursors (nitrogen oxides, carbon monoxide, methane and non-methane volatile organic compounds), by source sector. Ozone precursor emissions are combined in terms of their tropospheric ozone-forming potential, and expressed in NMVOC equivalents.
Greenhouse gas emissions by sector; Transport (2007) (E3)	This indicator shows the greenhouse gas emissions of key source categories. A key source category is defined as an emission source category that has a significant influence on a country's greenhouse gas inventory in terms of the absolute level of emissions, the trend in emissions, or both. The different greenhouse gases are weighted by their global warming potential, and the results are expressed in CO2 or equivalents.
Greenhouse gas emissions from transport; Road Transport (2007) (E4)	This indicator shows trends in the emissions from transport (road, rail, inland navigation and domestic aviation) of the greenhouse gases regulated by the Kyoto Protocol. Only three gases are relevant in the context of transport (carbon dioxide, methane, and nitrous oxide) and these have been aggregated according to their relative global warming potentials.
Greenhouse gas emissions from transport; Transport (2007) (E5)	
Energy consumption of transport, by mode; Final energy consumption - Air transport (2006) (EN1)	This indicator covers the consumption of energy in all modes of transport, with the exception of maritime and pipelines.
Energy consumption of transport, by mode; Final energy consumption - Rail transport (2006) (EN2)	This indicator covers the consumption of energy in all modes of transport, with the exception of maritime and pipelines.
Energy consumption of transport, by mode; Final energy consumption - Road transport (2006) (EN3)	This indicator covers the consumption of energy in all modes of transport, with the exception of maritime and pipelines.
Gross inland energy consumption, by fuel; Crude oil and Petroleum Products (2006) (EN4)	Gross inland consumption is calculated as follows: primary production + recovered products + total imports + variations of stocks - total exports - bunkers. It corresponds to the addition of final consumption, distribution losses, transformation losses and statistical differences.
Volume of freight transport relative to GDP (2006) (EN5)	This indicator is defined as the ratio between tonne-kilometres (inland modes) and GDP (chain-linked volumes, at 2000 exchange rates). It is indexed on 2000. It includes transport by road, rail and inland waterways. Rail and inland waterways transport are based on movements on national territory, regardless of the nationality of the vehicle or vessel. Road transport is based on all movements of vehicles registered in the reporting country.

Analyses are performed by using STATISTICA pocket program. In table 2 significance tests of models can be seen. The test statistics values and p values of canonic correlation coefficients, which are obtained from the analysis, is illustrated in Table 2. When the values are examined, it can be seen that only the first canonical root's canonical correlation coefficient is statistically significant (χ^2 =202.1752, df=25, p<0.05) and the others are not significant.

TABLE 2

Significance Tests of Model

	Chi-Square Tests with Successive Roots Removed (				
Root Removed	Canonicl R	Canonicl R-sqr.	Chi-sqr.	df	p	Lambd Prime
0	0,999729	0,999458	202,1752	25	0,000000	0,0001
1	0,794434	0,631126	32,9632	16	0,007496	0,2310
2	0,567230	0,321750	10,5239	9	0,309800	0,6264
3	0,251909	0,063458	1,7885	4	0,774579	0,9235
4	0,117612	0,013833	0,3134	1	0,575602	0,9861

TABLE 3

Eigenvalues of Roots Extracted

	Eigenvalues (enerji ve çevre değişkenleri kanoni)				
Root	Root 1	Root 2	Root 3	Root 4	Root 5
Value	0,999458	0,631126	0,321750	0,063458	0,013833

TABLE 4
Extracted Roots and Variances

Factor	Variance Extracted (P		Variable	Variance Extracted (P	
	Variance extractd	Reddncy.		Variance extractd	Reddncy.
Root 1	0,94001:	0,93950:	Root 1	0,75308:	0,75267!
Root 2	0,03818!	0,02410:	Root 2	0,09164{	0,05784:
Root 3	0,01945(	0,00625{	Root 3	0,07811:	0,02513:
Root 4	0,00206:	0,00013:	Root 4	0,02456!	0,00155!
Root 5	0,00028{	0,00000:	Root 5	0,05258{	0,00072:

As can be seen in Table 6 that, the redundancy coefficient of Root 1(left set) canonic function is 0,939502 and redundancy coefficient of Root 1(right set) canonic function is 0,752675. This means that the main contribution to the variance explanation is provided by the first canonic root.

TABLE 5
Canonical Coefficients of Environment (Left Set) and Transportation (Right) Data Set

Variable	Canonical	Variable	Canonical V
	Root 1		Root 1
E1	0,135	EN1	0,06891:
E2	-0,12:	EN2	-0,06940:
E3	268,62:	EN3	1,16663:
E4	0,944	EN4	-0,16217:
E5	-268,58:	EN5	-0,00926{

Because of the statistical significance, when the first canonical root is taken into account, model and coefficients could be gathered as seen in Figure 1.

0.135***E1**0.123***E2**+268.624***E3**+0.944***E4**-268.583***E5**	=	0.068914***EN1**-0.069403***EN2**+1.166634***EN3**-0.162177***EN4**-0.009268***EN5**

FIGURE 1
Model and Coefficients

When the Figure 1 examined, it can be seen that E3 has positive and E5 has negative biggest coefficient values. On the other hand when the transportation variables analyzed, it can be seen that the biggest effect has been found from EN3 variable with 1.166634 coefficient value. This means that the biggest impact on environment comes from road transport.

CONCLUSIONS

We know that logistics, especially transportation, has great effect on environment. In this study we want to determine the variable which has significant effect on environment. Up to the results of the canonical correlation analysis, the main contributor is road transportation. This result is not surprising, because countries are aware of this and by using Kyoto protocol road transportation's effect on environment is tended to be decreased. But it is clear that road transportation, alone, has biggest impact on environment. For a green environment investment on rail transportation must be increased and the measures taken into account for road transportation must be strictly applied.

For further studies the variables that measure transportation and environment can be increased so that more sensitive analysis can be performed. Because of lack of information in EUROSTAT database, unfortunately this study is performed with a data gap.

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QUALITY VARIABLES IN HOUSE AND OFFICE MOVING INDUSTRY: A STUDY IN TERMS OF SERVICE PROVIDERS AND CUSTOMER PERCEPTION

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Abstract *— In this study, the aim is to evaluate the services of home and office moving industry and to determine the quality variables from the perspective of service providers and customers. In the study, after the literature review, the process of home and office moving service distribution system was analyzed. With the actors in the process, a qualitative research technique namely focus group was conducted and service quality variables were determined. Home and office moving industry service providers, public and private institutions, personnel from transportation companies and representatives of customers joined the study. The questions related to home and office moving service quality variables were asked to the members of the focus group. The results showed that main determinants of quality in home and office moving industry can be categorized as vehicles, equipments, packaging materials, personnel and reliability on the moving company. Main contribution of this study is the analysis of the home and office moving industry and determination of the service quality factors.*

Keywords — House and office moving, service quality,

INTRODUCTION

Home moving has been performed by the people since years. In most cases, moving represents an exciting time in a person's life. For teenagers going to college or university, moving means newfound independence. For newlyweds moving into their first flat, this means the start of a brand-new life together. Families moving into a dream home represent growth. For career-driven people who are relocated to a different place as part of a promotion, moving signifies success. In circumstances such as these, moving is always seen as a happy event. In other circumstances home moving can create headache [1].

Home moving are not just about packing for the moving. In order to get house moving done, you have to sort out all your belongings and categorize which ones you will take with you to your new home, which ones you will throw away and which ones you will put into storage. Not only that, you would also need to make an inventory of your belongings and then pack them in crates and boxes with the hope that nothing would be lost, broken or misplaced [1].

Today instead of having the home moved by the people themselves, more and more house or office moving companies give house and office moving service in order to facilitate the life of people. Although they give the similar types of services, quality of services differs. Since the quality is an essential competitive element, the concern for quality in house and office moving industry is evident.

Since the eighties, service quality has been one of the most important issues in marketing literature and is considered as a vital element in management strategies in order to succeed and/or to outlive in competitive environments [2]. The pressure of competition in most industries has forced managers to look for ways to enhance their competitive position. Many have decided to improve service quality in order to differentiate their services from those of their competitors [3].

The focus of this paper is to determine the service quality variables in order to measure the service quality in the home and office moving industry. Many business organizations have felt the critical need to use a tool for evaluating service quality in order to appropriately assess and improve their service performance. After the review of the literature, a study that measures service quality in home and office moving industry could not be

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reached. Therefore, it became necessary to develop a reliable and valid instrument to evaluate the service quality in home and office moving industry.

SERVICE QUALITY

Service quality is considered an essential strategy for success and survival in today's competitive environment. However, unlike goods quality, which can be measured with some objectivity, service quality is abstract and elusive. The unique features of services such as inseparability of production and consumption, intangibility and heterogeneity make measurement of quality a very complex issue. In the absence of objective measures, firms must rely on consumers' perception of service quality to identify their strengths and /or weaknesses, and design appropriate strategies [3] . The complex feature and the importance of service quality attracted the attention of researchers and practitioners all over the world [4] and they have increasingly focused their attention on customer service and how to improve the quality of external service encounters between the contact employee and external customer. While some researchers were interested in the physical surroundings that improve service encounters, Parasuraman et al. [5]-[6] focused on minimization of organizational ''gaps'' that affect customer satisfaction. However, internal service quality is equally important because an organization's ability to meet the needs of external customers relies on employees' internal capabilities to satisfy the needs of internal customers.

While the literature on service quality is reviewed, it is seen that two schools of thought dominate the extant thinking. One is the Nordic school of thought based on Grönroos's two-dimentional model. And the other is the North American school of thought based on Parasuraman et al's five dimensional SERQUVAL model. Reference [4] indicates that other significant conceptual and empirical works (models) in the area service quality can be encompassed as follows: (1) customer's experiences with the tangibles, reliability, responsiveness, assurance, and empathy aspects of services delivered by a firm [5]; (2) technical and functional quality [7] ; (3) service product, service environment, and service delivery [8]; and (4) interaction quality, physical environment quality, and outcome quality [9]. All these four models share a common feature: They propose a multidimensional service quality conceptualization that it is inherently linked to the measurement of consumer quality perceptions. Therefore, service quality models offer a framework for understanding what service quality is, as well as how to measure service quality in each proposed conceptualization [10]. The service quality models can also be categorized in three distinct groups, showing the limitations of each conceptualization: (1) Multidimensional reflective model such as RSQS- Retail Service Quality Scale (Dabholkar, Thorpe and Rentz's Model). (2) Multidimensional formative models such as GM (Grönroos' Model), ROM (Rust and Oliver Model), SERVQUAL (Parasuraman, Zeithaml, and Berry's model) and SERVPERF(Cronin and Taylor's Model). (3) Multidimensional formative–reflective model such as BCM (Brady and Cronin's multidimensional and hierarchical Model) [10].

In the literature, it is seen that many studies has been performed in different industries regarding service quality. However, there are very limited studies in logistics and no study has been encountered on service quality in home and office moving industry. Some of the studies in the literature related to service quality are as follows: Measuring service quality in the hotel industry [11]-[12]-[13]-[14]-[15]-[16], in banking [17], in transport service [10], in retail industry [18] - [19], in automobile repair and maintenance industry [20], in airline service [21]-[22]-[23], in shipping [24], in e-business [25] , in restaurants [26] , in railways [27], in health care services [28]-[29]- [30]-[31], in travel agency industry [32] , in telephone service quality [33].

THEORIES AND STUDIES ON HOUSE MOVING INDUSTRY

Although no direct study has been confronted regarding service quality in home and office moving industry, there are some studies on home moving. The topic of home and office moving is discussed in the literature as "house moving" and this topic has been formulated as 'residential mobility' and has been examined from more psychological, economic and policy oriented perspectives. The studies in this area have tended to use more quantitative methods in order to examine the causes and effects of such mobility. Moreover, they have tended to conceive residential mobility as a problem, as opposed to the norm of a stable home, where mobility was intimately tied to poverty, inadequate housing and ill-health, as well as family and community breakdown[34]. This pathologisation of mobility was only tempered by Rossi's pioneering study which argued that residential mobility was in fact normal and could be seen as an effect of transitions in the family life-cycle. The early theory on housing mobility is the so-called ''life cycle model'' . According to this model, frequency of mobility will increase in connection with changes in life stages, e.g. finishing education, marriage, divorce, new job, retirement, children leaving home, death of spouse, or infirmity. Further studies confirm that the propensity to consider moving and actually to move is higher at such times [34]. Another theory on housing mobility is the so-called ‘‘stress threshold model’’ first developed by Wolpert [35]-[36] and later developed further by Brown and More [37], Speare [38] and Fokkema, Gierveld and Nijkamp [39]. Wolpert assumes that a decision on moving is a function of what he calls the location’s utility to the person in question. The location is not just the dwelling, but also the physical surroundings and the social environment. If the utility of a location is high, there is no reason to move, even though the utility of another location might be higher. If utility decreases for some reason, the person will feel a certain stress. However, only if this feeling of stress is sufficiently high and exceeds a certain threshold, will the person consider moving [34]. Brown and More suggest that there are two steps: first, to consider moving and, secondly, the decision as to where to move.

Beside the theories explaining why people move their house, following studies have looked at the topics from similar perspective. Some of the studies encountered related to house moving are as follows: The reasons of older people’s decision on moving their house [40] . The psychiatric symptoms of moving house on children [41] . The childeren’s understanding of moving house and homelesness experience [42] . Home moving and childeren’s homlessness experience [43]. The health complaints and annoyance after moving into a new Office building [44] . The interrelation of congestion and residential moving behavior [45]. The family moving home and social stratification [46] .

All previous theories and studies deal with the reasons and the results of house moving. However, no accessible study has dealt with the house and office moving industry from the service quality perspective of logistics service providers.

Logistics Services in House and Office Moving Industry

Home and office moving services are not different from the logistics services and quite similar activities are carried out. The services given in house and office moving industry can be categorized as follows: transportation (both intracity and intercity transportation), transportation insurance, expertise (supervising), packing, wrapping and stretching, elevator services, loading, unloading, stuffing into the truck, assembly and disassembly, warehousing and storage, supplying garment rails for clothing, supplying cartons and packaging materials and tracking systems.

As it is seen at **Figure 1**, the process of moving the home and office is not different from the logistics processes. It starts with the order of the customers and it is completed by reaching the cargo to its destination. Between these two points a series of logistical activity carried out by the service providers and majority of these activities are the same as logistics activites.

Authorized Parties Deal With Home and House Moving Activities

The rapid developments of transport and developments in economic, commercial and social life in Turkey cause home and office moving industry to have a stronger legal infrastructure. Consequently, Road Transport Act Numbered 4925 was accepted and has come in to force by Sublime Parliament in order to correct the irregularities in the industry and to order the industry in line with the needs of economic, technical, commercial and social life [47].

According to the article no. 6 of Road Transport Act Numbered 4925, the only authorized party who can carry out the home office moving activities in Turkey is the parties who have K3 certificate. In order to obtaining the K3 certificates, parties have to fulfill the general conditions stated in the Article 12 and special conditions stated in Article 13 of Road Transport Act Numbered 4925. According to Article 13, the party apply for the K3 certificate has to have the vehicles which have the total carrying capacity of at least 30 tons and the equity capital of 5,000 Turkish Liras. According to Article 80 of the regulation, the party who applies for the K3 certificate for intracity home and office moving activities has to pay TL 6,471 for the certificates.

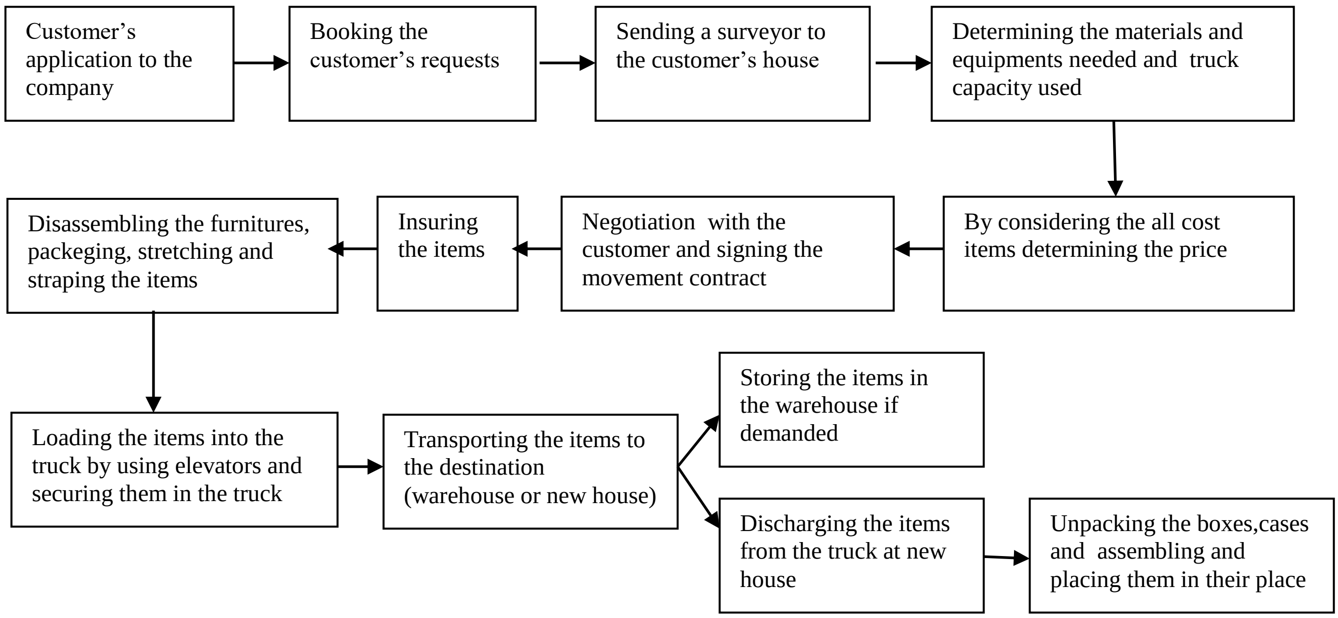

FIGURE 1
The Process of Home and Office Moving Activities

METHODOLOGY

The main aim of this study is to evaluate the services of home and office moving industry and to determine the quality variables from the perspective of service providers and customers. A qualitative study is aimed and the methodology used is focus group discussion. A focus group is a distinctive type of group in terms of purpose, size, composition and procedures. Participants who do not exceed 10-12 in number are selected because they possess certain characteristics in common that relate to the topic or theme of the research. Focus group interviews, originating in marketing research, were developed in the 1930s. Differing from the traditional information gathering techniques, focus group discussion is a qualitative methodology where around 10 open-ended questions are directed towards the group of participants in an average of one hour period with the help of a moderator to state, explain and share their experiences, attitudes and opinions with no influence or boundaries [48]-[49].

Figure 2 summarizes the focus group discussion procedures. The steps in the procedure are question development, group composition and recruitment, interview protocol and logistics, implementing the focus group discussion and data analysis [50]-[49]

Data Collection Forms and Question Contents

Two separate forms are used for the research. The first one aims to collect information on the demographic profile of the participants and the second one is the moderator's discussion guide with blanks under each question to record key ideas. The form searching the demographic profile of the participants covers questions on the gender, age, occupation, education, etc. The moderator's discussion guide used for this research is given in **Appendix 1**. When developing the questions, both Parasuraman et al's five dimensional SERQUVAL model and four marketing mix elements which is product, price, place, promotion were taken into account. The questions included variables related to the home and office moving industry.

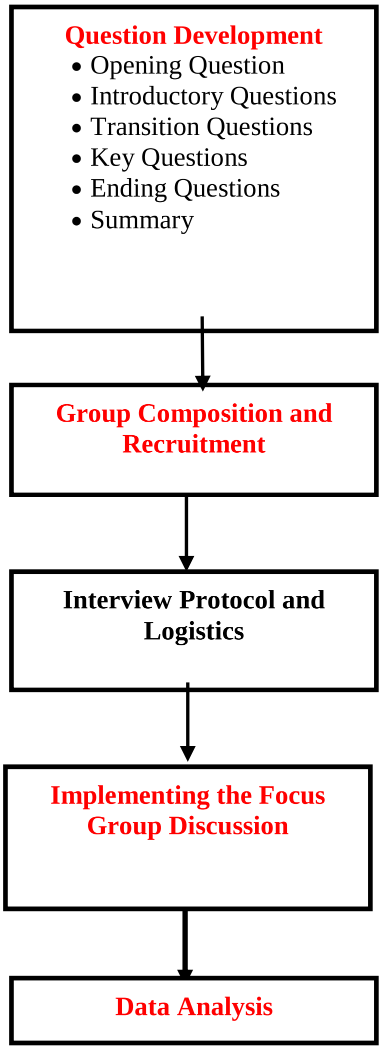

FIGURE 2

Focus group discussion procedures

Group Composition and Recruitment

The focus group is composed of 9 people. People directly related with home and office moving industry such as service providers, customers and people from the Chamber of Truck Drivers which is the member of Izmir Chamber of Tradesman and Craftsman were included into the group. The profiles of the respondents are given in **Table 1**.

TABLE 1
Profile of the Focus Group Participants

Gender		**Education**		**Occupation**		**Age**	
Male	9	Primary School	4	Public sector	2	20-35	4
Female		High School	3	Private sector		36-45	2
		Undergraduate	2	Entrepreneur	7	46-over	3

The participants were selected in a differentiated way to represent the qualifications appropriate for the objectives of the study. In addition to these qualifications the probable activity level for the focus group discussion was also taken into account. In **Table 2** the company or organization of the participants are clarified.

TABLE 2
Company or Organization of the Participants

Participant No.	Company or Organization
1	Akdoğan Nakliyat (Akdoğan Transport)
2	İzmir Kamyoncular Odası (İzmir Chamber of Truck Drivers)
3	İzmir Kamyoncular Odası (İzmir Chamber of Truck Drivers)
4	Salmanoğlu Nakliyat (Selmanoğlu Transport)
5	Dokuz Eylul University (Home moving service taker)
6	Dokuz Eylul University (Home moving service taker)
7	Sihirli Home and Office Moving Company
8	Sihirli Home and Office Moving Company
9	Dünya Nakliyat (Dunya Transport)

Interview Protocol and Logistics

The logistics of the focus group discussion include the location and scheduling. The building of the Chamber of Truck Drivers was chosen as a place that is easy for the participants to find and to access. The participants were contacted 15 days before the session, the nature of the study was explained and they were invited to the meeting at the specified day and hour. All of the participants reached the meeting place by their own means. 2 assistant moderators joined the meeting to assist the moderator in handling the operational or environmental conditions and logistics.

The meeting room was organized in a manner that the moderator's table stood in the middle and the assistant moderators sat behind the moderator, and around the moderator the participants' seats were designed in a circle. Beverages and cookies were served before the discussion started. Questionnaires and discussion guides were prepared in necessary numbers beforehand. The focus group discussion was recorded by videotaping and also by written notes. All the related equipment was checked before the meeting to maintain efficient operating conditions during the meeting.

Implementing the Focus Group Discussion

Before starting the discussion, the objective of the meeting was briefly explained to the participants and the questionnaires related to the participants' demographic profile were distributed and asked to be completed. Afterwards the focus group discussion guide that is given in **Appendix 1** was taken into account and every question in the guide was asked to each participant orally. The replies were recorded in written notes and by videotaping. The assistant moderators took part in assisting the moderator with these operations and also warned the moderator by written notes where necessary. After the completion of the structured questions a period of 15 minutes was maintained for unstructured discussion among the participants and this discussion were also recorded. Completion of the participants' questionnaires, the discussion guide and the unstructured discussion period lasted in a total of 1 hour and 45 minutes.

Data Analysis

After the discussion the moderator and the assistant moderators met to analyze the discussion briefly and to find out the common and conflicting points reached by the participants. Afterwards the data collected by the videotapes and as written notes are transcribed, coded and analyzed. Thus the moderator have identified the major outcomes of the discussion.

Overview of Results

The sequence of the questions in the focus group discussion guide were prepared in a manner that it was aimed to receive the opinions of the participants on home and office moving industry, particularly, services provided by the home and office moving industry, the new developments in the industry, economic, social and environmental effects of the industry, the adequacy of regulations, factors effecting the determination of the quality of services, the adequacy of warehouses, trucks and equipments, the competency of the work force, the transportation insurance and transportation costs etc. In this manner **the initial questions** were directly related to what services are provided by home and office moving companies and what services are received by the customers.

Home and office moving consists of a series of processes. The initial point of the process is that the customer calls the carrier. Upon receipt of this call, the carrier sends and surveyor free of charge to address of the customer, considering the feature of the demand. The surveyor carries out a detailed investigation on such aspects regarding the carriage as the quantity of the items to be carried, the amount of the packaging materials to be used (e.g. crafts, barrels, hanging wardrobes, etc.), the plan to be designed on how to carry the items, and the freight to be charged for the carriage. Following the completion of the contract, the transport staff detach the items to be moved, package them within the new packaging materials in as hygienic manner as possible, stretch, place them in the wardrobes with hangers, and using the relevant elevator move them out. The items of carriage then are loaded on the carrier to be taken to the destination where they are unloaded and reinstalled. In the meantime, the home and office items are stored in warehouses designed particularly for such items.

The primary points considered by the customers are receiving the service on time in compliance with the agreement and the period agreed on, getting justifiably compensated for the damage made on the items carried and on the home, being assured that no further amounts will be charged, during the shipment and no extra amount will be charged for the elevator to be used.

Still another point of consideration on the part of the customers is receiving proper surveying service. They state that such carriage is to be carried out by those companies with K3 certificates expertised exclusively in this field.

The second questions was related to the most important developments/ innovations recently introduced in home and office moving industry. Participants stated that elevators, packaging materials, expertise services, promotion through internet, employing furniture producers or carpenters within the companies, increase in the quality of the packaging materials, carriers' assurance in carriage risks and enhancement of organization skills in factory moving are the most important developments in the industry.

The third questions was related to if home and office moving industry today manages the carriage and warehousing business more effectively, when compared with the conventional one. The service providers think that through providing surveying service free of charge, a considerable phase accomplished in favor of providing a better and faster home and office moving service. The vehicles, apparatus, and materials used now are a lot more modernized. They stated that the packaging processes are now much more better, safer and proper. Another plus favoring a more satisfying service is introducing the elevator within the system. Still another factor affecting and improving the customer satisfaction is the quality warehousing system, through which the items are stored outdoor in the warehouses or they are placed in certain exclusively deployed boxes or trunks.

The fourth questions was related to the role of home and office moving industry and the stresses experienced by the service receivers. Professional home and office moving companies have diminished the carriage anxiety to a great extent. In most cases, the service receivers are not involved in the process, they are not required to get prepared for the carriage, the home and the office is moved by the company as a whole and the furniture is replaced and reinstalled at the destination. The experience gained and the equipment used have decreased the stress on the part of the service receivers. Prior to reinstallment, in case of necessity, a house cleaner is provided by the carrier to clean the house.

The fifth questions were related to economic, social, cultural and environmental effects of the industry. The participants think that the home and office moving industry provides a great deal of equipments and materials; e.g. trucks, auxiliary parts, fuel-oils, boxes, packing materials etc., from many other industries. This is a kind of economic contribution to the relevant country. Still another contribution to the economy is the taxes paid by this industry. Besides, the industry employs around 15 persons per each company, thus contributes to the employment. In terms of cultural contribution, however, home and office moving industry has not yet been popularized and favored to a satisfactory extent in Turkey. As a result of such unfortunate and inadequate fame of the industry, certain over aged trucks with no proper certificates used in home and office moving which consume lower quality fuel-oil cause environmental pollution.

The sixth questions was related to regulations and compensation of the damages related to home and office moving industry. The participants believe that the regulations pertaining to home and office moving are adequate. According to these regulations, these companies with K3 certificate are authorized to carry out home and office moving. Along with such companies with K3 certificates, however, there are many other ones having no such certificate but carrying out this job. Such companies are not unfortunately inspected to a satisfactory extent, benefit from an unjustified competition through low quality service they provide and lower prices they offer.

Regarding the carriage contracts, carriage agreements are issued for the carriages fulfilled by the the companies with K3 certificates. In accordance with the agreement requirements, the carriers are responsible for any damages caused. In case of having no such agreement, however, the customer has no legal rights to claim for any compensation. Carriers meet those damages stated within the agreement clauses only.

Customers are not well informed about the contents/clauses of the carriage agreements. Unless the carriers provide the customers with such agreement forms, no agreement is issued and in case of suffering any damages, customers are vulnerable and unable to claim for any compensation. In terms of protecting the rights of the customers, the Chamber of Truck Drivers have no legal power on making the carriers compensate the damages caused during home and office moving.

The seventh questions was related to the factors determining the quality of service provided in home and office moving industry. The expertise service provided, the equipment used, the personnel and the elevator are the seen the main determinant of quality.

The eighth questions was related to the standards of warehouses, trucks, equipments and the competency of the employees. The participants think that there has been no problem about the physical competency of the professional companies with K3 certificate. The trucks and the warehouses of such companies are in good condition provided with proper equipment. Their packaging materials are quality and adequate.

According to the Road Transport Regulation Article No. 17, the age of the trucks to be used by the new entrants to the industry for home and office moving should not exceed 22. When trucks of these companies already working in the industry reach at the age of 22, they are to pass the visa investigation procedures, if they are to be kept in working at home and office moving. At present, the trucks being used in city to city home and office moving are relatively young and mostly 2006-2007 model. Those working in the intracity transports are around 10-15 years old, equipped with isolated cases, which are as important as the trucks themselves and are quite costly.

Professional companies working in this industry have permanently employed competent and professionally specialized personnel. Throughout the whole industry present an overall picture revealing that those with K3 certificate have qualified personnel.

On the other hand, however, within this industry there have been a great number substandard companies with no K3 certificate. The employees of such companies, with inadequate and incompetent vehicles and equipment, are temporarily employed and unqualified ones.

The ninth questions was related to transportation insurance and transportation prices. Participants state that all customers want to be provided with insurance certificates. Such certificates, however, are issued for intercity transports but not for those intracity ones; the damages caused during the latter, nevertheless, are met by carriers. The clauses of the insurance policies are not usually carefully examined by the customers. The insurance companies compensate not all types of damages but only those caused during carriage while the relevant truck is on route.

There appears an unfair competition within the industry between the companies owning K3 certificate with those who do not have it. The overall profit rate earned in this industry is around 5-10 %. Those with no K3 certificates usually tend to offer lower prices. For instance, while the cost of an intracity moving carried out by a company with K3 certificate is about 600 TL, another company which do not have this certificate can offer to do the same carriage for 300 TL. Such an unfair competition prevents the certificated companies from doing their job.

The tenth questions was related to the companies which officially carry out the home and office moving activities in Turkey. It is stated that such activities are carried out by the companies with K3 certificates in Turkey.

The eleventh questions was related to advertising and promotion activities for home and office moving industry. The participants indicate that the companies usually carry out their advertising activities through internet or through certain printed brochures. Another means of advertising is done through daily paper ads and stickers. Still another means made use of in accessing the potential customers is the recommendations of the existing customers. The attitudes and performances displaced by the company personnel on job could also be another source of advertisement particularly for the potential customers who observe such attitudes and performance at work.

Receiving a trade mark within the industry is said to be rather difficult, particularly for too great number of the companies included in the industry. Nevertheless, most companies tend to have their trade mark marks registered, have their own logos, receive ISO 9001 quality certificates and refer their customers to certain carriages they have previously fulfilled. Such a tendency is a step towards accomplishing trademark.

The twelfth questions was related to elimination of the problems caused in the intracity traffic by home and office moving industry. The participants state that narrow roads prevent large trucks from entering certain roads. Before the transport truck enters a road, the cars parked along that road are taken away. Transport trucks are permitted to enter certain places at certain time periods and they are to receive special permission to enter certain places. Therefore, the drivers of such trucks are to be careful about such permitted time and they have got to receive the required permission in time. Besides, in order not to block the roads for a long time, the loading/ discharging operations must be carried out rapidly. In order to do this, the elevator must be used effectively and the items to be loaded must be prepared for loading beforehand. Furthermore, home and office moving should not be carried out at night and at the rush hour for the residents involved.

The thirteenth questions was related to the efforts to improve the quality and the customer satisfaction in home and office moving industry. The participants believe that in terms of enhancing the quality service, the primary factors are using new and adequate truck and equipment along with quality packaging material. More important, however, is the competency and reliability of the personnel carrying out the job. It might be image damaging to appoint for such moving incompetent personnel who are likely to make undesirable and unacceptable impressions. Another point which causes the customers dissatisfied is the differences between agreed price and prices asked during the loading of the truck. Some transportation companies increase the price while loading the items by claiming that number of items is more than they expected. Also some firms send small trucks which can not take all items and for remaining cargo another truck is appointed and extra money is requested. This is also a point which dissatisfies the customers.

In terms of increasing customer satisfaction, reliability seems to be one of the most important criteria. Those employees who lack work discipline and whose wearing style does not comply with the work carried out causes a dissatisfaction on the customers. Besides, having received ISO 9001 and ISO 18001 certificates seem to be important in terms of improving the service quality. Still in this regard, another important point in improving the service the service quality is the questionnaires conducted to assess the service quality

Service Quality Determinants in Home and Office Moving Industry

By carefully analyzing the focus group study results, 29 service quality determinants have been extracted. These are given as follows:

- High quality hygienic packaging materials
- New and adequate equipment
- Specially designed elevators
- New vehicle and adequate vehicle capacity
- Good warehouses and storages equipped with necessary equipments
- Having K3 certificate
- Having a trade mark and logo
- Having ISO quality certificates
- Giving surveying / expertise service
- Insuring the items
- Giving turn key services
- Giving house cleaning services
- Better, safer, proper packaging process
- Planning the moving operations very carefully from beginning to the end
- Having organizational skills in factory moving
- Reliability of the moving company
- Supplying the service on time
- Complying with period of transportation

- Competency of the personnel carrying out the job
- Reliability of the personnel carrying out the job
- The external appearance and clothes of the employees
- Making moving contracts and complying with agreement
- Compensating the damages
- Assuring that only the amounts stated in the contract will be charged
- Assuring the customer against carriage risks
- Using all kind of media in reaching to the customer
- Not giving harm to the environment by consuming low quality fuel-oil
- Preparing questionnaires conducted to assess the service quality
- Price

CONCLUSION

Home and office moving activities have been carried out for years and almost every person experienced it at least once in his/her life. Although it is seen an happy event for some people if the people move to better place, it can sometimes creates headache if it can not be done properly. For avoiding the problems, it is necessary to have the home and office moved by the companies which supply high level of services. In other words, the service quality of the company must be satisfactory. In order to understand if a companies' service level high or not, the service quality determinants must be known and according to these determinants service quality is evaluated. Although in many sector, service quality has been studied and many thoughts have been developed like Parasuraman et al's and Grönroos, no study has been encountered on service quality in home and office moving industry. In order to fill this gap and determine the service quality variables, a qualitative study namely focus group has been carried out by home and office moving service providers and service takers. The study showed that the only authorized parties deals with home and office moving business is the parties which have K3 Certificates. However, besides these companies some other companies are carrying out the job illegally. The results reflect that this industry is in its beginning stage in Turkey and will develop by the years. The most important part of the study is the determinants of service quality in home and office moving industry. 29 variables have been extracted from the focus group study. Some of them are: High quality packaging materials, new and adequate equipment, using special elevators, Having K3 certificate, giving expertise service, reliability of the company, supplying the service on time, competency and reliability of the personnel, compensating the damages etc. The variables stated here will be valuable for the researchers who will make similar studies.

When we looked the industry from the point of logistics, it is seen that home and office moving industry serves all logistical services to customers. From order booking to concluding service contract, from transportation to warehousing, from packaging to loading / unloading and stuffing, from insuring to damage compensation. Therefore, home and office moving industry can be seen as a logistics service provider industry.

In the focus group study, majority of the participants are service providers. Therefore, if the study is carried out again only with service takers (customers), different variables can be obtained. Thus, this can enrich the study.

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SERVICE QUALITY AT THE SEAPORTS: AN APPLICATION OF QUALITY FUNCTION DEPLOYMENT TO MERSIN INTERNATIONAL PORT

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Abstract — *Seaports have been in subject to a major privatization effort in Turkey. Mersin, İskenderun, İzmir, Derince, Bandırma and Samsun Ports have been decided to privatized since 2005, but only Mersin Port's privatization has been fully completed, and the others are expected to be completed soon. Mersin International Port (MIP) operates the Mersin Port since 2007.*

Seaports are the main gates in global logistics. The service quality level of a port activities affects the productivity level, customer satisfaction and profitability of the port authority. To reach the highest level of service quality, it is necessary to understand and to satisfy the customers' needs. Quality Function Deployment (QFD) is a powerful technique to determine the customer wants (WHATs), and to match what the port authorities do to meet the customer requirements (HOWs). This builds a better service design for the port activities.

This study aims first to determine the customer wants and how the port authority satisfies the customer expectations in order to design better services in ports, and second, to show the port authority which activites are more important in satisfying the customer needs. A survey was prepared by face-to-face interviews, and sent to the major logistics companies in Mersin. We dtermined the logistics service providers' needs and then the survey results were shared with the MIP executives to understand what the MIP does to meet the customer wants. At the end, we provided a good information regarding how to reach customer satisfaction at the seaports.

Keywords — *Service quality of ports, Quality function deployment, House of quality, Product/service development*

INTRODUCTION

Ports are the main gates of global trade in any country. Service quality of the ports affects the trader's decisions which port should they use for entering the importing country. Eventhough, all the ports are publicly operated or there is no competitor port aroud it, the port authorities have to measure their service quality and improve their service level in order to increase the trading volume. Ports are very important for a country's global trade. If the service quality is low, the export and import level reduces and the cost of the trade increases.

The World Bank's publication of the countries' logistics performances by the factors of customs, infrastructure, international shipments, logistics competence, tracking & tracing and timeliness. The performance measures indicates how the countries scored overall and by each performance factor. It suggests the countries what to do and what to focus on in order to increase their logistics performance. Generally it is related with doing reforms and modernization of border management institutions, changing transport regulation policy and investing significantly in trade-related infrastructure in order to improve trade logistics (World Bank,2010). Turkey scored 3.22 (out of 5) places 39th place within 155 countries. Turkey's scores include 2.82 in customs (46th place), 3.08 in infrastructure (39th place), 3.15 in international shipments (44th place), 3.23 in logistics quality competence (37th place), 3.09 in tracking & tracing (56th place) and 3.94 timeliness (31st place) in the Logistics Performance Index (LPI) 2010. The individual scoring showed that Turkey's worst score is in tracking and tracing and international shipments. The index shows the developments needed to be more competitive in the global market. All the players in trade (i.e. government, logistics companies and ports) must act effectively to get better results in LPI

Quality and its Features

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The American Society for quality defines the quality as “the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs” (Heizer and Render, 2000).
Quality of a tangible products can be encountered with product specifications. But, this is not very easy to identify the spesifications in services. Eventhough, the service companies set their standards to satisfy their customers, there is no guarantee that every customer’s satisfaction level will be the same. It may lie on two reasons (Harvey, 1998):

- The services are intangible. Therefore, it is hard to set the standards.
- Production and consumption occur at the samae time and at the same place. If you cannot detect the failure right away, there is no chance to make up.

Harvey (1998) categorizes the service quality as: quality of results and quality of process, search and experimental qualities, reality and perception, and expectations and satisfaction.

a) Quality of Results and Quality of Process:

In order to satisfy the customer needs, the result must be reached (quality of result). But, before that, customer must feel himself right into the process. Sometimes, the process seems to be very technological, but, in some certain point, the customer wants to understand the process and being in the solution process which is called quality of process. The connection of the quality of process and the quality of results make the customer happy.

b) Search and Experimental Qualities:

Customers want to test the product before purchasing. This helps the customer understand if the product/service which he/she wants. The customer reaches the preliminary result before buying it (called search quality). Quality of a product can also be determined while using it (experimental quality). The customer has to be satisfied in both ways to be fully satisfied. Then, he/she will suggest his/her friends and relatives. Word-of-mouth may be the most effective way to persuade the prospective customers. Therefore, word-of-mouth is the most effective way to get a new customer while satisfying the existing ones.

c) Reality and Perception

Service quality can be based on perception or objective reality. In either case the result is the same: customer satisfaction or dissatisfaction. The perception may come up with an ambience or behaviour. Customer has to feel in good hands and in the process.

d) Expectations and Satisfaction

“Initial expectations set the threshold that will determine whether disappointment, satisfaction or delight results from an encounter. Satisfaction is an emotional response.” The reason is the level of expectations. Past experience, word-of-mouth, advertising on-site signs and need may play role on setting the expectation level high.

Table 1: Customer satisfaction – Technical quality matrix (Harvey, 1998)

Customer satisfaction	**Technical Quality**	
	Low	**High**
Low	II. Not viable	I. Technically oriented company: “We know we are doing a good job”
High	III. Survival because of lack of competition: Customers are captive	IV. Positioned to build customer loyalty and long-term competitiveness

Table 1 summarizes the Harvey’s conclusions. The companies set the strategies where they are and where they want to go. Their corporate strategy was be set by these positions.

There must be a chain of events to reach the full customer satisfaction in service sektor. The basic resons to break the chain can be summarized as follows: (Harvey, 1998)

- Not understanding the needs of customer
- Being unable to translate the needs of the customer into a service design that can properly address them.
- Being unable to translate the design into adequate service qualifications or standards that can be implemented.

- Being unable to deliver the services in conformity with spesifications.
- Cretaing expectations that cannot be met (i.e. gap between customer expectations and actual service delivery)

The first three are related with the service design, and the others are with conformance quality. Our paper aims to construct an understanding of customer needs to translate them to the activities within the company to satisfy the customers. In this way, the company will be able to hold its customers and will gain new customer because of the word-of-mouth promotion technique in marketing. For this reason, we use Quality Functions Deployment (QFD) to design port services to be able to reach the customer satisfaction.

Customer satisfaction is not only needed in a competitive market. The ports are classified as privately-owned, publicly-owned, municipial and affiliated (Oral et. al). In Turkey, the major ports are mainly publicly-owned, only Mersin Port has been privatized, but, İskenderun Port is on the privatization process (auction date Sept. 16th, 2010). That means, in a short time period, there may be a competition between Mersin and İskenderun Ports to handle the importing & exporting goods.

The motive of this study is based on this fact that the port authorities must understand the expectations of their customers, make design processes to meet those expectations and finally apply the design of services to satisfy their customers. Customer satisfaction is also needed because of the volume of foreign trade in a country. If customers are not satisfied from the service, they may use competitors . But, in port activities in Mersin has a different position. The closest port is in İskenderun. The companies which want to use the ports to enter South east of Turkey, they can use only Mersin and İskenderun ports. The other major ports are not a danger for Mersin Port because of higher transportation costs. But, the exporters and importers may use other countries (i.e. Syria) to their transit goods to Iraq and Iran. This may be a good motive to be a customer oriented company. The other reason is that the port services must be effective because the port authority makes Money when it is loading and discharging the containers.

Mersin International Port's revenue comes from loading/discharging ships, handling of containers, and storage of containers and dry/liquid bulks. The main expectations of customers from the ports are delivering their goods and containers undamaged, less costly and safely. In Turkey, we find additional duties of ports, such as handling and storage of the goods and products. This makes the port service process more complex and hard to manage. In our survey questionaire, the reader may find the main and sub-topics to achieve these goals.

Port Governance in Turkey and the Case of Mersin Port

Port governance in Turkey can be classified into three main periods (Oral et al., 2007): a nationalization period, a period of both public and private port operations and, a privatization period. Turkey is in the privatization period in port operations. Mersin, İskenderun, İzmir, Derince, Bandırma and Samsun Ports' auctions have been decided to be done since 2005, but only Mersin Port's privatization has been fully completed. İskenderun Port will be in a privatization process and the deadline for betting in the auction is extended to Sep 16th, 2010. The other port privatizations are expected to be completed soon.

Turkey is in a privatization process which means most of the ports are owned by the public, and they compete with the new privatized ports. The main purpose of the privatization is using the facilities more effectively, then increase the rate of capacity usage and finally generate the most profit possible.

FIGURE 1
Location of the Main Ports in Turkey (Oral et.al, 2007)

Mersin International Port is one of the two major ports in Eastern Mediterranean Region in Turkey. It has a wide hinterland including European countries, MiddleEast and Turkish Republics and as inland: Ankara, Adana, İstanbul, Gaziantep, Kayseri, Konya, Karaman (Oğuztimur, 2006).

Mersin port has located in 110 hectares with 21 berths. The port has the capacity to be able to handle 2,500,000 TEU containers/year, 500,000 ton/year for general cargo, 4,000,000 ton/year for Dry Bulk & Liquid Bulk, and 50,000 unit-vehicle/year for Ro-Ro shipping.

With privatization of the ports, customer satisfaction became more important, and expected to be more customer oriented port management. After the privatization of Mersin International Port (MIP), all port services within the Mersin Port have been done by the MIP employees and/or its contracted third party logistics (3PL) firms.

Measuring the performance of ports directs the management to take action to improve the service quality. There are different perspectives in performance measure. United Nations Conference on Trade and Development (UNCTAD) categorizes the port performance indicators as financial (i.e.tonnage worked, berth occupancy revenue per ton of cargo, corgo handling, labor expenditures, capital equipment expenditure, contribution per ton of cargo) and operational indicators (i.e. arrival late, waiting time, service time, turn-around time, tonnage per ship, fraction of time berthed ships worked, number of gangs employed per ship per shift, tons pership-hour in port, tons per-ship hour at berth, tons per gang hours, fractipn of time gangs idle) (Marlow and Casaca (2003). Then, Marlow and Casaca (2003) proposes a new approach in port performance measures as

- Timeliness in picking up shipment and in delivering it
- Reliability of transit time/transport availability
- Responsiveness of transport suppliers in meeting customers' requirements
- Adaptability of existing processes to customers's requirements
- Flexibility of operations
- Accuracy of information regarding status of shipment
- Accuracy in processing information
- Compliance with customers' requirements
- Value for Money
- Notification of any changes in the multimodal process
- Level of damages in the shipment
- Overall transport cost
- Lead-time to service delivery

- Level of conflict with other processes
- Employee interaction with customers

The authors provide a framework towards an agile ports. They suggest that the new indicators will be different than other competitive ports. By using the new indicators help ports to focus on their core competencies and what type of services will meet customers requirements. In our study, the customer requirements match most of the performance measures of Marlow and Casaca.

Methodology

Improving quality of services is discussed in many platforms with different perspectives. Because of the difficulty of measuring, controlling and improving service quality, the problems must be solved industry by industry and company by company. We can argue the same for the port authorities. Every industry and every company holds their unique features. In this study we would like to catch the features of service industry and company basis in order to provide better information and right solution.

Data Collection

Data collection in this study can be collected in 3 parts: face-to-face interviews with the customers, constructing a survey questionare & conducting the survey to the customers for determining the importance ratings of WHATs, determining how the company meets the customer requirements (HOWs) & their relations with customer requirements (WHATs). The survey includes 54 attributes (customer expectations) and 2 additional company type and size questions. The survey was distributed to the customers which are directly related with the port operations: shipping agencies, customs consultants, logistics firms, forwarders and other related companies. Fourty three companies returned our surveys, but we had to exclude 2 of them because of too many missing answered attributes in the questionaire. We assume that they do not involve the port operations directly (such as forwarders and importer/exporters) and they do not have thoughts for those activities in detail. Therefore, the analysis covers fourty-one companies.

The factor analysis was done to make a classification of the factors and to reduce the number of attributes. But, the analysis showed that there are 34 factors which mean that all the factors have an importance rate and cannot be classified in smaller groups. Therefore, it is decided to continue with the same number of attributes.

During the interviews with the company representatives and search on the company website & brochures, we found 20 port activities related with the customer requirements. The house of quality analysis was constructed with the 20 technical measures.

Quality Function Deployment (QFD) and House of Quality (HOQ)

One of thewidely used method in the literature is the quality function deployment (QFD), spesifically house of quality (HOQ). The QFD concept was introduced by Yoji Akao in 1966 and first used in 1972 by Prof. Mizuno (Deros et.al, 2009). QFD is a powerful method to determine the customer needs and company's activities to improve the product/service design and production/service processes. QFD has been applied to transportation and communication, electronics and electrical utilities, software systems, manufacturing, services, education and research industries for the functional fields of product development, quality management, customer needs analysis, product design, planning, decision making, management, teamwork, timing, costing (Chan and Wu, 2002).

A full HOQ process has 9 steps (Chan and Wu, 2005): Step 1: Identify customers & collect customer needs (WHATs), Step 2: Determine relative importance of ratings of WHATs, Step 3: Identify competitors, contact customer competitive analysis & set customer performance goals for WHATs, Step 4: Determine final importance ratings of WHATs, Step 5: Generate technical measures (HOWs), Step 6: Determine relationships between WHATs and HOWs, Step 7: Determine Initial Technical Ratings of HOWs, Step 8: Conduct technical competitive analysis & set technical performance goals for HOWs, Step 9: Determine final technical ratings of HOWs

The most widely used steps in the literature are Steps 1,2, 5 and 6. The other steps are not used often because they are difficult to use and unnecessary in practice (Chan and Wu, 2005). Thus, we will apply the following steps for the process of improving service design:

S1: Identification of customers and their needs (WHATs)

S2: Determine relative importance of ratings of WHATs
S3: Generate technical measures (HOWs)
S4: Determine relationships between WHATs and HOWs
S5: Determine Initial Technical Ratings of HOWs

The first step (S1) of HOQ of the quality functions deployment (QFD) is determining the expectations (WHATs) of the customers of ports. By doing that, we conducted face-to-face interviews with the executives and port operations managers of the shipping agencies, customs coscultants, and logistics companies, operated in Mersin. The list of the companies are provided from the Mersin Chamber of Shipping, Mersin Chamber of Commerce and Industry and The Association of Customs Cunsultants Mersin Branch. The reason of selection of the firms is the MIP serves mostly these companies. Eventhough the hinterland is very wide, the selected companies are the representatives of the importers and exporters.

The topics wich we discussed in the interviews were converted to a survey questionnaire. Eventhough the expectations are considered the local, we found many similarities with the customer requirements published in the international journals. This wasn't surprised us because all of the interviewers are doing business with international partners and international ports. But,we found additional expectations regarding cultural differences and local business conjunctures in Turkey. Therefore, our survey questions became twice as much as the surveys used in other papers. We also used the survey forms of Ding (2009) and Ha (2003) to reflect both features.

The second step (S2) of HOQ is that determine relative importance ratings of WHATs. The questionare was distributed to the shipping agencies, customs colcultancy firms, forwarders and logistics companies to be filled out by the executives or the managers charged with port operations in order to find the importance ratings of the WHATs. They were asked to grade each factor for the customer needs and how MIP meets the requirements from 1 to 5 (1 means very low importance and 5 means very high importance). The average of all the participants are taken to determine the relative importance rating of each factor.

The third step (S3) must be prepared with the company managers and employees to understand what the company does to meet the customer requirements. Sometimes it is hard to generate those activities because the complexity of the job and the industry as in the port operations. In order to generate MPI's activities to meet the customer requirements, we first made a research in the company website and its brochures to understand their business overall, and then had meetings with the company manager and employees. Table 4 illustrates the customer wants (WHAT) and the company activities (HOWs).

In the fourth step (S4), during the meeting with the employees, we asked them to determine the relationship rate of each WHAT and HOW from 0 to 3 (0: no relations, 1: low relation, 2: moderate relation and 3: high relation). The decision of the relationship rate was made after the discussion of the participated employees.

The fifth step (S5) measures the technical ratings of each HOW. To compute the technical ratings of each HOW, we multiply the importance of each factor by the corresponding company activies. For the technical rating of a particular activity (HOW), the figures for each column are summed. After receiving the total ratings for each activity, we can make a conclusion which activities must be focused on to increase the quality of the port services.

RESULTS

We start our analysis with doing the two-sample t-test for determining if there is any differences with the score means for WHATs and HOWs according to company profile and company size. Since the majority of the participants are shipping agencies and customs cunsultants, the first distinction is if there is difference in means of the given scores by these company groups. The null-hypothesis is that there is no difference between the scores given by the company groups (H_0=0). As shown in Table 2, we can conclude that we cannot reject the null-hypothesis for the majorityof the attributes which means the scores are similar. The port's performance ratings for each attribute showed that almost all the attributes have similar ratings within two types of customers.

The second distinction is that if there is a significant difference between company sizes. We made two distinctions small&mid sized companies and large companies. The results show that there are 7 attributes in the customer requirements and 4 in the port performance rating significantly different between the groups (0.05 significance level).

The both figures indicate that the companies have reached the same conclusions for the importance of customer requirements and the port's performance rating.The summary of the factors are given in Table2.

Table 3 illustrates the rankings of the customer requirements (WHATs) and MIPs performance from the customer point of view. The importance of customer requirements ranges from 3.07 to 4.90; and the MIP's performance ranges from 1.80 to 4.15. The figures show us that some of the MIP's lowest scores (i.e. Arrangement of the local authorities to organize out of the port) are not one of a port's major duties, but there are some other attributes which are related directly with a port's scope.

In order to built a good customer relationships, we need to focus on the important port activities. The Quality Function Deployment (QFD) and House of Quality (HOQ) detect which activities should the company focus on to increase customer satisfaction.

Table 5 shows the customer requirements (WHATs), what the company do to meet the requirements (HOWs), the importance rates for WHATs, and the relationship between WHATs and HOWs). The technical ratings for each column (HOWs) illustrates the important activities to improve quality of the service. The HOQ indicates that assignment of the personnel, assignment of equipment, and electronic communication ranks the highest scores. The HOQ suggests that MIP need to invest those activities as first priorities. But, we should also notice that other activities have close scores; therefore, the company need to decide the investment strategy to incease the quality of the service.

CONCLUSION

This paper aims to set a framework for increasing the service quality in the ports. The quality function deployment (QFD) was used to identify customers' needs and requirements (WHATs), finding the importance level of each requirment, determining what the company do to meet the requirements (HOWs), setting the relationships between WHATs and HOWs, and finally computing the technical rating of each HOW.

During the interviews of determining what the customers want and conducting the survey, we realized that the customers know what they want. It is also correct for the port's management team. This is reflected to building the house of quality. The importance weight of customer requirements stays very high level, also, the performance of the port authority MIP weights between moderate and good level on average from the customer point of view. To increase the quality of port service will help to meet the customer needs and wants, then total satisfaction of the customers.

The service quality at ports is a vital concept because the ports are the main gates to the global market for each country. The study showed that the port authority has to invest mostly on personel, equipment and technology in order to increase the quality of the port services. But, the other activities received also higher scores. It is suggested that the company needs to set the priorities to build the corporate strategy by using findings. The port authority, the customers and finally national economy will benefit from developing the service quality at ports.

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TABLE 2 T-test for Customer Requirements and Degree of Satisfaction

	Customer Requirements		The Degree of Satisfaction from MIP	
CUSTOMER REQUIREMENTS	Customer Type	Firm Size	Customer Type	Firm Size
A. INFORMATION FLOW OF PORT ACTIVITIES				
Existence of document Information System andits efficient use				0.0341
Existence of harbor information system and its efficient use		0.0424		
Announcement of Port operation/programme via internet/intranet		0.0277		
The connection of information system with other public agencies (i.e. Republic of Turkey Undersecreteriat of Customs)	0.0274			
B. PORT UTILIZATION				
The convenience of connection of Port to the highway and its efficient use				
The convenience of connection of Port to the railway and its efficient use		0.0366		
The convenience of connection of Port to the airport and its efficient use			0.0217	
Availability of expansion of the port depending on demand	0.0273			
Provide productive use of field layout				
Existence of loading/unloading field of hazardous materials				
Existence of field for cleaning and maintenance of container				
C. PORT ACTIVITIES				
The efficient use of harbor operations system				
The efficient use of berth operations system				
The efficient use of handling operations system			0.0059	
The efficient use of storage operations system			0.0298	
The efficient use of piloting, towing, mooring and unmooring operations system	0.0027	0.0024	0.0279	
Increasing the speed of staff assignment for operations		0.0436		
Detection of container place real-time				
Provide faster service for ship approach				
Avaliablity of enough berths and efficient use of the berths			0.0402	
Operated 7/24				
Process the containers and commodities damage-free				
Provide services to stay ships and containers in the shortest time period				
Set the standard times for each process and match the actual time				
Lower the waste of time during the shift-change	0.0370			
Assign the staff faster according to demand		0.0296		
D. EQUIPMENT & MACHINERY				
Provide Sufficient equipment				
Use of latest technolgy in equipment and machinery	0.0371			
Prevention of equipment breakup				
E. PORT MANAGEMENT				
Managing the ship traffic	0.0425			
Managing the traffic within the port				
Convenient connection to out-site of the port				0.0390
Competitive pricing with competitors			0.0072	
Early announcement of price change				
Easy payment prosedure		0.0266	0.0257	
Quick refund system				
Prepare and send the invoices quickly				
Accurate billing prosedure				
Measuring the employee performance and increasing the performance				
Provide safety in the work place				
Proficiency of the employees				
Sufficient number of staff employed				
Increase the motivation of the employees				
Make sure all employees know their duties and authority				
Attempt to work customs officers 7/24	0.0441		0.0466	0.0352
Arrangement of the local authorities to organize out of the port	0.0363			0.0197
Promoting the port in Turkey and in the world				
F. CUSTOMER RELATIONS				
Measuring customer satisfaction				
Agent offices within the port				
Taking the customer complaint, suggestion and request and process them quickly	0.0386		0.0316	
Efficient announcement process for meetings	0.0042			
Rapid resolve the damage of container and commodity problems				
Provide official operations quickly				
Transmitting the regulation/law changing requests to the officials				

Table 3
Rankings and Importance Weights of Customer Requirements and Performance

Code	Factors	Ranking Requirements	Ranking Performance	Importance Weight of Requirements	% of Performance
	A. INFORMATION FLOW OF PORT ACTIVITIES				
A1	Existence of document Information System andits efficient use	26	21	0,019	0,019
A2	Existence of harbor information system and its efficient use	20	18	0,019	0,020
A3	Announcement of Port operation/programme via internet/intranet	33	11	0,019	0,021
A4	The connection of information system with other public agencies (i.e. Republic of Turkey Undersecreteriat of Customs)	49	44	0,018	0,016
	B. PORT UTILIZATION				
B1	The convenience of connection of Port to the highway and its efficient use	27	22	0,019	0,019
B2	The convenience of connection of Port to the railway and its efficient use	44	23	0,018	0,019
B3	The convenience of connection of Port to the airport and its efficient use	54	54	0,012	0,011
B4	Availability of expansion of the port depending on demand	23	45	0,019	0,016
B5	Provide productive use of field layout	10	43	0,019	0,016
B6	Existence of loading/unloading field of hazardous materials	45	25	0,018	0,019
B7	Existence of field for cleaning and maintenance of container	52	53	0,016	0,012
	C. PORT ACTIVITIES				
C1	The efficient use of harbor operations system	12	26	0,019	0,019
C2	The efficient use of berth operations system	34	15	0,019	0,020
C3	The efficient use of handling operations system	17	48	0,019	0,015
C4	The efficient use of storage operations system	43	41	0,018	0,017
C5	The efficient use of piloting, towing, mooring and unmooring operations system	53	5	0,016	0,022
C6	Increasing the speed of staff assignment for operations	6	24	0,019	0,019
C7	Detection of container place real-time	35	3	0,018	0,022
C8	Provide faster service for ship approach	36	2	0,018	0,023
C9	Avaliablity of enough berths and efficient use of the berths	37	13	0,018	0,021
C10	Operated 7/24	4	1	0,019	0,026
C11	Process the containers and commodities damage-free	13	7	0,019	0,022
C12	Provide services to stay ships and containers in the shortest time period	28	8	0,019	0,022
C13	Set the standard times for each process and match the actual time	21	34	0,019	0,018
C14	Lower the waste of time during the shift-change	7	9	0,019	0,022
C15	Assign the staff faster according to demand	8	42	0,019	0,017
	D. EQUIPMENT & MACHINERY				
D1	Provide Sufficient equipment	2	37	0,020	0,017
D2	Use of latest technolgy in equipment and machinery	3	29	0,020	0,018
D3	Prevention of equipment breakup	14	33	0,019	0,018
	E. PORT MANAGEMENT				
E1	Managing the ship traffic	47	10	0,018	0,022
E2	Managing the traffic within the port	41	30	0,018	0,018
E3	Convenient connection to out-site of the port	38	31	0,018	0,018
E4	Competitive pricing with competitors	29	49	0,019	0,015
E5	Early announcement of price change	5	14	0,019	0,020
E6	Easy payment prosedure	22	12	0,019	0,021
E7	Quick refund system	42	16	0,018	0,020
E8	Prepare and send the invoices quickly	24	20	0,019	0,019
E9	Accurate billing prosedure	18	6	0,019	0,022
E10	Measuring the employee performance and increasing the performance	39	19	0,018	0,020
E11	Provide safety in the work place	30	4	0,019	0,022
E12	Proficiency of the employees	15	39	0,019	0,017
E13	Sufficient number of staff employed	1	47	0,020	0,016
E14	Increase the motivation of the employees	51	35	0,017	0,018
E15	Make sure all employees know their duties and authority	25	32	0,019	0,018
E16	Attempt to work customs officers 7/24	48	36	0,018	0,018
E17	Arrangement of the local authorities to organize out of the port	50	50	0,017	0,015
E18	Promoting the port in Turkey and in the world	16	27	0,019	0,019
	F. CUSTOMER RELATIONS				
F1	Measuring customer satisfaction	11	52	0,019	0,014
F2	Agent offices within the port	46	40	0,018	0,017
F3	Taking the customer complaint, suggestion and request and process them quickly	9	51	0,019	0,014
F4	Efficient announcement process for meetings	31	17	0,019	0,020
F5	Rapid resolve the damage of container and commodity problems	32	46	0,019	0,016
F6	Provide official operations quickly	19	28	0,019	0,019
F7	Transmitting the regulation/law changing requests to the officials	40	38	0,018	0,017

TABLE 4
What the Company Do for Meeting Customer Requirements (HOWs)

Code	HOWs
H1	Corporate Culture
H2	Sponsorships for Activities (i.e. Fairs)
H3	Maintenance Programme
H4	Investment Plan
H5	Obeying IMO Requirements and ISPS Safety Sertificate
H6	Electronic Communication in Document Transfer
H7	Online Services (Forms, Tariffs and Port Entrance Procedures)
H8	Daily Customer Meetings
H9	Online CustomerSuggestion, Request and Complaint Form
H10	Port Activities Statistics
H11	Preparing Daily Action Plan and announcement
H12	Port Field Planning
H13	Field Improvement Plan
H14	Strategic Position
H15	Attracting Qualified Personnel Philosophy
H16	Personnel Education
H17	Career Development Opportunity
H18	Meeting with Local Authorities
H19	Personnel Assignment
H20	Equipment Assignment

TABLE 5
House of Quality

Customer Requirements	Customer Importance Rating	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20
A. INFORMATION FLOW OF PORT ACTIVITIES																					
A1	0,0188				3		3	3											3		
A2	0,0190				3		3	3											3		
A3	0,0186				3		3	3											3		
A4	0,0175						3	3											3		
B. PORT UTILIZATION																					
B1	0,0188				3								3		3						
B2	0,0178				1								3		3						
B3	0,0124												3		3						
B4	0,0189				3								3								3
B5	0,0193												3	3							3
B6	0,0178				3	3							3								
B7	0,0163												3	3							
C. PORT ACTIVITIES																					
C1	0,0192			3			3					3					1			3	3
C2	0,0185			3			3					3					1			3	3
C3	0,0191			3			3					3					1			3	3
C4	0,0179			3			3					3								3	2
C5	0,0159			3								3								3	
C6	0,0194																			3	
C7	0,0184																			3	
C8	0,0184						3														3
C9	0,0184																				3
C10	0,0195			3																3	
C11	0,0192			3																3	3
C12	0,0188																				
C13	0,0190																			3	
C14	0,0194																			3	
C15	0,0194																			3	
D. EQUIPMENT & MACHINERY																					
D1	0,0197			3																	3
D2	0,0196			3																	3
D3	0,0192			3																2	3

Continued

TABLE 5
House of Quality (Continued)

Customer Requirements	Customer Importance Rating	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20
E. PORT MANAGEMENT																					
E1	0,0177							3	3											2	3
E2	0,0181							3	3												2
E3	0,0184							3													
E4	0,0187							3			1										
E5	0,0195										3										
E6	0,0190						3														
E7	0,0181						3														
E8	0,0189						3													2	
E9	0,0191																			3	
E10	0,0183	3														3	3				
E11	0,0187	3				3										3	3				
E12	0,0192	3				3										3	3	3			
E13	0,0198					3										3	3	3		3	
E14	0,0173	3														3	3	3			
E15	0,0189	3				3										3	3				
E16	0,0177																		3		
E17	0,0174																		3		
E18	0,0192	3	3																2	2	
F. CUSTOMER RELATIONS																					
F1	0,0193	3								3											
F2	0,0178																				
F3	0,0194	3							3	3									3		
F4	0,0187	3																	3		
F5	0,0187									3											
F6	0,0191																		3		
F7	0,0183																		3		
Technical Rating		**0,5072**	**0,0576**	**0,5634**	**0,3537**	**0,2833**	**0,6694**	**0,4408**	**0,1657**	**0,1722**	**0,0772**	**0,2729**	**0,3643**	**0,1069**	**0,1471**	**0,3368**	**0,3936**	**0,1690**	**0,5923**	**0,9415**	**0,7539**

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SUPPLIER SELECTION WITH QUALITY FUNCTION DEPLOYMENT APPROACH: AN APPLICATION IN A VEHICLE MOUNTED CRANES FACILITY

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Abstract *— Organizations have to work with a lot of supplier firms in order to continue their activities. Selecting the supplier firms from a group of candidates is a difficult decision making problem. This article suggests a new method that transfers the house of quality (HOQ) approach typical of quality function deployment (QFD) problems to the supplier selection process. To test its reliability, the method is applied to a supplier selection process for a firm that products cranes and transformation vehicles. The study starts by identifying the features that the purchased product should have (internal variables ''WHAT'') in order to satisfy the company's needs, then it seeks to establish the relevant product characteristics that comes from suppliers (external variables ''HOW''). The correlation matrix between what's and How's is formed and at the end of the study, the best supplier meeting the company's needs is chosen, house of Quality (HOQ) for the product is formed.*

Keywords — House of quality, quality function deployment, supply chain management, supplier selection

INTRODUCTION

Today, in which competitiveness is felt intensely, embracing a purchasing strategy towards competitiveness maintains an increase in market share of the enterprises. An effective purchasing system must only focus on minimizing the costs and at the same time must aim to maintain cooperation with a supplier which is amicable with the enterprise's strategic targets [1].

Purchasing department decides on the source of the supply after researching the supply sources properly. Generally purchasers are intending to work especially with suppliers which propose low prices. This kind of purchasing is eligible in one-time purchase under the condition of appropriate quality achievement. However for long term suppliers, adequacies such technical, financial, managerial, consistence on quality procedures and just in time delivery must be found. At is important to give a long-term service, if not enterprise would have to re consider finding a new supplier process. Because of this, supplier's role in the success of an enterprise is indisputable. Supply management is total of a study between the main industry and the supplier to minimize the total cost. Supply function has a massive importance in enterprises. Because a small disruption in supply chain will directly cost to enterprise with production, time and pecuniary circumstances. Low quality and flawed products increase production costs. Thus adversely affects sales [2]. One of the most important subtitles of supply management is supplier selection [3]. Supplier selection is a very important problem which contains quality, performance, technology etc. Not just material cost but at the same time managerial cost maintenance, development and support cost are had to be considered during the selection of supplier. Therefore, among the criteria related to economy and performance which are used to obtain a systematic process for vendor selection criteria are needed to be evaluated and prioritized. This process will also shorten the selection process and will increase the success of decision making [4].

In today's' conditions, the growing importance of customer requests are also important for suppliers. In this study, Quality Function Deployment, developed in Japan in 1970's, is proposed for supplier selection. Quality house matrix is composed in supplier selection for the hydraulic pump which is equipment requirement for onboard mobile winch and transportation vehicle Producer Company and a selection is made between the

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suppliers which afford company requests. After the first part as introduction of the study, supplier selection, methods for supplier selection and studies related to supplier selection will be mentioned in the second part. In the third part, information about meaning and the development of Quality Function Deployment, studies in our country, House of Quality and its constitution will be given.

LITERATURE SURVEY

Even though some examine studies about supplier selection are explanatory and explain only priorities according to criteria, some studies explain how criteria are used during evaluating supplier selection criteria. Although supplier selection criteria did not change basically, in time, priorities of the criteria have changed since 1960's till today [1].

Supplier selection is a multi-criteria decision-making problem which includes both countable and uncountable factors. In this kind of problems, if there are capacity and other constraints of the suppliers' two main issues raises. Which are the best suppliers, how much order should be given to chosen suppliers? Basically there are two type of supplier selection problem. In the first type of problems (constraint less supplier selection problem) it is considered that all suppliers can fulfil company's quality, delivery conditions, and other constraints. However there are constraints such as quality, capacity etc. in limited supplier selection problems. In other words, a single supplier can not meet all of the company needs. For first type problems, Buffa and Jackson [5] proposed goal programming (GP), Sarkis and Talluri [6] proposed analytical network process approach (ANP). In second type of problems, Karpak [7] used GP approach. In the other way authors who use GP and multi-criteria linear programming approach can give different weights to criteria however there have been problems on engaging uncountable factors to the model. Because of this in recent years, integrated mathematical models with analytical hierarchy process (AHP) which can contain both countable and uncountable factors are used [8]. Thus supplier related priorities are determined and optimal order quantities which can be given to selected suppliers are found. The incorporation of both countable and uncountable factors and the ability to express relations of factors as selection model, different then AHP, make ANP surpass than others [9].

Ghodsypour and O'Brien [8] in their studies, have their reference from criteria such as cost service, product flaw measurement, supplier process capabilities, supplier respond capabilities for changes and supplier process flexibility. De Boer et al. [10] have made a research on the complexity of purchase process and on determination of different methods which are used in supplier selection according to their importance. A model, which uses both artificial neural networks and condition-based inference methods together for supplier selection and evaluation, takes place [11]. Chen et al. [12] put forth, fuzzy TOPSIS which is composed of fuzzy logic and TOPSIS method for supplier selection and evaluation process in their studies. Haq and Kanarin [13] put forth that they used fuzzy analytical hierarchy and genetically algorithm in related to integrated supplier selection and multi-level inventory distribution model. Çelebi and Bayraktar [14] proposed a new integrated Artificial Neural Network/Data Enveloping Analysis (ANN/DEA) for supplier evaluation process when there is deficient data about supplier evaluation criteria. In literature, there are lots of applied supplier selection model. Some authors proposed to consider suppliers on a lot of criteria and proposed a linear weight model which can unite these degrees on one degree as a categorical model [15].

Basically, categorical methods can be named as qualitative methods. Historical data and purchasing experience or known suppliers are gathered by a group of criteria. Evaluations are done by categorizing suppliers' performances as positive, neutral or negative. It is one of the oldest methods [16].

In weighted point model, it is easier to optimize supplier selection decisions both flexible and productive. It is expensive but more objective than categorical model even it is more reliable for purchaser evaluation in evaluation of supplier. Total cost approach covers all cost in seller selection. Cost rate is practicable; it is developed cost calculation system aided complex model. Mathematical programming models generally stands on only quantitative criteria. This approach covers principal component analysis (PCA) and artificial neural network (ANN). Two advantages of PCA are handling and accessibility of conflicted behaviours. ANN models bring money and time. Disadvantage of the model is that requirement of private software and specialized qualified personnel. Multi Attribute Utility Theory (MAUT) provides applicable formulation of research strategy and professional calculation. However this method only used in international supplier selection, complex and risky conditions [15]. Another approach, analytical hierarchic process is method which is developed for alternatives when there has to be consideration of multi-criteria and this method permits decision maker to configure complex problems which are hierarchical. This method contains both quantitative and qualitative criteria. It is one of the most recommended methods for supplier selection in practical [15].

Bevalacqua et al. [17] applied House of Quality approach for supplier selection problem which is turned into Quality Function Deployment (QFD) to mid-sized manufacturer. Bevalacqua et al. [17] proposed fuzzy-QFD approach for supplier selection, recommended a method which is an application of House of Quality which is an approach of QFD for supplier selection process. To test its reliability, it is applied to a supplier selection process of a firm which produces gripping cord for industry scaled from small to large. Study starts with the identification of a purchased product's internal variables which are needed for satisfaction of customer requirements, and then continues with establishing appropriate supplier evaluation criteria which is for fuzzy appropriate index related last evaluation. Karsak and Özoğul [18], in their studies, proposed QFD based fuzzy lineal regression for ERP software selection and goal programming based method. Recommended structure includes both enterprise request and enterprise resource planning (ERP) system characteristics and not just shows relation between enterprise requests and ERP system characteristics but also integrates ERP system characteristics thorough QFD principals.

SUPPLIER SELECTION

Shortening of product life durations as a result of competition and customers' inclination towards more qualified, rapid, cheap and different demand of goods and services has forced enterprises to leave some of their activities to experienced suppliers. This, in turn, has increased the importance of the aforementioned suppliers. For obtaining the quality, cost, and speed performance, these suppliers, in line with the purposes of the enterprise, have to work in accordance with the enterprise [19]. Hindering of suppliers' activities related with the enterprise means halting of the all supply-chain. Therefore, selection of the true supplier while on the one hand diminishes purchase costs; it on the other hand increases competition advantage of the enterprise. Selecting a wrong supplier can create serious operational and financial problems. Close relations of enterprises with their suppliers make the former dependent on the latter and results of mistakes due to co-decision can put the enterprise on the spot [10].

Decision-making process within supply-chain is one of the important decrees. Correspondingly, supplier selection is both one of the prominent steps of decision-making process, and ranks within supply-chain. Supplier selection process is generally composed of the following steps [10]:

- Definition of the problem,
- Identification and combination of the decision criteria,
- Pre and final selection of the potential suppliers.

Supply process in enterprises plays some strategic roles and outsider suppliers have an influence over success or failure of the enterprise. Such aforethought strategies are as follows [17]:

Improvement of the relations between supplier and customer: Modern supply strategies, especially when they include cooperation agreements, require new investigation methods. Developing relations between consumers and sellers has turned into more continued co-relations which include short-run agreements. Even, in order to guarantee market advantage, firms have restricted the number of suppliers they did business. This means firms' constructing more stable and lasting relations with the group of suppliers. In this way, there has been achieved an important amount of saving and a new price that hosts quality has been obtained. Differently from the conventional multiple source approach, this new approach began to include constructing relations with suppliers who give the cheapest price on time.

Definition of the Evaluation for Special Situation Criteria Supplier selection process is complex because of the changing criteria that are needed to be considered in decision-making process. While determining the right supplier, the quality, price, delivery and service are taken into consideration.

Problems Related With Procedure: As is the case in majority of decision-making processes, supplier selections include two basic but distinct actions: Evaluation and selection. Evaluation phase is generally based on scaling qualifications of each supplier in the light of pre-determined factors that know qualifications and the criteria about the decision. Selection can be defined as determination of the most convenient supplier among the many suppliers.

Decision-model evaluation: It's the last title of accepted strategies used to control the reliability of the model.

Supplier selection decisions provide distinguishment of how much order to be made from the selected sellers and decision of which seller to be selected as a source of supply. Naturally, supplier selection is a complicated decision. This complexity has three main reasons. First, the decision contains more than one selection criteria during the selection process. Products of the supplier firms include more than one feature, for example; price, quality and service. In addition to this, members of purchasing team introduce various criteria about purchasing decision related with their own departments; such as cost, quality, and delivery credibility. Second, in supplier selection process, criteria may contradict with each other. For instance, a seller who gave lower price may not to have test quality, or the seller who provides the best quality may face problem in delivery on time. Third, the environment, where modern production strategies such as Just in Time (production) (JIT) and Total Quality Management (TQM) as well as Supply-chain management take place, raises the importance of the analysis of the selection criteria [20].

Purchasing in supply-chain management emphasizes the conventional supplier interaction and comparative different seller-buyer relationship. Existing trend is acknowledgement of suppliers, who provide more quality and lesser product, as business partners. This new relationship is based on long-run seller-buyer relationship. Improvement of long run supplier skills, which include saving in cost, development in quality and delivery credibility, is critical for common achievements [20]. Considering the fact that, enterprise competition is now within supply-chains, it is clear that the power and success of enterprises not only dependent on their performances, but also on the performances of all other units within the supply-chain. At this point, one of the important matters is selection and evaluation of supplier firms, which has a critical importance within selection circle. Importance attached to supplier selection provides improvement of long-run relations with suppliers based not only on the price of the supplied product and these relations affect the competition power of the enterprise in a good manner in the long run [21].

QUALITY FUNCTION DEPLOYMENT (QFD)

Suggested by Yoji Akao at Japan in 1966, this method provides many advantages in diminishing the product or service improvement costs, shortening the period of improvement, increasing productivity and providing consumer satisfaction [22]. Although were realized on the same person just before the Industrial Revolution, nowadays; marketing, engineering and production are employed by different units within an enterprise. Communication between different units during product and process design is conducted by top managers. In this phase, when top management comes together with marketing, design and production managers, for a more efficient management, QFD and quality house step in. Each group should understand the other group’s or groups’ needs and provide the accurate knowledge in order to meet these needs [23].

The first practice of QFD was realized in 1972 at Kobe Shipyard of Mitsubishi. In the aftermath of these practices, with the acknowledgement of QFD in Japan, in a short time, including the service enterprises, various management methods have been begun to be implemented [24]. QFD is one of the quantitative tools and techniques of Total Quality Management (TQM) that can be used in order to revolve customer needs and specifications via the convenient techniques and services. This is important for meeting the customer needs or fulfilling a product or order service [25]. The most important task of QFD is accurate determination of product qualifications or the functions a product will perform in line with customer demands and needs. As a result of listening consumers, it can be decided to add some new qualifications to the product, or the vice versa. That is to say: When the product is on the point A on a coordinate plane, it is moved to the point B; the point on which the customers want a product to be onto. Thus, here also mobility is on the nail. The place of the product concept is changed [26]. QFD process is composed of some structural matrixes. The first of them is named “House of Quality”. On the left of the matrix is customer demands and needs (voice of the customer); on the top of the matrix are the technical answers of the team developed for meeting these demands and needs (Fig. 1). Matrix is bounded by many sub-matrixes and sub-sections via different ways. House of Quality is composed of the following parts [27];

Part 1 of Matrix; Includes the structured list of customer demands and needs. This structure is generally based on qualitative market research.

Part 2 of Matrix; includes high step identification of the product or service planned to be developed in a technical language of the enterprise.

Part 3 of Matrix includes:

- Qualitative data, relative significance degrees of customer demands and needs and enterprise’s and satisfaction degrees of customers to contemporary offers of the enterprise and its rivals,
- Strategic purposes fort he new product or service,
- Calculations for degrees required for customer needs and demands.

Part 4 of the Matrix; illustrates the relations between the customer demands and needs and developed teams’ technical answers to each of them.

Part 5 of the Matrix; includes the team’s evaluations for performing the technical answers that are related with each other.

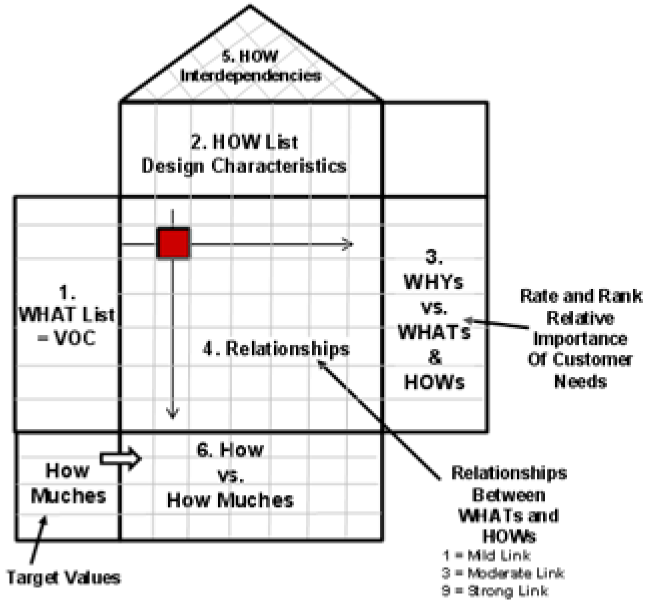


FIGURE 1
House of Quality [28]

Part 6 of Matrix includes:

- Technical answers based on relations in Part 4 and customer demands and needs in Part 3,
- Compared knowledge of technical performances of the rivals,
- Technical performance purposes.

QFD process is composed of four phases. The first phase is illustrated with "*i"*. In this phase, preliminaries needed for QFD practice are made. After completion of these preparations, QFD practice is initiated [27].

Phase i: Planning
Phase ii: Collection of "Voice of the customer"
Phase iii: Formation of the Quality House
Phase iv: Analysis and interpretation of the results.

SUPPLIER SELECTION WITH QFD: A CASE STUDY

The usage of the QFD which is used via firms to increase the supplier productivity will be mentioned in this section. The firm which QFD is applied is founded in 1993 and manufactures vehicle mounted cranes. The production of knuckle boom mobile cranes, telescopic mobile cranes and truck mounted platforms are actualized in 46.000 m^2 (18.000 m^2 is indoor) with 200 employees in Konya Industry Zone. It has a production range between 30 tons/meters to 270 tons/meters. The company, Turkey's leading manufacturers of cranes, can integrate new technologies into the production of European standards.

The application is deal with supplier selection of the firm. The supplier selection is consists of the main parts in the firm. The first part is selection of suppliers and the second part is evaluation of the suppliers performance. Evaluation is made according to pre-determined criteria and is used to light further supplier selections. The evaluation is categorized form A to D via gained scores. The best supplier so desired supplier is taken a place in A. These scores and categories are below;

A (100-85) : The supplier is agreed first.
B (84-70) : The supplier is needed to be close relationship and followed.
C (69-50) : Employable but it requires close monitoring and technical assistance.
D (49-0) : Not workable, it needs develop self.

Under the scope of study, the most appropriate supplier between current suppliers and alternatives among the designated company demands and their compensation level will be chosen for the hydraulic pump equipment which is one of the main parts of hydraulic systems.

Step 1: The list of customer expectations

The features of a hydraulic pump will be taken as a list of customer expectations (What's).

a) The definitions of What's (the desired characteristics of hydraulic pump):

Length of usage	(10)	Not too noisy	(7)
To provide desired pressure	(9)	High productivity	(10)
Does not heat up quickly	(6)	Portability	(3)
Quality	(10)	Easy to assembly	(4)
The availability of spare parts	(7)	Fair price	(7)

The priorities (1-10) of desired features about hydraulic pump which is defined by the company authorities are given above.

Step 2: The list of technical definitions

In this step of the quality house, the technical characteristics of hydraulic pumps will be determined to meet expected features of hydraulic pumps.

b) The definitions of How's (The technical characteristics of hydraulic pumps)

Energy use	Duration of use	Weight	Productivity
Max pressure value	Noise level	Compliance quality certifications	Price

Step 3: The matrix which shows the relationship between customer expectations and technical definitions (relationship matrix)

The third step of preparing quality of house is creation the body of quality house (Table 1) that indicates which customer expectations will be met which technical features. So the relationships between What's and How's would be examined in two ways.

TABLE 1
Quality House Matrix

HOW / **WHAT**	**Signif.**	Energy use	Duration of use	Weight	Productivity	Max pressure	Noise level	Quality Cert.	Price
Length of usage	10								
Not too noisy	7								
Providing desired pressure	9								
High productivity	10								
Does not heat up quickly	6								
Portability	3								
Quality	10								
Easy to assembly	4								
Fair price	7								
Availability of spare parts	7								

- Is there any effect on the technical definition of customer expectation?
- If any, what is the degree of this effect?

In this point, the relationships between customer expectations and technical features are shown with symbols. The used symbols are shown in Table 2 and with these symbols Table 3 is prepared.

TABLE 2
Symbols and Definitions [29]

Symbol	**Relationship**	**Weight**
⦿	Strong	9
O	Medium	3
△	Weak	1
-	No relation	0

There is a development direction which is increased customer satisfaction for each technical requirement. The development direction is determined via filling the "must be …… more" blanks. These symbols are used to determine this direction [27].

⬇ : Direction of development should be reduced for target value.

⬆ : Direction of development should be increased for target value.

- : Meeting a specific goal is the best for customer satisfaction.

Table 3 shows the development directions of technical requirements for customer satisfactions.

TABLE 3
The Effects of How's on What's

Development Direction		⬇	⬆	⬇	⬆	⬆	⬇	•	⬇
How's? **What's**	**Signif.**	Energy use	Duration of use	Weight	Productivity	Max pressure	Noise level	Quality Cert.	Price
Length of usage	10		⦿		O	△			
Not too noisy	7		O		O		⦿		
Providing desired pressure	9	⦿	⦿		O				
High productivity	10		O		⦿				
Does not heat up quickly	6	⦿	O		O	△	O	△	
Portability	3			⦿					
Quality	10	O	O		⦿	⦿	⦿	⦿	
Easy to assembly	4			⦿					
Fair price	7	O	O		O	O		O	⦿
Availability of spare parts	7		⦿		O				

If we look at the development direction row, marked with ⬆ must be increased; marked with ⬇ must be reduced by more than now. Marked with ● shows that the current situation has targeted value.

Step 4: Correlation matrix of technical indicators

While creating the roof of quality house, the correlation matrix is used to show internal affairs of technical definitions (Fig. 2). As in the previous step, using the symbols and letters in this matrix would be more beneficial. In this study, we determined positive: +1; middle: 0; negative: -1 for the correlation matrix.

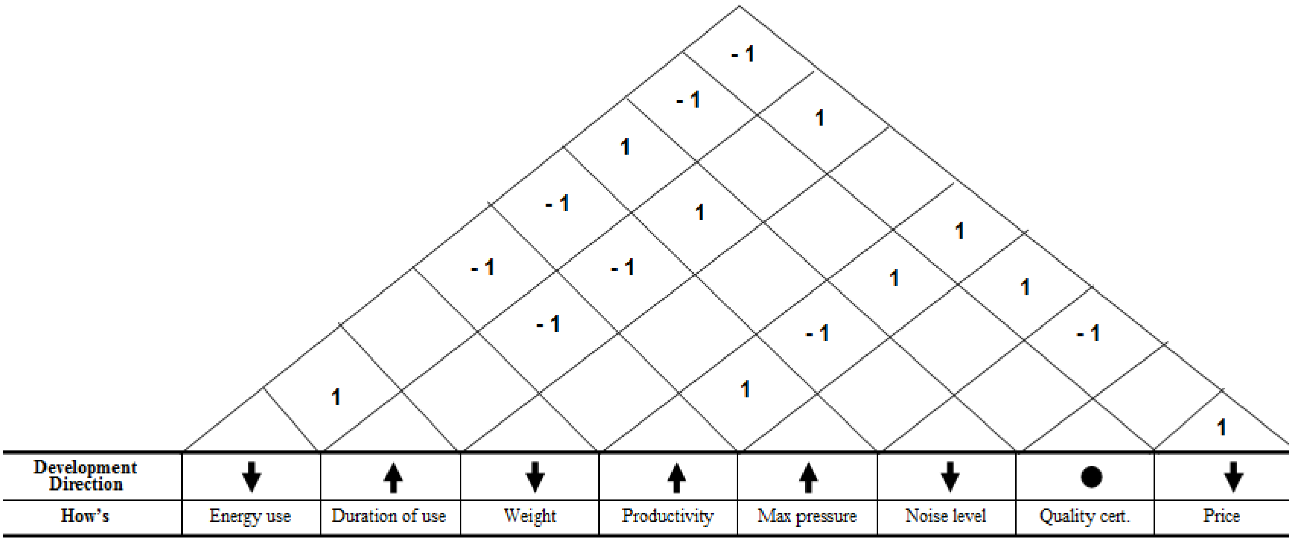


FIGURE 2
The Roof of Quality House

Step 5: Competition matrix

It takes a place at the right of relationship matrix (Table 4). In competition matrix, meeting the expected features of hydraulic pump for current supplier and other competitors suppliers is determined by the company from one to five as 1: the worst; 5: the best [18].

TABLE 4
Competition Matrix

Customer Requests	Signif.	Current Supplier	Supplier A	Supplier B	Supplier C	Target Supplier	Progress Rate	Importance Score	Importance (%)
Length of use	10	3	2	3	2	5	1,67	16,67	16,35
Not too noisy	7	4	3	5	4	5	1,25	8,75	8,58
Providing desired pressure	9	5	3	4	5	5	1	9	8,83
High productivity	10	4	3	5	4	5	1,25	12,5	12,26
Does not heat up quickly	6	4	3	5	4	5	1,25	7,5	7,36
Portability	3	3	2	4	2	5	1,67	5	4,90
Quality	10	4	3	4	3	5	1,25	12,5	12,26
Easy to assembly	4	3	2	4	2	5	1,67	6,67	6,54
Fair price	7	3	2	4	1	5	1,67	11,69	11,46
Availability of spare parts	7	3	3	3	4	5	1,67	11,69	11,46
Total								101,96	100,00

"Current Supplier" column shows the compensation degrees of hydraulic pump according to company. For instance, company marked with 3 for the length of use hydraulic pump for current supplier. Supplier A, B and C columns shows the compensation degrees of desired features by the company. *"Target Supplier"* column specifies the suppliers which company imagines. "Progress Rate" column is calculated via dividing the "Target Supplier" values to "Current Supplier" column values. For length use criteria, the progress rate is 5 / 3= 1.67. Importance Score column is calculated via multiplies with Significance value and Progress Rate. For not too noisy criteria, the importance score could be found as 7 x 1.25= 8.75. *"Importance (%)"* column contains via normalizing the *"Importance Score"* column values. So, the importance rating of each business request is divided by total importance score. Thus, the importance percentages in business requirements are calculated.

Step 6: Correlation matrix

TABLE 5
Correlation Matrix

Customer requests	**Significance**	Energy use	Duration of use	Weight	Productivity	Max pressure	Noise level	Quality Cert.	Price	Percentage
Length of use	10		⦿		O	△				16,35
Not too noisy	7		O		O		⦿			8,58
Providing desired pressure	9	⦿	⦿		O	⦿				8,83
High productivity	10		O		⦿					12,26
Does not heat up quickly	6	⦿	O		O	△	O	△		7,36
Portability	3			⦿						4,90
Quality	10	O	O		⦿	⦿	⦿	⦿		12,26
Easy to assembly	4			⦿						6,54
Fair price	7	O	O		O	O		O	⦿	11,46
Availability of spare parts	7		⦿		O					11,46
Absolute importance	Σ1477	186	351	63	318	208	171	117	63	100,00
Relative importance (%)	100,00	12,59	23,76	4,27	21,53	14,08	11,58	7,92	4,27	

Absolute importance = $\sum$ (matrix weight $\times$ customer importance degree). For instance; the suitability of quality certification’s absolute importance degree is calculated via multiple and sum of does not heat up quickly, quality and fair price, respectively.

Absolute importance= (1x 6) + (9 x 10) + (3 x 7) = 117

Then, total importance (1309) is obtained via summing absolute importance of technical features and the relative importance values were founded via dividing the absolute importance degree of each feature to this value. The relative importance of suitability of quality certifications is calculated as below,

$$\text{Relative importance} = \frac{Absolute\ \text{Im}\,por\tan ce}{Total\ \text{Im}\,por\tan ce} \times 100 = 117/1477 \times 100 = \%\ 7,92$$

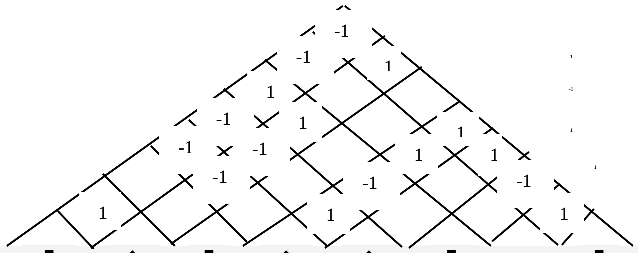
Step 7: Technical comparisons

TABLE 6
Competition Matrix

Customer Requests	**Significance**	Energy use	Duration of use	Weight	Productivity	Max pressure	Noise level	Quality Cert.	Price	Percentage
Length of use	10		⦿		O	△				16,35
Not too noisy	7		O		O		⦿			8,58
Providing desired pressure	9	⦿	⦿		O	⦿				8,83
High productivity	10		O		⦿					12,26
Does not heat up quickly	6	⦿	O		O	△	O	△		7,36
Portability	3			⦿						4,90
Quality	10	O	O		⦿	⦿	⦿	⦿		12,26
Easy to assembly	4			⦿						6,54
Fair price	7	O	O		O	O		O	⦿	11,46
Availability of spare parts	7		⦿		O					11,46
Absolute importance	Σ 1477	186	351	63	318	208	171	117	63	100,00
Relative importance (%)	100,00	12,59	23,76	4,27	21,53	14,08	11,58	7,92	4,27	
Measurement Unit		Kcal/h	Year	Kg	η	Bar(kg/cm²)	Decibel	Yes	Money	
Current Supplier		10	6	60	85	350	80	Yes	300	
Supplier A		15	5	65	80	330	85	Yes	310	
Supplier B		12	6	55	88	340	75	Yes	285	
Supplier C		10	5	65	85	350	80	Yes	305	
Target Supplier		10	6	55	90	360	70	Yes	280	

Step 8: Creation the matrix of quality house for hydraulic pump supplier selection

TABLE 7
Quality House of Hydraulic Pump



	Significance	Energy use	Duration of use	Weight	Productivity	Max pressure	Noise level	Quality Cert.	Price	Current Supplier	Supplier A	Supplier B	Supplier C	Target Supplier	Progress Rate	Importance Score	Importance (%)
Development Direction		⬇	⬆	⬇	⬆	⬆	⬇	•	⬇								
Length of use	10		⦿		O	△				3	2	3	2	5	1,67	16,67	16,35
Not too noisy	7		O		O		⦿			4	3	5	4	5	1,25	8,75	8,58
Providing desired pressure	9	⦿	⦿		O	⦿				5	3	4	5	5	1	9	8,83
High productivity	10		O		⦿					4	3	5	4	5	1,25	12,5	12,26
Does not heat up quickly	6	⦿	O		O	△	O	△		4	3	5	4	5	1,25	7,5	7,36
Portability	3			⦿						3	2	4	2	5	1,67	5	4,90
Quality	10	O	O		⦿	⦿	⦿	⦿		4	3	4	3	5	1,25	12,5	12,26
Easy to assembly	4			⦿						3	2	4	2	5	1,67	6,67	6,54
Fair price	7	O	O		O	O		O	⦿	3	2	4	1	5	1,67	11,69	11,46
Availability of spare parts	7		⦿		O					3	3	3	4	5	1,67	11,69	11,46
Absolute importance	Σ 1477	186	351	63	318	208	171	117	63							101,96	100,00
Relative importance (%)	100,00	12,59	23,76	4,27	21,53	14,08	11,58	7,92	4,27								
Measurement Unit		Kcal/h	Year	Kg	η	Bar(kg/cm²)	Decibel	Yes	Money								
Current Supplier		10	6	60	85	350	80	Yes	300								
Supplier A		15	5	65	80	330	85	Yes	310								
Supplier B		12	6	55	88	340	75	Yes	285								
Supplier C		10	5	65	85	350	80	Yes	305								
Target Supplier		10	6	55	90	360	70	Yes	280								

CONCLUSION

Table 7 shows the whole quality house. The conclusions which is gained according to QFD matrix are given below,

a) The company sorted the expected features according to importance values; length of use (10), high productivity (10), quality (10), providing desired pressure (9), not too noisy (7), availability of spare parts (7), fair price (7), not heat up quickly (6), easy to assembly (4) and portability (3), respectively.

b) The technical characteristics of hydraulic pump are determined as follows; energy of use, length of use, weight, productivity, max pressure value, noise level and price, respectively.

c) In the characteristics of hydraulic pumps, energy of use, weight, noise level and price must be reduced; length of use, productivity, providing desired pressure and suitability to quality certifications must be increased.

d) The company wishes the following technical characteristics from its suppliers; length of use (% 23, 76), productivity (% 21, 53), max pressure (% 14, 08), energy use (% 12, 59), noise level (% 11, 58), providing quality certifications (% 7, 92), weight and price have % 4, 27 importance percentages.

e) According to energy use, current supplier and supplier C are the same and they are better than supplier A and B. According to length of use current supplier and supplier B are the same and they are better than supplier A and C. According to weight, the best supplier is supplier B and after this, current supplier is come. According to productivity, supplier B is the best. According to max pressure, current supplier and supplier C are the same and supplier B follows them. According to noise level and price, supplier B provides the best value.

There are three main objectives of this study. First one is selection of best supplier for a certain product between different alternatives. The second one is suggesting house of quality method to solve the problem, and the third one is aiming to learn the main expectation of the product and exposing the technical requirements. In this study, quality function deployment is suggested for the supplier selection. Determining the expected features by the company takes much time in the study. After determining the expectations, finding the technical features to meet these expected features and defining the relationships between them are handled. With this study, "is there a better supplier than the existing one?" is queried. Considering all these results, the company should change its current supplier and deal with supplier B. for the further researches, the QFD technique could be used by the studied firm to get the importance weight of the customer requirements from customers that the firm had not dealt with them earlier. This is to identify the critical quality characteristics that need to be enhanced by the firm in order to enhance the firm's ability to attract more customers, get more business and market shares, thus able to achieve better customer satisfaction.

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INTERMODAL CONTAINER TRANSPORTATION IN TURKEY AND THE POTENTIAL OF RAILWAY TRANSPORT

A.Güldem Cerit[1], Lerzan Kasapoğlu[2]

Abstract *— Intermodal freight transport is the concept of utilizing two or more suitable modes, to form an integrated transport chain aimed at achieving operationally efficient and cost-effective delivery of goods. It is important to recognize that not all freight currently carried by road is suitable for switching to other modes. In the usage of intermodal container transportation, the railways have a key role for the transport chain. Turkey has a vital importance for global transportation network since from past to present Turkey has been the cross road for many important routes. Railway transport is an important part of the intermodal transport network in terms of container transport. Throughout this research, intermodal container transport and the potential of railway transport in Turkey are examined, and this potential that affects Turkey's logistic sector is analysed within the scope of strategies which should be followed for improvement.*

Keywords —Container, Freight, Intermodal Transport, Railway

INTRODUCTION

The freight transportation market is an essential component of any economic system. It supports production, trade, and consumption activities by ensuring the efficient movement and timely availability of raw materials and finished goods.

In freight transport; economy, speed, and safety are the properties required to be sought for every transport mode. Besides these, the minimum pollution of the environment, utilization of the energy resources available in the country and in the meanwhile, low energy consumption per tone-km, the initial installation and maintenance-repair ease are the other elements which should be taken into consideration in preference of the transport modes.

There is no country in the world benefiting from only one of the transport modes in passenger and freight transport. In almost every country, besides railway, land, air transport, maritime transport according to the geographical location of the country and pipelines in liquid freight transport are utilized. Because of that, intermodal freight transportation has a key role for global logistics. Container transport makes the basis of intermodal transport in which the container is used as a handling, storage and transport unit.

Intermodalism has been increasing both in the world and in Turkey due to the demand and supply side developments in transport industry. Turkey has a great potential in terms of intermodal transportation, due to its geographical position in the middle of European, Asian and Middle Eastern countries.

The railways have a vital role for the transport chain and Turkey's railway system is under development to accomplish an efficient intermodal freight transport process. In this perspective, the potential and the service quality of railway transport of Turkey and developments are evaluated from the point of view of the actors participating in intermodal container transportation.

DEFINITIONS AND CONCEPTS OF INTERMODAL FREIGHT TRANSPORTION

Intermodal freight transportation is the movement of freight from one mode of transport to another, commonly taking place at a terminal specifically designed for such a purpose [1].

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Intermodalism is one of the elements of the wave of technological change affecting logistics. It is one more option increasing flexibility for shippers and offering opportunities for cost savings, and it is a foremost case of the value of coordination in the logistics process. The success of intermodal depends on information technology applications [2].

The principal benefits of unit-load intermodalism is that it can provide [3]:

- Lower transit over long journeys;
- Potentially faster delivery times in certain circumstances;
- A reduction in road congestion;
- A more environmentally acceptable solution to congestion and related problems;
- Reduced consumption of fuels since the long-haul section of the route is more fuel efficient;
- Safer transit for more dangerous products.

It is important to recognize that not all freight currently carried by road is suitable for switching to other modes. In the usage of intermodal container transportation, the railways have a key role in the transport chain. Rail transport is a part of the logistics chain, which facilitates international trade and economic growth in most countries.

The special position of railways in the world transportation can not be denied by looking through its historical process. Historically, railroads have handled the largest number of ton-miles within the continental United States, The Europe and the other places in the world. As a result of early development of a comprehensive rail network connecting almost all cities and town, railroads dominated intercity freight tonnage until after the World War II. However, rail transportation has entered into a stagnation process. Because of that, railroads are being shown as an alternative and potential transportation mode to road transportation instead of being a principal one.

It is often possible to combine rail transportation with road transportation, simply by carrying trailers. This is called ‘piggy back’ and it is increasingly used to efficiently combine the inland potentials of rail and road transportation. The most flexible one is obviously the Ro-Ro method where the tractor and the trailer are directly loaded on a rail platform. The driver usually rolls in with an outbound carriage and rolls out with an inbound carriage. Overall, rail transportation is more efficient than road transportation, although its main drawback is flexibility as traffic must follow fixed routes and transshipment must be done at terminals [4].

THE CURRENT SITUATION OF TURKEY’S RAILWAY NETWORK

The railway network’s length of Turkey is 10.991 km. Only 4.4 % of this network has a couple or more lines. 95% of this network is operated as a single line. The electrified lines are 21% and this is lower than EU’s average value (50%). Only 24% of Turkey’s railways are signalized. 38% of the lines are nonstandard and 34% of the lines are older than 25 years. Table 1 shows the line and track lengths of Turkey’s Railways, in 2007.

TABLE 1

Length of Railway Lines and Tracks in Turkey

The length of the mainlines	8.697 km
Subsidiary lines (Station lines, the links of factories)	2.294 km
Total	10.991 km

Source: TSR, 2008.

In Turkey, the railways are operated by a government corporation which is Turkish State Railways. There are six major ports connected by railways and these ports are Bandırma, Izmir, Samsun, Derince, Iskenderun and Mersin. However; the ports in Trabzon, Antalya, Tekirdağ, Ambarlı do not have railway connection. There has been some developments on railways during the last years, therefore the ratio of railway transportation have started to increase. Table 2 shows the increase on freight transportation via railways. As seen in Table 2, from 2003 to 2008, the quantity of freight transportation increased 45%, and there is an increase of 22% in freight traffic in terms of tone-km [5].

TABLE 2
Freight Transportation via Railways in Turkey

Freight transportation (Million)	2003	2004	2005	2006	2007	2008
Tonnes	16	18	19	20	21	23
Tonnes-Km	8.669	9.417	9.152	9.676	9.921	10.552
The average distance of transport (Km)	547	527	479	483	468	461

Source: TSR, 2008.

In 2001, Turkish State Railways changed its concept of transportation from partial transportation to block train transportation. Block trains are operated between the countries of Turkey-Europe, Turkey-Middle East, Turkey-Middle Asia. The branch lines are 434 km and connect 318 freight centers (factories, organized industrial zone) to the mainlines. The number of private sector's wagons was 771 in 2003. In 2008, this number increased to 2.458. In 2008, the transportation via private wagons reached 4,3 million tonnes and it is 19% of total railway freight traffic [6].

THE SERVICE QUALITY ANALYSIS OF RAILWAYS IN TURKEY WITHIN THE SCOPE OF INTERMODAL CONTAINER TRANSPORTATION

Previous research on port services have concentrated on (1) effects of port services on port performance (Frankel 1987; Chadwin et al 1990; Japan International Cooperation Agency 1994; Teurelincx 1998) and (2) effects of port services on competitive advantage of the maritime transport function (Cerit 1998). On the other hand service quality determinants have been tested in several service producing industries other than ports [7].

The aim of this study is to analyze service quality factors on railways within the scope of intermodal container transportation.

The characteristics of railway infrastructure and operations are different from other industries and the previous studies that have been performed about several service sectors had to be re-considered regarding these differences. This study includes the importance of the characteristics of the railway transport and intermodal container transportation with respect to the (1) physical infrastructure and (2) operations. A previous study on the port industry focused on respective determinants and reached the conclusions that for such organizational markets service quality considerations should include both the infrastructural and operational varables [8].

Methodology

A sample and a developed research that is based on a field study is realized to analyse service quality factors on railways within the scope of intermodal container transportation.

Questionnaire Development

To reach the objectives of the study, a questionnaire consisting of four different parts is developed. The first part covers 9 open-ended and multiple-choice questions about the company profile (see Table 3 and Table 4).

The second part consists of 13 statements on a 5-point Likert-scale aiming to determine the opinions of railway companies on the physical infrastructure in Turkey, relating the service quality of the railways (see Table 5). The third part consists of 11 statements formed on a 5-point Likert scale (see Table 6) designed to analyze the operational variables of the railway services affecting the service quality of the railway companies. The fourth part covers 22 questions (5 open-ended questions aiming allocation of points among sub-factors of service quality, 22 statements on a 5-point Likert-scale) concerning the opinions of the railway companies on service quality performance factors present in the railways in Turkey (see Table 7).

The Sample

The sample of the research includes 33 railway companies in Turkey, which are logistics, transport and forwarder companies and carry out intermodal container transportation.

Data Analysis Procedures

Data processing is maintained by the SPSS (Statistical Package for the Social Sciences) Program. Open-ended and multiple-choice questions aiming profile construction are analyzed by relative frequencies.

For Likert scaled statements aiming factor analysis, means for sample sizes and the standard deviations are calculated to measure the level of importance of each specific dimension for the companies. Factor analysis is accomplished to reach the factors matrix and reliability analysis is covered.

RESULTS AND EVALUATION

Profiles of Companies and the Employees who responded the questionnaires

Table 3 shows the profiles of the companies. The year of establishment, the number of years spent in railway transport, the number of employees and the number of wagons the companies own.

TABLE 3
The Profiles of Railway Companies in Turkey

Variable	**n**	**Percent %**	**Variable**	**n**	**Percent %**
The year of establishment			**Years in railway transport**		
Before 1980	6	18.2	0–5 years	12	36.4
1981–1990	9	27.3	6–10 years	8	24.2
1991–2000	3	9.1	11–15 years	7	21.2
2000 -	15	45.5	More than 15 years	6	18.2
Total	33	100	**Total**	33	100.0
The number of			**The number of wagons**		
0–50	25	75.8	0	19	57.6
51–100	-	-	1–50	6	18.2
101-	8	24.2	51–100	3	9.1
Total	33	100	101–150	2	6.1
			151–200	0	0
			201–250	2	6.1
			251-	1	3.0
			Total	33	100

Table 4 gives the profiles of the employees who have responded to the questionnaires. These are the title of employees, time spent in the company, their recent position and education.

TABLE 4
The Profile of the Respondents

Variable	N	Percent %	Variable	n	Percent %
Title			**Years in the company**		
Operation	13	39.4	0–5 years	20	60.6
Sales and Marketing	3	9.1	6–10 years	5	15.2
Manager	4	12.1	11–15 years	2	6.1
Top Manager	5	15.2	More than 15 years	6	18.2
Other	8	24.2	**Total**	33	100.0
Total	33	100			
Years in recent position			**Education**		
0–5 years	25	75.8	Primary School	1	3.0
6–10 years	6	18.2	High School	1	3.0
11–15 years	1	3.0	Vocational School	5	15.2
More than 15 years	1	3.0	BSc	23	69.7
Total	33	100.0	MSc	3	9.1
			Total	33	100.0

Frequency Distribution

The frequencies of the answers to the Likert type questions are calculated. Table 5 summarizes the determined variables about phsysical and infrastructure facilities. The effects of these variables on railway transport are shown within the scope of the sample.

As seen in Table 5, the highest mean belongs to the number of locomotives and wagons. These numbers have a vital role on the companies' activities because they are primary necessities on railway transport. Some companies do not own wagons, they obtain wagons from the Turkish State Railways.

TABLE 5
The Effects of Physical Infrastructure and Facilities on Railway Transport

	Variables	n	Mean	Standard deviation
1	The number of wagons and locomotives	33	4,3636	1,1677
2	The charactericties of the lines	33	4,1212	1,3171
3	The type of wagons and locomotives	33	4,1212	1,1926
4	The situation of track maintenance and repair	33	4,0606	1,3449
5	Connection with ports	33	4,0303	1,3575
6	The capacities of wagons and locomotives	33	4,0303	1,2866
7	The length and position of the lines	33	3,9697	1,3343
8	Connection with roads	33	3,9091	1,5485
9	The number and capacities of railway containers	33	3,8788	1,2688
10	The regulation on railways	33	3,8485	1,2021
11	Information facilities	33	3,8182	1,5094
12	The number of track maintenance and repair units	33	3,6970	1,1855
13	Telecommunication	33	3,6061	1,4564

Likert Scale: 1:completely disagree, 5: completely agree

Table 6 summarizes the determined variables on operations of the railway companies. The effects of these variables on railway transport are shown within the scope of the sample.

As seen in Table 6, the highest mean belongs to changing the transportation concept to block train transport concept. This change has a vital role on the companies because this concept ends in different operation activities when compared with partial transport.

TABLE 6
The Effects of Operations on Railway Transport

	Variables	**n**	**Mean**	**Standartd deviation**
1	Block train concept	33	3,9697	1,4249
2	Speed and efficiency of the information flow in stations	33	3,7879	1,2932
3	Container transfer speed in stations	33	3,6667	1,4068
4	Container stowage and storage speed in stations	33	3,6667	1,4068
5	The speed of document controls	33	3,6364	1,4538
6	Container charging/discharging speed in stations	33	3,6364	1,4322
7	Container entrance and exit speed in stations	33	3,5758	1,5213
8	The speed of custom procedures of containers in stations	33	3,5455	1,5631
9	The speed of loading/unloading into container in stations	33	3,5455	1,4809
10	The safety of employees	33	3,3030	1,2866
11	The security of freight and equipments	33	3,0303	1,4249

Likert Scale: 1:completely disagree, 5: completely agree

Table 7 gives the determined variables about service quality of railway companies. The effects of these variables on railway transport are shown within the scope of the sample.

As seen in Table 7, the highest mean belongs to physical facilities are visually appealing. The characteristics of the lines, the type of locomotives and the situation of track maintenance and repair follow this variable and these are the most important attributes for service quality. The lower values of the means prove that the service quality should be developed significantly.

TABLE 7
The Effects of Service Quality Indicators on Railway Transport

	Variables	n	Mean	Standard Deviation
1	Physical facilities are visually appealing	33	3.2121	1.2932
2	Error-free records	33	3.0606	1.2976
3	Employees are never too busy to respond our request	33	3.0606	1.0589
4	Employees pay us personal attention	33	3.0303	1.4249
5	Employees are always willing to help us	33	3.0303	1.1315
6	Personal Requirements	33	2,9091	1,0713
7	Employees are neat appearing	33	2.8485	1.1489
8	Employees have knowledge to answer our questions	33	2.8182	1.1027
9	Convenient operating hours	33	2.7879	1.1926
10	Sincere interest in solving problems	33	2.7879	.9273
11	Behavior of employees	33	2.7273	1.0390
12	Safe transactions	33	2.7273	1.0085
13	Our best interest at heart	33	2.6970	1.0749
14	Courteousness of employees	33	2.6970	1.0150
15	Individual attention	33	2.6667	1.1637
16	Employees tell us exactly when services will be performed	33	2.6364	.9293
17	Employees give us prompt service	33	2.6061	1.0880
18	Services at times promised	33	2.6061	.9981
19	Doing something at the certain time it is promised	33	2.5758	1.0317
20	Materials are visually appearing	33	2.3939	1.1440
21	Performing the service right the first time	33	2.3636	1.0553
22	Modern looking equipment	33	2.2424	1.0616

Likert Scale: 1:completely disagree, 5: completely agree (Zeithaml et al., 1990).

CONCLUSION

Turkey’s existing railway infrastructure is under improvement considering the determinants of successful intermodalism. One of the most important infrastructures in effective intermodality is the interchange points where different modes of transport intersect. For national and international intermodal transports, the countries should consider the requirements of intermodal container transportation. The negative effects of the domination of road transport mainly ends in the strong demand for railway infrastructure. In order to solve these problems, existing railroads must be improved and the planned railroads must be constructed immediately. This will provide continuous connection between roads and ports. The factories and other industrial facilities need to have railway connections due to energy minimization, pollution control and lower transportation costs.

The development of containerisation increases the investment on railways projects. The service suppliers must improve the service quality with these projects. In Turkey, there are some points which do not benefit from railways because in the current situation it is difficult to get closer to some demand centers. The railway transport has a vital role on intermodal container transportation, therefore railways should be connected and share the potantial freights with the other modes. In the frequency distribution, the highest mean belongs to changing the transportation concept into the block train transport concept. This change has a vital role on the companies because this concept ends in different operational activities when it is compared with partial transport.

The number of stations and railway terminals, loading/unloading units and storage units should be increased and they should be developed. Telecommunication, signalization and electrification differences have negative affects on efficiency. These terms should be improved and for efficient service, the charging/discharging facilities should be developed. Physical conditions have a key role, that can be seen in this study, because the highest mean belongs to physical facilities and their visual characteristics. The started restructuring studies should be finalized and the Railways Law should be published. The regulation on using wagons and locomotives should be regarded and the number and capacities of track maintenance and repair units is important for service quality. The employees on railway sector should be more educated and the efficiency should be increased.

With the realization of these improvements not only social requirements will be fulfilled, but also the necessities of the natural and economic environments will also be foreseen.

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RAIL AS A VIABLE PARTNER IN FREIGHT TRANSPORT: THE CASE OF TURKEY

Hülya Zeybek [1]

Abstract — *Growing concerns over environmental issues and the increasing role of the transport sector in creating environmental pollution have had a significant impact on transport policies and investments worldwide. There is increasing emphasis on the importance of transporting goods in the most sustainable ways, and, as one of the environmentally friendly modes, rail transport is increasingly moving into the focus of logistics operators. It appears that in Turkey too a policy shift has taken place in favour of rail transport as a consequence of both environmental concerns and the will to integrate into international transport networks. Although rail is increasingly moving into the focus of logistics operators, it has still not yet managed to gain increased market share. In spite of the apparent advantages for rail freight transport, this mode continues to lag significantly behind road transport. Besides technical solutions, there is a need for customer orientation of railways and customer willingness to see rail as a viable partner in freight transport. This paper summarizes the results of the survey which assesses the perceptions of a diverse group of stakeholders on how rail freight services in Turkey can be improved, the range of customer-focused services desired and the facilities required for rail transport to provide such service and also the challenges faced by logistics operators. This research has been carried out with the finance of the World Bank.*

Keywords — *rail freight transport, customer orientation, stakeholder perception, Customer Relations Management (CRM)*

INTRODUCTION

The work and results presented herein are part of the Component 1- Railway Freight Survey of the “TCDD Freight Market Research” Project which has been initiated by Turkish State Railways(TCDD) with the finance of the World Bank. The project will be completed in February 2011.
In Turkey, freight transport by rail is carried out by the state-owned Turkish State Railways. Although it has been desired at the transport policy level and is increasingly moving into the focus of logistics operators, rail has still not yet managed to gain increased market share[1].

Rail freight is technology-driven, capital-intensive, and dependent on a rail infrastructure, which makes its use complex and the barrier to entry high rail freight and various value-added distribution services [2]. However, besides technical solutions, there is a need for customer orientation of railways and customer willingness to see rail as a viable partner in freight transport [3].

This paper evaluates the results of the survey initiated to analyse and monitor the current situation of rail freight transport in order to understand the satisfaction and the critical factors from the customer point of view and to identify the strengths and weaknesses of the rail freight service.

OBJECTIVE OF THE RESEARCH

The key objective of the Railway Freight Survey is to understand customer requirements for freight transport with specific focus on the part served by rail, critical factors related to customer purchase decisions and planning; to monitor levels of service delivered by TCDD in its rail freight offering, measurement of level of customer satisfaction, level of importance to the customer of rail transport services delivered by TCDD, suggestions from customers on rail freight services, information channels used customer needs and expectations outlook on competitors, relationships with TCDD and suggestions for improvement quality perceived by customers in relation to elements of the rail freight service offering delivered by TCDD to determine strengths and weaknesses, niche markets.

The main research question of the study is:

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How can TCDD improve freight service levels and ensure its long-term viability?

Four subquestions follow the research question, with an objective to support the research purposes, which are:

1) What are the critical factors related to the purchase decisions on the type of transport to be chosen?
2) What is the quality perceived by customers in relation to elements of the rail freight service delivered by TCDD?
3) What are the strengths and weaknesses of TCDD according to the stakeholders?
4) What are the customer needs and expectations from TCDD?
5) What are the niche markets?
6) How the stakeholders see the future of rail freight?

RESEARCH METHODOLOGY

Qualitative survey methods are being used increasingly in research and policy studies to understand customer perceptions, attitudes and behavior in order to gain a more thorough understanding of the related market. The three most common qualitative methods are participant observation, in-depth interviews, and focus groups[4]. Although recent studies about Turkish rail freight transport addressed policy, mode choice and productivity, competitiveness e.g., [5], [6] and intermodal opportunities e.g.,[7] building on literature analyses and second-hand statistics and in some studies qualitative methods are used [5]. There exists a lack of studies mainly concentrating on market actors point of views.

SURVEY

The survey process started with format design of the questionnaire instrument used in the survey and the identificaton of the methods of collecting data to be followed by the creation of the contact list that include key stakeholders in the 7 regions of TCDD who possess appropriate background to respond to the survey questions as possible. 3 types of questionnaires were designed and taylored for; a)retail manufacturing companies customers and non customers of TCDD in the last year, b) main forwarders, shippers, MTOs, Logistics customers and non customers of TCDD in last year, c)main institutional Stakeholders, chambers of commerce, NGOs, etc.

A large variety of questions was drafted and then by selection and rewording, editing and reconsidering, a draft questionnaires were constructed. Then, a set of test interviews were held, each representing a different stakeholder group. Significant revisions have been made to the draft questionnaire based on the inputs obtained from the test interviews. Railway freight survey was conducted as in depth semi-structured interviews by Survey company. In-depth interviews are useful when you want detailed information about a person’s thoughts and behaviors or want to explore new issues in depth[8]. The interviews were held between May and June 2010.

About 96 in-depth interviews (47 to Forwarders and 49 to Manufacturers) from a representative sample of companies taken from the list of the clients of TCDD. Another 13 interviews were carried out with the institutional stakeholders, NGOs etc. The face to face interviews for Pilot and Rail Freight Surveys were designed for a duration of about 50 mins. Stakeholder interviews had a duration of approximately 50 -80 mins. In this paper, the results of the institutional stakeholders’ interviews will not be taken into consideration.

SURVEY CONCLUSIONS

Critical Factors Related to the Mode Choice

The most critical factor related to the purchase decisions on the type of transport to be chosen is the *cost*, but *transportation time*, *security* and *type of freight* are also found as the critical factors .

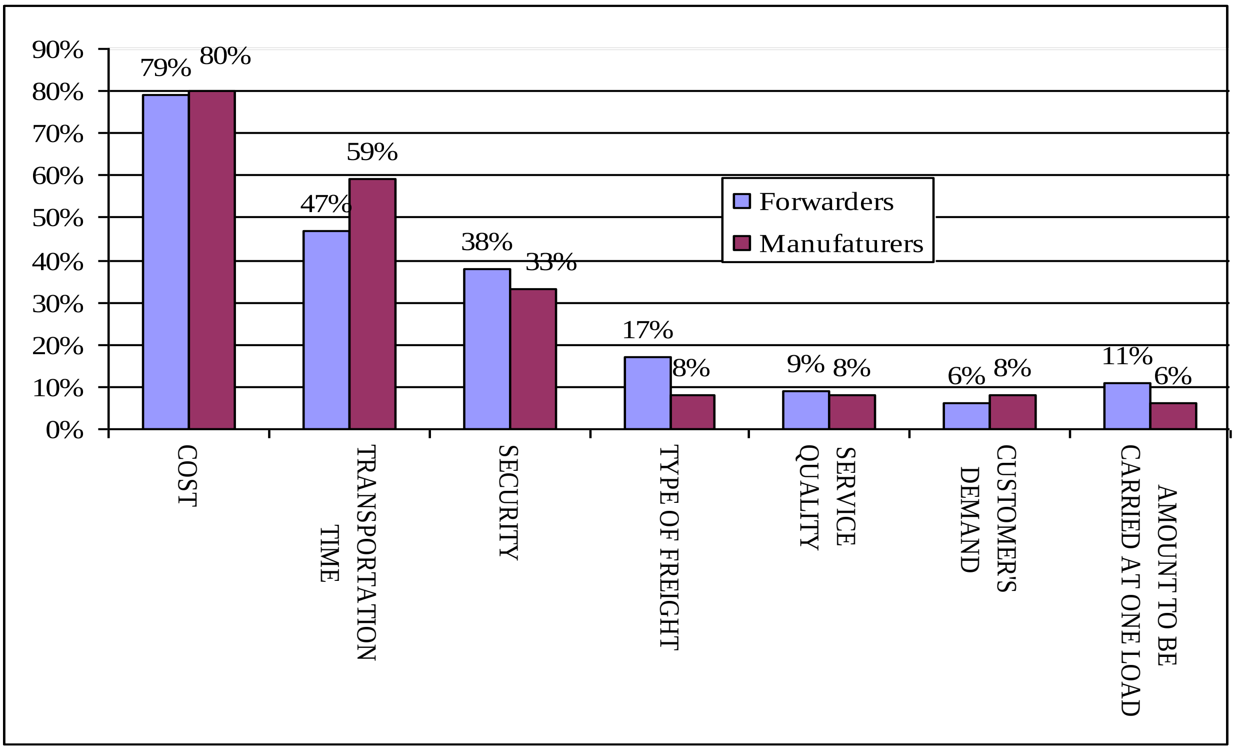

FIGURE. 1
Critical Factors in Modal Choice Process

Quality Perceived by Customers in Relation to Elements of the Rail Freight Service Delivered by TCDD

Majority of forwarders works directly with TCDD. 15% of forwarders work with TCDD through another forwarder. 45% of manufacturers works directly with TCDD, while the 33% through forwarders. Manufacturers compared to forwarders are slightly more satisfied regarding the administrative aspects. Both forwarders and manufacturers give much importance to administrative aspects. The reason for such satisfaction level in some cases is that they do not work directly with TCDD but through forwarders. The ability to understand customer needs and the ability to solve problems are considered very important and are judged highly satisfactory by customers. Whereas time to market is considered a critical factor. All the elements judged by customers register values higher than 6 with an average of 6.75. The highest satisfaction is registered in the ability to face problems and solve them with a judgement of 7.06. The ability for problem solving is considered highly important by the customers but is evaluated below average satisfaction level and therefore TCDD should invest on those aspects to increase customer satisfaction. Even for manufacturers the ability to understand customer needs is considered highly important and generates high satisfaction, whereas time to market is an element for which customers show great satisfaction, while not considering it important and this is correlated to the fact that they transport bulk. The highest judgement is given to the ability to understand customer needs, while the most critical element is registered for flexibility to new suggestions with a value of 5.64.. Regarding the relations with the regions, the highest score is given to the ability to understand customer needs while the critical factor that emerges with a negative score of 5.63 is the flexibility to new suggestions of TCDD. For the regionals, the element that registers the highest importance for manufacturers is the ability of responding to customer loading and unloading requests which is considered critical and not satisfactory. Manufactuerrs give a high score to ability to understand customer needs (7.5) while flexibility to new suggestions is considered a non satisfying factor (5.65). For the forwarders and manufacturers, the main point of reference is at logistic manager level in the stations (40% & 49% respectively). In relation to the problem solving ability, the forwarders find that the Ankara Headquarters are better performing even though they are less considered as contact points of reference, whereas manufacturers score higher satisfaction at freight unit level (in regional directorates) with an average of scores higher than 7.5. The majority of manufacturers say they do not want to refer to Ankara headquarters when they have problems, since they do not have a clear contact point there, and so try to avoid waiting too long for a response. Forwarders give a higher score (7.15) to logistic managers in station whilst manufacturers give a high score both to logistic managers in stations (7.68) and to the internet web site (7.73) so they use internet to get information. But the contact with the central freight unit is attributed a negative value of 5.71. In the study, many customers communicated that actually there is no contact with central freight or marketing units in Ankara unless they contact them themselves. Many companies stated that they are expecting some contacts (ideally periodically) from these departments. It can be various forms such as through visits or phone calls. For the quality/price ratio , this element is considered the most important of all both by forwarders and manufacturers with scores reaching top level of 10. The question was asked for all modes of transport and in the comparison, rail registers the lowest score in relation to quality price ratio : Forwarders = 5.98 and Manufacturers= 6.19. While forwarders give an average score of 8.14 to air transport and manufacturers attribute an average score of 8 to ship transport both forwareders and manufacturers attribute scores higher than 7.5 to all modes of transport except for rail. In fact rail registers a score that is much lower .

In order to compete with other modes, there is a need to increase the quality of the service compared to the price. In relation to the operational aspects of the service regarding the conventional railway service, the most important elements are considered the performance of delivery times and the performance relative to transport safety from failures and damage as well as that of the availability of wagons according to requests. While the satisfaction for these last two elements is good, customer express a negative satisfaction for delivery times though they are highly important (8.14). Delivery times register a value (6.00) that is lower than average (6.17) in terms of satisfaction, therefore this is an element to be invested upon to improve satisfaction of the service.

For manufacturers, in conventional rail service, the most important factors are delivery times (8.35) and performance related to availability of wagons requested (7.85). Both these elements register also a good level of satisfaction by manufacturers, respectively 7.06 and 7.46. The ability to face sudden requests, is considered a critical element by customers and therefore it would be better to invest in this factor.

The most important elements relating to operational aspects of intermodal services are still delivery times (8.14) and transport safety from failure and damage (6.33). The highest score of satisfaction is registered for ability to satisfy wagon requests (7.26) and for delivery times (7.19) while the highest criticality is manifested in relation to the ability to face sudden requests (5.72) while the average score is 6.58.

For manufacturers, in intermodal services, the most important factors are delivery times (8.35) and performance related to availability of wagons requested (7.85) . The highest score of satisfaction is given to transport safety from failure and damage (7.69) and delivery times (7.41). The major critical factor that is registered in all cases is the ability to face sudden requests (5.63) which is well below average scores registered of 6.71. Therefore TCDD should invest on this aspect to improve customer perception. The propensity to repurchase train freight services is very high both for forwarders and manufacturers. While Forwarders would highly advise their customers to use the train, manufacturers are less willing to advise others to use the train.

In relation to the overall service quality provided by TCDD compared to the year before, 29% declare that the service has improved compared to the same period of the year before, while 11% declare that it has worsened, 54% declare that the service quality level has remained more or less the same. 6% declare they do not have terms of comparison.

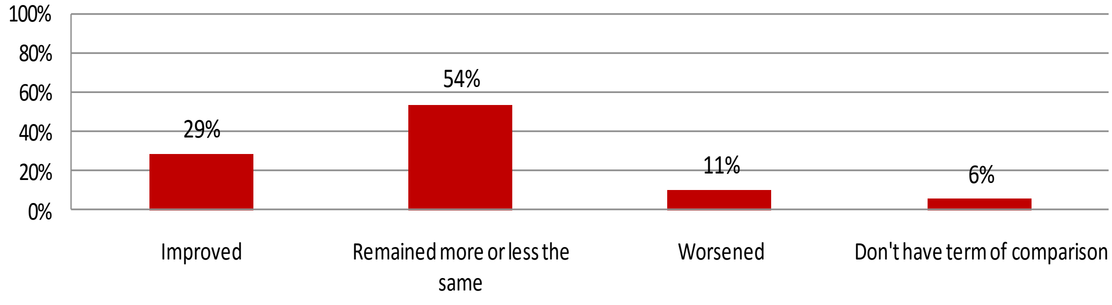

FIGURE 1
Overall Quality of TCDD Freight Service Percived by Customers Compared to 2009

The reasons given for the improvement and the deterioration are given in Table 1.

TABLE 1
Reasons of Quality Improvement or Deterioration

Reasons for improvement	Reasons of worsening
Faster transportation	Higher prices
Better wagon delivery service	Van Lake transfer problem
Better customer relations	Not enough locos
Personnel are working more effectively	Longer delivery times
Better wagon quality	Not enough personnel
Better service quality	Not enough space at terminals
Better line quality	Difficulties to get wagons
More technical equipment	TCDD is giving priority to their wagons

Even though around 60% of customers interviewed declare that the situation has not changed much, around one third of customers in general find that the rail freight service has increased quality in terms of faster transportation and the fact that TCDD provides more wagons, but they also register that the level of prices is high and that more locos are necessary.

Strength and Weaknesses

The majority of the customers observed the major strengths of TCDD in freight transport as its trustability and its large capacity, being state organisation (19%) and that fact it is a monopoly (11%). All aspects are related to the concept of reliability. Loading-unloading, long journey times, high prices and bureaucracy were also noted as weaknesses (see Table 2).

TABLE 2
Strengths and Weaknesses of TCDD Percived by Customers

Strengths	Weaknesses
Trustability	Loading & unloading
Large capacity	Long journey times
Being state organization	Not modern enough
Good prices for heavy goods	High prices
More availability of wagons/ More suitable wagons	Bureaucracy

Customer Needs and Expectations from TCDD

The expectations and suggestions of customers from TCDD for improving freight service levels and ensure its long-term viability are presented in Table 3.

TABLE 3
Suggestions of Customers for Quality Improvement of Freight Service Levels

Forwarders	Manufacturers
Better and more competitive prices (28%)	Better and more competitive prices (20%)
Faster freight delivery (time to market) (21%)	Faster freight delivery (time to market) (20%)
Investment in infrastructure (17%)	Investment in infrastructure (10%)
Van lake transfer problem (11%)	More communication with customers (10%)
Investment in technical (9%)	Faster loading and unloading (10%)
More communication with customers (9%)	No more blocked trains (6%)
Better customer relations of frontline staff (6%)	
Increase number of locos (6%)	
Less bureaucracy (6%)	

The first two suggestions of both forwarders and manufacturers are majored on better and more competitive prices and faster freight delivery.

The majority of not current TCDD customers use road transportation instead of rail (73%). Among the 15 non users interviewed, 20% of non users never used rail. 7% use sea/road container transport instead of rail. It is remarkable that 33% of non current TCDD customers interviewed do not have intention to work with TCDD in the future for the reasons stated above.

Niche Markets

When discussing with interviewees about the niche markets, majorty of the respondents stated transport of dangerous goods, autpomotive transport and container as niche markets for rail mode (see Table 4) .

TABLE 4
Niche Markets for Rail Freight According to Customers

Forwarders	Manufacturers
Transport of dangerous goods (oil,lubricants,chemicals,acids,liquid gas) Transport of automotives Fresh fruit & vegetable transport	 Container transport Dangerous goods Food transport-Fresh fruits & vegetable transport

Future of Rail Freight

Both forwarders and manufacturers believe in the economic growth of the Country in relation to trade and therefore they expect a growth in their transportation needs in 2010 and 2011. Forwarders show better expectations of growth compared to manufacturers (+11% in 2010 vs 2009 and +13% in 2011 vs 2010). Both forwarders and manufacturers declare they are expecting a growth in international transportation needs.Therefore in a context of overall growth, both Forwarders and Manufacturers expect a higher increase in the demand for international transport. Basically future is seen positive.

CONCLUSIONS

This study has provided insights into the customer perceptions on railway freight market in Turkey. The purpose of the study was to analyse and monitor the current situation of rail freight transport in order to understand the satisfaction and the critical factors from the customer point of view and to identify the strengths and weaknesses of the rail freight service. Study's empirical data was gathered by semi-structured indept-interviews. Since research was a qualitative case study analysis, qualitative research method was chosen as a research type and concentrated on descriptive analytical approach. Overall 96 in-depth interviews were conducted. Previous studies have concentrated on second-hand data and literature analyses. First-hand data gathered via interviewing market actors can be seen as attenuating the existing empirical gap. ***Through this survey freight customers have sent the rail freight sector a message that in order for it to achieve growth and long term viability they want to see significant improvements in what matters most to them – competitive pricing, responsiveness to customer needs, reliability of service and journey time.***

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THE ANALYSIS OF MULTIMODAL TRANSPORT ALTERNATIVES BETWEEN TURKEY AND GERMANY: A CASE STUDY ON THE FOODSTUFF EXPORT

Deniz Önder[1], Durmuş Ali Deveci[2], Gül Denktaş Şakar[3]

Abstract — *The main purpose of this paper is to investigate and analyze possible alternatives along a specific trade corridor between Turkey and Germany and to compare these alternatives in terms of cost/distance and transit time based on a cost model of multimodal transport, which has been adapted from Beresford (1999). Firstly literature review on multimodal transport and carrier/transport mode/route selection is carried out and then alternative routes between Ankara and Bergheim are identified and related cost and transit time for each route are calculated. Data related to the case study is collected from logistics service providers, freight forwarders and shipping lines both in Germany and Turkey. Germany as the biggest export partner of Turkey has firstly been examined in this study and it intends to provide a clear understanding of multimodal transport alternatives for the buyers and users of this service and practitioners may develop new service offerings to their customers based on the suggestions from this study.*

Keywords —*Multimodal Transport, carrier and transport mode selection criteria, cost modeling, case study*

INTRODUCTION

In this global era, because of international competition, exporters have been focusing on integrated production and transport logistics strategies to reduce overall costs with the perspectives of creating new opportunities and contributing market shares and powers. Addition to these, the transport and logistics industry has been undergoing considerable changes since the introduction of multimodal transport and many alternatives regarding the mode(s) to be chosen, the parties to be involved and cost and service measures depending on the characteristics of the shipment and customer requirements have been considered by the users and the buyers of this service. Due to growing world trade, importance of scale economies, increasing awareness towards achieving more efficient, sustainable and environmentally friendly transport solutions, multimodal transport and other concepts such as intermodal or combined transport have emerged and they represent a rapidly expanding sector in the transport industry in the most developed regions in the world. Considering the main benefits that new transport alternatives may bring to the actors in the transport chain, transport service providers and the countries where they operate have started to evaluate the alternatives which may emerge and the use of these alternatives in country's domestic and foreign trade.

Since Turkey is one of the important trade partners of European countries, a detailed investigation regarding the alternative modes of transport between Turkey and Europe, the transit time between the selected origin and destination points is needed. Together with the increasing focus on multimodal transport in Europe, Turkey needs to improve the understanding of multimodal transport concept and develop multimodal transport strategies in order to provide environment friendly and sustainable transport solutions. This paper mainly focuses on the foodstuff -trade between Turkey and Germany by considering different routes and transport mode combinations. The study firstly provides brief literature review on multimodal transport and mode choice decisions and then the methodology of the study is explained. This is followed by the case study analysis regarding the route and mode combinations between Ankara and Bergheim. In this analysis, transit

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time, detailed cost items and distances are calculated and their performance is evaluated. Lastly, the conclusion and suggestions for further research is given briefly.

Multimodal Transport and Logistics

There are various definitions and concepts related to the use of more than one mode in freight transportation. They are sometimes used interchangeably and sometimes in different contexts and definitions such as intermodal, multimodal, combined and through transport. According to UNCTAD definition, international multimodal transport is *"the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by the multimodal transport operator to a place designated or delivery situated in a different country"*. (UNCTAD, 2010). In EU's communication from the commission on freight transport logistics, multimodality is defined as: *"the carriage of goods by two or more modes of transport, irrespective of the types of freight, within a single transport chain"* (EU, 2006). Multimodal transport combines different transportation ways together organically and constitutes the integration of continuous and comprehensive transport of goods. The mode of transportation combines the sea, railways, highways, inland waterway transportation and airline together organically by taking the container as a medium. So it can better achieve the "door to door" transportation and provide economic and reasonable and convenient transportation service for customers (Xiang Feng, 2009).

Together with the developments that triggered the emergence of multimodal transport, some advantages have been observed. An integrated multimodal transport system provides lower costs, reduces congestion and energy consumption, generates higher returns from public and private infrastructure investment. For door-to-door deliveries, it must be possible to coordinate customer service and total delivery time through the whole chain. The target is to satisfy the customer needs and attract new business by offering services in the right place, at right price, at the right time. In multimodal transport, many factors such as organisational, legal, technological and environmental effects are integrated because different organisation structures, their policies and legal implementations are connected due to the use of different transport modes and parties. Multimodal technologies include physical movement and terminal handling technologies as well as the information and communication technologies required for coordination. Cargo handling technologies, communication and information links are important tools that can be used for bridging the gaps in multimodal transport. Vehicle and cargo tracking technologies such as Global Positioning System (GPS) enable any delays or problems to be monitored and provide feedback about the location of the cargo and the vehicle (Denktas Sakar, 2010).

Mode Selection and Multimodal Transport

Freight transportation selection or decision-making on which carrier or mode to use from the view point of transportation service users have been an important research area in the literature. Since the beginning of the 1970s many empirical pieces of research and reviews have been done in freight transportation selection criteria and this concept has been examined in two main categories of modal choice and carrier choice since they are closely related with each other. Since the main focus of the study is the mode combinations and multimodal transport between Turkey and Germany, mode choice decisions will be explained in this section specifically.

Mode choice is a critical decision making process which has considerable impacts on the overall transportation system. Banomyong and Beresford (2001) identified that the choice of transport mode or combination of transport modes has a direct impact on the efficiency of a multimodal transport system. Depending on the mode chosen, the overall performance of multimodal transport will be affected. When one transport mode becomes more advantageous than another over the same route or market, a modal shift may take place. A modal shift involves the growth in the demand for one transport mode at the expense of another, although a modal shift may be accompanied by an absolute growth in both of the concerned modes. The comparative advantages behind a modal shift can be in terms of costs, convenience, speed or reliability (Rodrigue *et al.* 2006).

In terms of mode choice and decision making criteria, many studies investigated the main determinants. Nutt (1981) argued that the quantitative and qualitative criteria of decision making for the choice of transportation mode might be interrelated to specific attitudes and perception of transportation actors. Qualitative criteria are mostly about service-related factors. Jeffs and Hills (1990) indicated that reliability of transport mode, control over despatch and delivery time, avoidance of damage to goods when in transit, security of goods in transit, transit time, and the ready availability of transport when required were service related factors. Also product characteristics such as value, volume to weight ratio, product type, handling characteristics and perishability may be regarded as determinants in mode choice. Harper and Evers (1993) mentioned the differing extent to which rail-truck combinations are accepted and used by potential customers. Murphy and Hall (1995) classified the main determinants over different decades and the most quoted determinants were reliability, freight rates, transit time, carrier considerations, shipper market considerations and the over/short, damaged nature of cargo. Evers et.*al.* (1996) listed the most important factors in terms of intermodal choice as; availability, timeliness, firm contact, cost, restitution and suitability. Pedersen and Gray (1998) classified all factors in terms of timing, price, security and service factors. Quantitative criteria involve freight rates/cost/price as mentioned in many studies. Liberatore and Miller (1995) listed cost factors as freight costs, carrying costs of inventory in the pipeline, carrying costs of cycle stock at the receiving location, carrying costs of the required safety stock at the receiving location and the investment cost required to produce the inventory to fill the pipeline.

Henstra and Woxenius (1999) argued that transport-related decisions are dependent upon a set of transport service requirements, such as lead-time, reliability, etc. which means that the shippers generally do not specifically demand a special transportation mode, but rather a transport performance. In this case, mode(s) which satisfy the customer and provide the highest performance will be used, so that if multimodal transport meets these requirements, demand regarding this combination of modes is likely to increase. The LOGIQ project funded by the European Commission under the Transport RTD Programme investigated the decision making process in intermodal transport by including a number of European Countries. LOGIQ report emphasised that the decision-making process for intermodal transport is very complicated and involved companies' characteristics, requirements, external factors and supply characteristics. Including three actors in intermodal transport (forwarders/road transport companies, shippers, shipping lines) in the project, the results were (LOGIQ 2000):

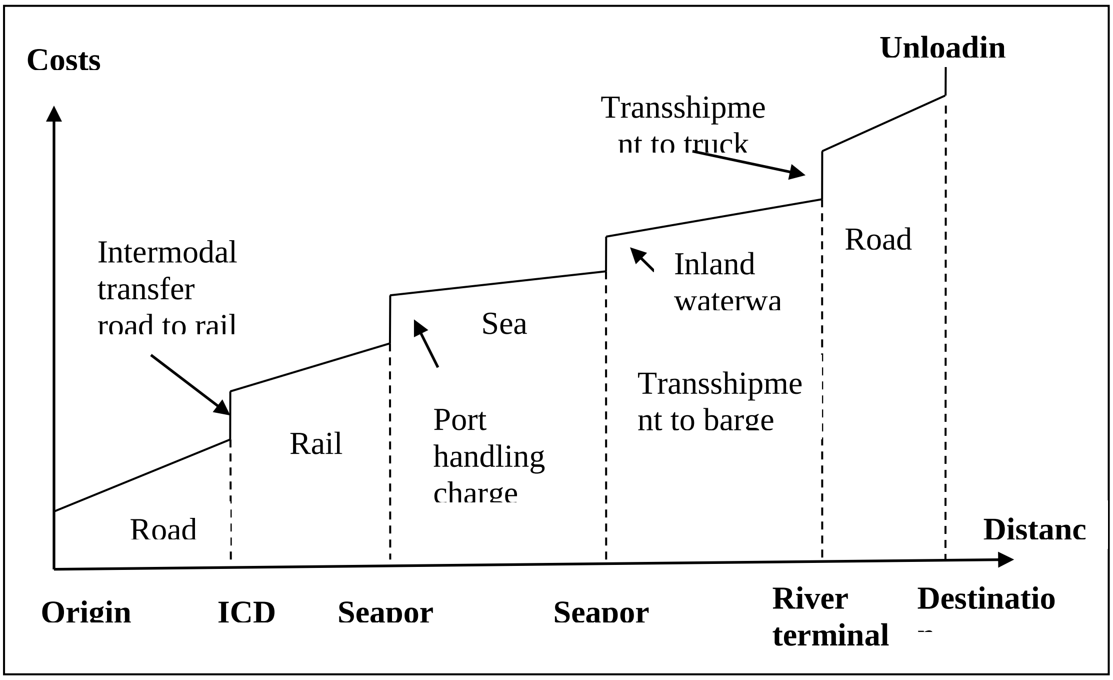
- The cost is the most important criterion in the decision making process
- Reliability is the most important quality criterion
- Frequency of services offered and rail operating systems used are the most important criteria considered from the supply side, essentially in meeting the actors' requirements for reliability.

In many of the articles and papers reviewed (Saleh and LaLonde 1972; Bardi et.al. 1989; McGinnis, 1990; Whyte 1993; Pedersen and Gray 1998; Lehmusvaara et.*al.*1999), it is noted that shippers play an important role in mode and carrier selection process. Many researchers mentioned the shippers' attitudes and perceptions in terms of mode choice. McGinnis (1978) concluded that variability of shippers' needs generally cut across product characteristics, traffic patterns, modal usage and industry lines suggesting that shippers perceive their transportation needs in terms of their channels of distribution, the competitiveness of their own markets and their own marketing strategies. Forwarders and 3PLs mainly provide services for small and medium shipments and thus influence their choice of route and mode. Major freight forwarders, shipping lines, transport operators, terminal operators, and other logistics service providers compete to control door-to-door transport chains (Islam, et.*al* 2005). Although most of the studies concentrated on one party only, some of them investigated more than one party (Tsamboulas 2000; Shinghal and Fowkes 2002). There may be one or more decision making parties in terms of mode choice and their roles may have different impacts in the supply chain, especially when multimodal transport is considered.

METHOLOGY

This study used a case study approach to investigate the possible route combinations between Turkey and Germany, Yin (2003, p.23) states that a case study is "*an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*". Or more specifically, the case study is a research approach that focuses on understanding the dynamics present within a single setting (Eisenhardt, 1989). Case study was intended to obtain in-depth information regarding the multimodal transport alternatives between Turkey and Germany. A multimodal transport cost model which has been adapted from Beresford and Dubey (1990) and improved by Beresford (1999) provides a clear understanding about cost-route related comparisons. The model includes both transport (road, rail, inland waterway, sea) and intermodal transfer (ports, rail freight terminals, inland clearance depots) as cost components. The model is based on the principle that unit costs of transport vary between modes that the steepness of the cost curves reflects the fact that for volume movements, sea transport should be the cheapest per ton-km, road transport should normally be the most expensive and waterway and rail costs should be intermediate. The main aim is to find the most competitive combination of modes and routes (Banomyong and Beresford, 2001). According to the model, a freight handling charge is levied without any material progress being made along the supply chain at ports and inland terminals, each vertical step in the cost curve represents the costs incurred (See Figure 1).

FIGURE 1
Cost Model For Multimodal Transport



Source: Adapted from Beresford, 1999

The model has many applications with different origin and destination points such as transport of whisky from Scotland to Greece (Beresford, 1999), garment (Banomyong and Beresford, 2001) from Lao PDR to European Union, flowers from Taiwan to China (Beresford et.al., 2006a), ATMs from Eire to China (Beresford et.al., 2006b).home textile products from Ankara (Turkey) to Birmingham (UK) (Denktas Sakar and Beresford, 2009). In this study, movement of foodstuff was chosen for the application of the model. In the first stage, data related to the routes and information regarding the cost, transit time and distance were obtained from different logistics service providers, freight forwarders and shipping lines, trucking companies in Turkey and Germany. Secondary sources were also used for distance calculations and transit time information. The next section will provide information regarding the case study analysis and the main routes and mode combinations investigated.

CASE STUDY FREIGHT MOVEMENT ON THE ROUTES BETWEEN ANKARA AND BERGEHIM

Turkey's location in terms of having a strategic importance in connection with its proximity to important routes and centers requires some actions to improve its transport structure. Increasing the volume of foreign trade have also accelerated this need.

When export and import partners of Turkey are considered, it can be mentioned that European countries play an important role especially in exports of Turkey. Total exports of Turkey in 2009, total export volumes of 61 billion amounted to 449 million US dollars, the main commodities by value in millions of US dollars exported from Turkey were motor vehicles (18.3), iron and steel (14.9), machineries and mechanical applicances (10.2), electrical machinery (7.9) and articles of apparel (7.8).[1] The above-mentioned considerations indicate that Germany is the biggest export partner of Turkey. As well as the mostly exported commodities, food products are seen in the lists predominantly (See table 1).

TABLE 1
Main Export And Imports Partners Of Turkey In 2008 (000 $)

Exports	
Germany	12.951.452
United Kingdom	8.158.836
United Arab Emirates	7.975.398
Italy	7.814.071
France	6.615.243

Source: TSI, 2009

Like other countries, sea transportation is the mostly using modes in Turkey with the advantages of transport high volume in fastest way and economies of scale. Because of this reason, % 90 of world trade and %86 of Turkey's foreign trade volume are transport with sea transportation with the Data's of TÜİK , in the year of 2008, % 86.5' of Turkey's Foreign trade volume with sea way, % 10.7 with inland way, % 1,1 with railway % 1,0 with other way and % 0,7 with Airway are used in transportation. [2]

According to the 2008 data of the Undersecretaries of maritime transport, it is shown that 314.577.439 ton of cargo are shipped in Turkey's ports which has 73.244.972 tones are export volume, 151.531.311 tones are import volume, 39.056.206 tones are cabotage and 50.744.950 tones are transit volume. [3]

In the process of deciding carrier, when comparing the mostly important line operators in Turkey for export trade, Msc is in the most important volume as 1.833,218 teu exported by the year of 2008, secondly ML states with the volume of 1.455.68 teu. In the time of selecting lines and port, the mostly exporting ports of Turkey and their shipment capacities are searched on the port statistics data (See table 2).

TABLE 2
Export Volume From Turkey's Ports to European Ports / Teu

LOADING PORT	DISCHARGE PORT	LINER	TEU
PORTS OF TURKEY	ANTWERP	MSC	11.757
		HAMBURG SUD	2.933
		HAPAG-LLOYD	1.552
		TURKON	1.528
		BORCHARD	308
		CMA	283
		CARGO CONTAINER LINE	277
		ML	236
		APL	60
PORTS	GENOA	TURKON	745

[1] TSI (Turkish Statistical Institute). (2009), 'Foreign Trade Statistics',(accessed 10 May 2009), http://www.tuik.gov.tr/VeriBilgi.do?tb_id=12&ust_id=4

[2] http://www.tuik.gov.tr visited on 21th March 2010

[3] http://www.dtm.gov.tr visited on 6th March 2010

		EMES	480
		MSC	265
		TARROS	145
		BORCHARD	113
		ML	33
		HAPAG-LLOYD	33
		HAMBURG SUD	29
		EVERGREEN	4.422
PORTS OF TURKEY	HAMBURG	HAMBURG SUD	3.855
		TURKON	1.947
		MSC	1.684
		CMA	469
		HAPAG-LLOYD	271
		CARGO CONTAINER LINE	61
		BULCON	43
		CSAV NORASIA	36
		EVERGREEN	27
PORTS OF TURKEY	BREMERHAVEN	ML	4.341
		MSC	1.713
		HAMBURG SUD	551
		SCL	94
		HAPAG-LLOYD	28
PORTS OF TURKEY	ROTTERDAM	MSC	4.422
		BORCHARD	1.024
		TURKON	760
		ML	639
		CMA	269
		CARGO CONTAINER LINE	182
		HAPAG-LLOYD	120
		EVERGREEN	79
		HAMBURG SUD	73
		…………….	…….

Source: Authors [1]

The reasons of selecting Ankara as origin point are firstly Ankara’s being approximately located in the middle of Turkey when producer need to have information about transportation cost near cities such as Kayseri and Konya which are really important cities in food production industries, these data can be used in indicatively, secondly distance between Istanbul and Ankara 500 km are relatively equal. Thirdly Ankara is the capital of Turkey and there are lots of producing companies are operated in.

[1] This table is prepared with the port statistics data 2009 from January to September for this study.

The reasons of selecting Bergheim as destination point are firstly there are lots of good wholesailer companies and their depots are located in, secondly it is the one of the Bergheim is a municipality in the Neuburg - Schrobenhausen district of the state of Bavaria[1] in Germany which is the Turkey's mostly exported country, Thirdly it is located in the middle of the Europe and short distance to important European ports such as Antwerp, Hamburg , Rotterdam and Genoa. And also it is 20 km away from Cologne.

TABLE 3

Mode And Route Alternatives For Freight Between Turkey And Germany

Route 1	Road+sea+road(all truck and all rail via Rotterdam)	Ankara–Bergeim by truck from Ankara and Ambarlı port, by sea transportation via Felixstowe transshipment, from Ambarlı port,to Rotterdam port, by truck and rail from Rotterdam port to Bergheim.
Route 2	Road+sea+road(all truck and truck+ rail via Hamburg)	Ankara–Bergeim by truck from Ankara and Ambarlı port, by sea transportation via Bremerheaven transshipment, from Ambarlı port,to Hamburg port, by truck from Hamburg port to Bergheim and by truck + rail from Hamburg port to Bergheim via Luxemburg
Route 3	Road+sea+ road (all truck, all rail and barge via Antwerp)	Ankara–Bergeim by truck from Ankara and Ambarlı port, by sea transportation via Deurganck transshipment, from Ambarlı port,to Antwerp port and by truck, by rail and barge taransportation alternative from Rotterdam port to Bergheim,
Route 4	All raod and all truck + rail via Luxemburg	Alltruck Ankaraİstanbul_Bulgary_Slovakia_Hungary_Austria_Germany (Bergheim) Truck +rail via Luxemburg Ankaraİstanbul_Bulgary_Slovakia_Hungary_Austria_Germany (Colognee_Luxemburg_Bergheim)
Route 5	Road+sea+road(all truck and all rail via Rotterdam)	Ankara–Bergeim by truck from Ankara and Ambarlı port, by sea transportation from Ambarlı port,to Bremerheaven port with direct service, by truck and rail from Bremerhaven port to Bergheim.
Route 6	Road+sea+road(all truck via Genoa)	Ankara–Bergeim by truck from Ankara and Ambarlı port, by sea ferry , from Ambarlı port,to Genoa port with direct service and by truck from Genoa port to Bergheim.

Source: Authors

Although all combinations shown in the table may be used in main assumptions for the application of the model are that on delivery leg at destination point, different modes and their different combinations using such as all truck, rail+ barge, truck + rail.... Distance from origin point to destination point are found, and all different measures were converted into km (1 mil = 1,609344 km), with using the average speed of each transportation modes, estimated transit time were calculated. All ports' loading unloading port charges were found and also freights are calculating by the average freight offers of Ml and MSC lines. [2] These rates are

[1] http://www.bergheim.de visited on 14th March 2010

[2] http://www.maerskline.com/appmanager/ last visited on 31 th March 2010

indicative, in the market there has been cheaper prices. The reason of selecting Ml and MSC is two of them is the most important lines operated on World trade with their high quality of service; high number of ships in their fleet , high accessible rates. When converting prices to each other this rates are used (1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28 UTC)[1] Beside these a standard TIR (Transports Internationaux Routiers)/trailer was used in the road legs of destination with average speed of 50 km/h. Delays were assumed in the border crossings, terminals and ports. 40' foot container was used at the sea leg of the routes. Foodstuff is used as commodity, also ATR document is a customs document used in to benefit from cheaper rates of duty and therefore certifies that the product has been put in free circulation either in Europe. Container ship speed is assumed to be 13,5 knots. In terms of the legs related to the road transport, all costs shown includes the transport and handling costs, customs fee, bridge and canal tolls, highway and parking fees, costs related to TIR carnet and CMR insurance as well as fixed costs for a single journey.

All routes start at the origin point of Ankara, Turkey and finish at destination point of Bergheim, Germany. In the first leg of all routes From Ankara to Ambarli port, inland transportation is operated by truck, the distance was 500 km. Loading and discharcing co by truck can be taken 4 hours beside this, the voyage can be taken 7.15 hours with the speed of 70 km/hour Addition to this 6 hours detention time total cost of leg 1 is $ 1280. Using truck for inland transportation is the most expensive and fastest mode especially in Turkey, because railway hasn't be used efficiently and also effectively. It is taken into consideration that some detention time could be so such hours added to transit time.

Second legs of all routes can be defined as container loading operation times and costs based, the container must be stuffed in port store yard 2-12 hours before ship's cut off. In Ambarlı port, Tr container operation ships can be take maximum 22 hours. This leg can be changed with ships for all routes identified below. Addition to this, detention time 16 hours which is average time of waiting time on the port, customs procedures and container gate in times included. The cost of leg 2 is totally $ 283 included Ambarlı port export local charges which included origin handling charge (OHC) , port security export (PSE), origin documentation fee (ODF) and temporary customs export (THC) .

In third legs, sea transportation is carried out to the destination of European ports (Rotterdam, Antwerp, Bremerhaven, Hamburg and Genoa). All the routes have different transit time and cost. The sea freight includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI). Forth legs identified as unloading container operation of ships in discharge port, with the cost as import local port charge included destination document fee (DDF), port security import (PSI) ,destination handling charge (DHC) ,customs and t1 document. Not only loading port but also unloading port operation has different operating and detention times. Average time of waiting on the port, customs procedures and container gate were included and calculated separately for all routes.

Last legs identified as Inland transportation between Discharge ports and Bergheim. This leg is diversified with using different modes, truck, rail, barge and their twice combinations are used. Costs and transit times are calculated by routes separately below.

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http:// www.mscturkey.com/tr last visited on 31 th March 2010

The rates are used with special assistance and kind advise about freight rates with detailed offers of Mr. Levent Tekin, Maersk Line Izmir Branch Sales Department Manager for his Msc Mersin Branch European Region Sales Executive, Ali Yüksek , Damco Land Side Service Department Executives, Fatih Yılmaz Karasu , Damco Sales Izmir Branch Assistant Manager, Sarper Kılıncoglu and Sales Executive, Comert Aksakal and Damco Hamburg Branch Pricing Department, Sales Executive, Dorien Warning

[1] http://www.xe.com/ucc/ visited on 4th March 2010

Routing Via Rotterdam (Netherland) Route 1

Different mode combinations can be considered in order to reflect the possible routes between Turkey-Germany ranging from all road option to multimodal transport options. Route 1 is clarified with the schedules of Ankara _ Ambarlı _ Rotterdam _ Bergheim via all truck and all rail alternatives. The route's length is 3895 km and it takes 1182 hours by truck with the cost of $ 3826 and it takes 1182 hours by rail with the cost of $ 3826.

FIGURE 2
Routing via Rotterdam (Netherlands) Route 1 Map

Source: Authors

The main leg of the route is considered to be sea transport and port of Rotterdam is used as the port of arrival. Beside this, multimodal choices such as rail and truck transportation are used in at destination and origin legs. The map figure is prepared by authors with Google map sources. But also all costs, transit times and distances of route's legs are shown detailed in table 4.

TABLE 4
Routing via Rotterdam (Netherland) Cost and Transit time based

Leg	**Mode**	**Transit Time**	**Distance Miles**	**Distance Km**	**Cost**	**Included**
1 Ankara _Istanbul	truck	8 hours		500 km	$1280[1] 1640TLR +VAT	
2 Ambarlı Port Local Charges		34 days			$283	FREE IN, ISPS;TCE; ODF[2]

[1] The rates are convering by using this equalization (1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28)[1]

[2] Maersk line Ambarlı port export local charges which included origin handling charge (OHC) , port security export (PSE), origin documentation fee (ODF) and temporary customs export (THC) .

3Ambarlı_Rotterdam	ship	21 days via felixstowe	3121nm[1]	5022 km	£360	BAS,CON,PRI,SER[2]
BAF					£390	BAF
4 Rotterdam Port Charge		20 hours			£ 35	DDF; PSI[3]
Destination Handling Charge					£185	DHC
Custom Clerance					£ 50	FOR 3 HTS CODE
T 1 Document					£ 45	
5_1Rotterdam_Bergheim	truck	14 hours 30 min		274 km	£570	
Fuel Surcharge			8%		£ 48	
Waiting Hours					£ 45 / per hour	
5_2Rotterdam_Bergheim	rail	21 hours 13 min			£470	

Source: Authors

For Rotterdam ships, Ambarlı port's loading operation takes 18 hours approximately and adding detention 16 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Sea transportation from Ambarlı port to Rotterdam port, total distance between these two ports is 3121 km and the service takes 21 days via Felixstowe , freight is $ 1015 (for 40 dc / container the commodity is food stuff. The freight includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI).Unloading container operation of ships in Rotterdam port, with the cost of $ 450, import local port charge included destination document fee (DDF), port security import (PSI) ,destination handling charge (DHC) ,customs and T1 document. For Ambarlı ships, Rotterdam port's loading operation take 20 hours approximately and adding detention 12 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Inland transportation between Rotterdam and Bergheim. This leg is diversified with using different modes, in this routes truck and rail are used. Transportation from Rotterdam to Bergheim by truck takes 4 hours 30 minutes, (the speed is 70 km/ hour) and adding approximately 10 hours for detention and waiting times, the distance is 274 km and cost is $ 823. Beside this, when rail is used the transportation takes 9 hours 13 minutes (the speed is 30 km/hour) and adding approximately 10 hours for detention and waiting times with the cost of $ 634.

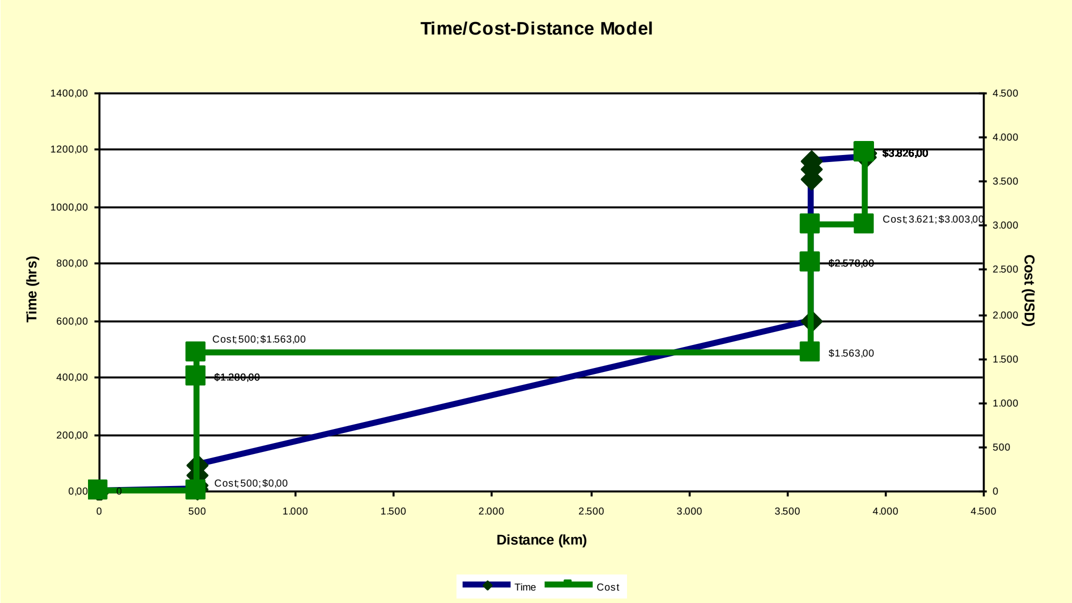
[1] http://www.distance-calculator.co.uk/distance-calculator.php#chosentown visited on 21 th May 2010

[2] The sea freights includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI). http://www.maerskline.com/appmanager/ last visited on 31 th March 2010/ http:// www.mscturkey.com/tr last visited on 31 th March 2010

[3] import local port charge included destination document fee (DDF), port security import (PSI) ,destination handling charge (DHC) ,customs and t1 document.

FIGURE 3

Time And Distance Cost Model Graphic For Ankara –Bergheim Via Rotterdam By Truck.

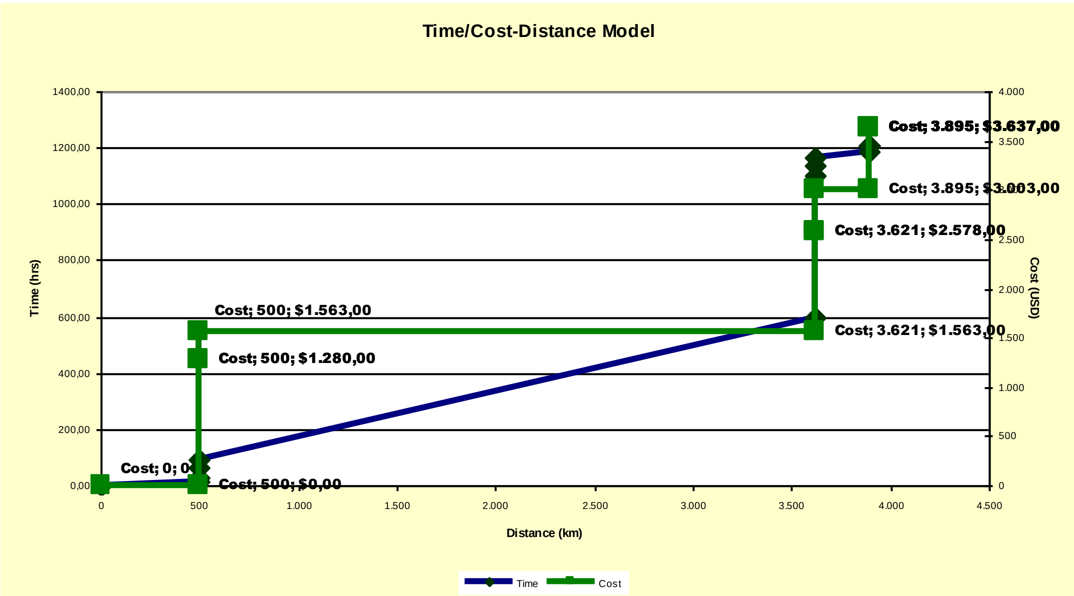


Source: Authors

The route’s length of 3895 km and it takes 1182 hours by truck with the cost of $ 3826.

FIGURE 4

Time And Distance Cost Model Graphic For Ankara –Bergheim Via Rotterdam By Rail.



Source: Authors

The route’s length of 3895 km and it takes and 1208 hours by rail with the cost of $ 3637.

Routing Via Hamburg (Germany) Route 2

Route 2 is clarified with the schedules of Ankara _ Ambarlı _ Hamburg _ Bergheim via all truck and all rail alternatives. The route's length of 6312 km and it takes 1293 hours by truck with the cost of $ 4092 and it takes 1304 hours by rail + truck with the cost of $ 4224.

FIGURE 5
Routing via Hamburg (Germany) Route 2 Map

Source: Authors

The main leg of the route is considered to be sea transport and port of Hamburg is used as the port of arrival. Beside this, multimodal choices such as truck and truck + rail transportation combinations are used in destination and origin legs. The map figure is prepared by authors with Google map sources. But also all costs, transit times and distances of route's legs are shown detailed in table 5.

TABLE 5

Routing via Hamburg (Germany) Cost and Transit time Based

Leg	**Mode**	**Transit Time**	**Distance Miles**	**Distance Km**	**Cost**	**Included** *
1 Ankara _Istanbul	truck	8 hours		500 km	1640 TLR+VAT	
2 Ambarlı Port Local Charges		32 hours			$283	FREE IN, ISPS;TCE; ODF
3Ambarlı_Hamburg	ship	23 days via Bremerhaven	3370 nm	5423 km	£450	BAS,CON,PRI,SER
BAF					£390	BAF
4 Hamburg Port Charge		34 hours			£ 32	DDF; PSI
Destinastion Handling Charge					£200	DHC
Custom Clerance					£ 50	FOR 3 HTS CODE
T 1 Document					£ 45	
51Hamburg_Bergheim	truck	17 hours 20 minutes		476 km	£650	
Fuel Surcharge			8%		£ 52	
Waiting Hours					£ 45 /per hour	
5-2 Hamburg _ Bergheim via Luxemburg	truck + rail	22 hours 50 minutes		485 km	£800	

Source: Authors

For Hamburg ships, Ambarlı port's loading operation takes 22 hours approximately and adding detention 10 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Transportation from Ambarlı port to Hamburg port, total distance between these two ports is 5536 km and the service takes 23 days via Bremerhaven, freight is $ 1134 (for 40 dc / container the commodity is food stuff. Unloading container from ship in Hamburg port with the cost of $ 445, import local port charge .For Ambarlı ships, Hamburg port's unloading operation takes 22 hours approximately and adding detention 12 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Inland transportation between Hamburg and Bergheim, transportation from Hamburg to Bergheim by truck takes 7 hours 20 minutes, (the speed is 70 km/hour) and adding approximately 10 hours for detention and waiting times, the distance is 274 km and cost is $ 877. Beside this, when truck + rail combination is used the transportation takes 4 hours to Luxemburg by truck with the cost of $ 877 and between Luxemburg and

* see table 2 for place of sign

(1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28 UTC)

Maersk line Ambarlı port export local charges which included origin handling charge (OHC) , port security export (PSE), origin documentation fee (ODF) and temporary customs export (THC) .

http://www.distance-calculator.co.uk/distance-calculator.php#chosentown visited on 21 th May 2010

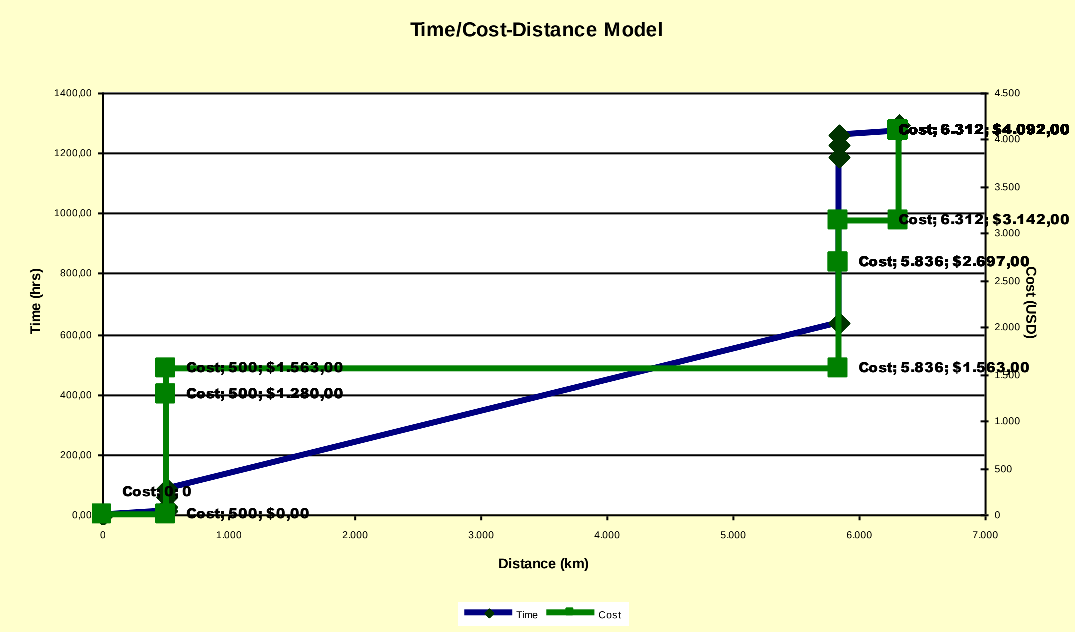
The sea freights includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI). http://www.maerskline.com/appmanager/ last visited on 31 th March 2010/ http:// www.mscturkey.com/tr last visited on 31 th March 2010

import local port charge included destination document fee (DDF), port security import (PSI) ,destination handling charge (DHC) ,customs and t1 document.

Hamburg transport by rail and it takes 6 hours 20 minutes (the speed is 30 km/hour) the cost of $ 205 and adding approximately 12 hours for detention, transshipment and waiting times with the total cost of $ 1082.

FIGURE 6

Time And Distance Cost Model Graphic For Ankara –Bergheim Via Hamburg By Truck

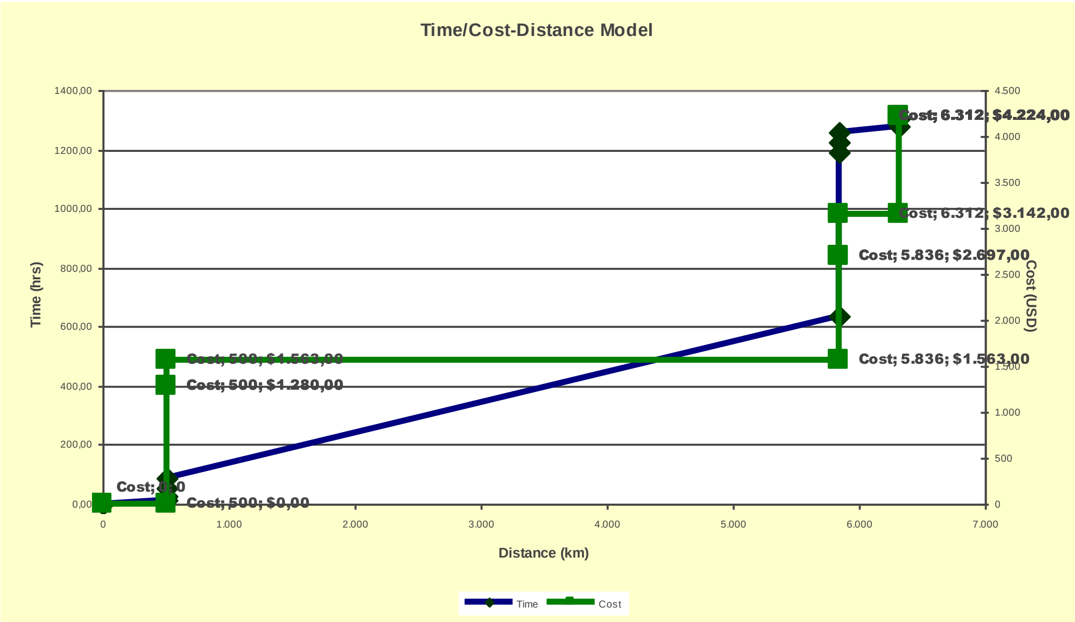


Source: Authors

The route's length of 6312 km and it takes 1293 hours by truck with the cost of $ 4092.

FIGURE 7

Time and Distance Cost Model Graphic For Ankara –Bergheim Via Hamburg By Truck + Rail Via Luxemburg.



Source: Authors

The route's length of 6312 km and it takes 1304 hours by rail + truck with the cost of $ 4224.

Routing Via Antwerp (Belgium) Route 3

Route 3 is clarified with the schedules of Ankara _ Ambarlı _ Antwerp_ Bergheim via all truck, all rail and barge alternatives. The route’s length is 5768 km and it takes 1343 hours by truck with the cost of $ 3729 ; it takes 1347 hours by rail with the cost of $ 3658 and it takes by barge 1368 hours and the cost of $ 3580.

FIGURE 8
Routing Via Antwerp (Belgium) Route 3 map

Source: Authors

The main leg of the route is considered to be sea transport and port of Antwerp is used as the port of arrival. Beside this, multimodal choices such as rail, truck and barge transportation combinations are used in at destination and origin legs. The map figure is prepared by authors with Google map sources. But also all costs, transit times and distances of route’s legs are shown detailed in table 6.

TABLE 6

Routing Via Antwerp (Belgium) Cost And Transit Time Based

Leg	**Mode**	**Transit Time**	**Distance Miles**	**Distance Km**	**Cost**	**Included** *
1 Ankara _Istanbul	truck	8 hours		500 km	1640TLR+VAT	
2 Ambarlı Port Local Charges		34 hours			$283	FREE IN, ISPS;TCE; ODF
3Ambarlı_Antwerp	ship	24 days via Deurganck	3114nm	5011 km	£400	BAS,CON,PRI,SER
BAF					£390	BAF
4 Antwerp Port Charge		34 hours			£ 38	DDF; PSI
Destination Handling Charge					£158	DHC
Custom Clerance					£ 50	FOR 3 HTS CODE
T 1 Document					£ 45	
5_1Antwerp_Bergheim	truck	14 hours 30 munites		257 km	£450	
Fuel Surcharge					£ 70	
Waiting Hours					£ 45 /per hour	
5_2Antwerp_Bergheim	rail	18 hours 50 minutes			£470	
5_3Antwerp_Bergheim	barge	27 hours 13 minutes			£412	

Source: Authors

Loading container on ships in Ambarlı port. For Antwerp ships, Ambarlı port's loading operation takes 18 hours approximately and adding detention 16 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Transportation from Ambarlı port to Antwerp port, total distance between these two ports is 5011 km and the service takes 24 days via Deurganck, freight is $ 1066 (for 40 dc / container the commodity is food stuff. Unloading container from ship in Antwerp port with the cost is $ 395 as import local port charge. For Ambarlı ships, Antwerp port's loading operation takes 22 hours approximately and adding detention 12 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Inland transportation between Antwerp and Bergheim, this

* see table 2 for place of sign

(1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28 UTC)

Maersk line Ambarlı port export local charges which included origin handling charge (OHC) , port security export (PSE), origin documentation fee (ODF) and temporary customs export (THC) .

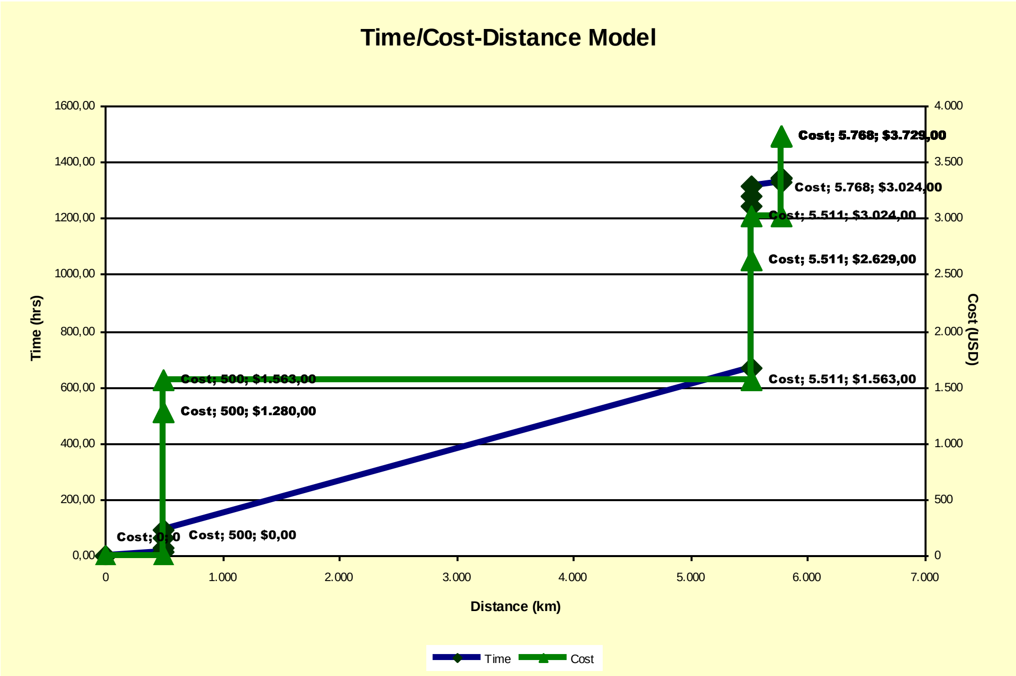
http://www.distance-calculator.co.uk/distance-calculator.php#chosentown visited on 21 th May 2010

The sea freights includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI). http://www.maerskline.com/appmanager/ last visited on 31 th March 2010/ http:// www.mscturkey.com/tr last visited on 31 th March 2010

import local port charge included destination document fee (DDF), port security import (PSI) ,destination handling charge (DHC) ,customs and t1 document.

leg is diversified with using different modes, in this route truck, rail and barge modes are used. Transportation from Antwerp to Bergheim by truck takes 4 hours 30 minutes, (the speed is 70 km/hour) and adding approximately 10 hours for detention and waiting times, the distance is 257 km and cost is $ 705. Beside this, when rail is used the transportation takes 8 hours 56 minutes (the speed is 30 km/ hour) and adding 10 hours detention with the cost of $ 634 and between Antwerp and Bergheim transport by barge and it takes 17 hours 20 minutes (the speed is 15 km/hour) the cost of $ 556 and adding approximately 10 hours for detention and transshipment.

FIGURE 9
Time And Distance Cost Model Graphic For Ankara –Bergheim Via Antwerp By Truck

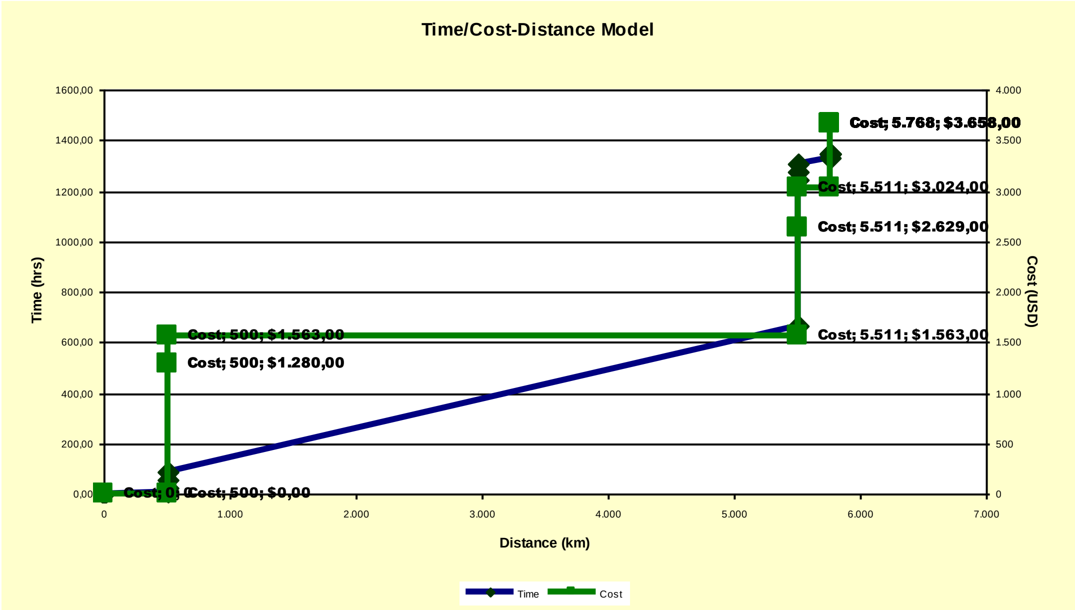


Source: Authors

The route’s length of 5768 km and it takes 1343 hours by truck with the cost of $ 3729.

FIGURE 10

Distance Cost Model Graphic For Ankara –Bergheim Via Antwerp By Rail

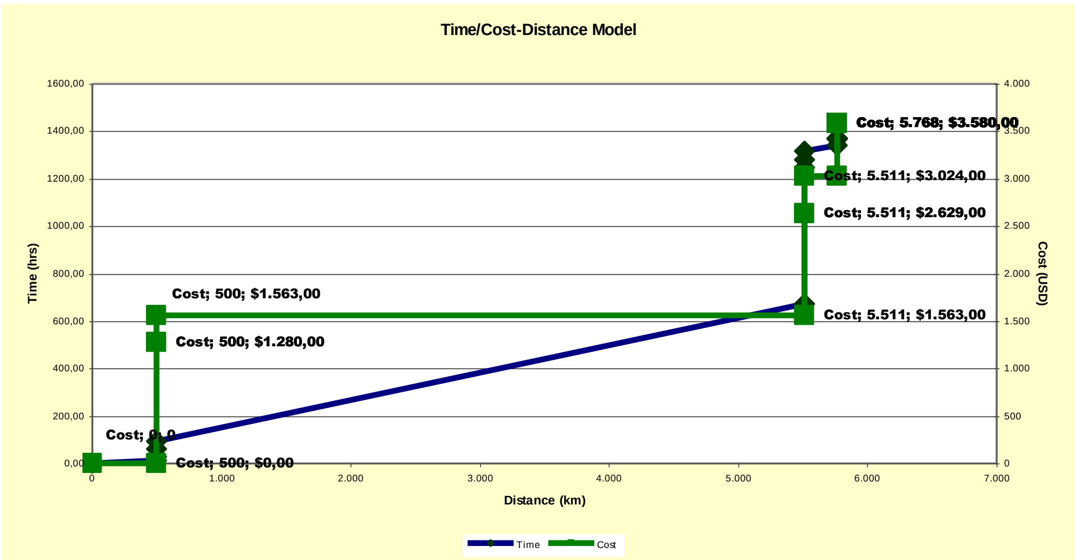


Source: Authors

The route's length of 5768 km and it takes 1347 hours by rail with the cost of $ 3658

FIGURE 11

Time And Distance Cost Model Graphic For Ankara –Bergheim Via Antwerp By Barge



Source: Authors

The route's length of 5768 km and it takes by barge 1368 hours and the cost of $ 3580.

Routing Via Istanbul (Turkey) Route 4

Route 4 is clarified with the schedules of Ankara _ Istanbul_ Bergheim via all truck, truck + rail alternatives. The route's length of 2548 km and it takes 254 hours by truck with the cost of $ 5300 and the lenght is 2506 km and it takes 293 hours by rail with the cost of $ 4654.

FIGURE 12
Routing Via Istanbul (Turkey) Route 4 Map

Source: Authors

The main leg of the route is considered to be road transportation and schedule has been shown as fallows Ankara _ Istanbul _ Bulgary _ Slovakia _ Hungary _ Austria _Germany (Bergheim). The map figure is prepared by authors with Google map sources. But also all costs, transit times and distances of route's legs are shown detailed in table 7.

TABLE 7
Routing Via Istanbul (Turkey) Cost And Transit Time Based

leg	**mode**	**transit time**	**distance km**	**Cost** [*]
1 Ankara _Istanbul	truck	8 hours	500 km	1640 TLR+VAT
2_1 Istanbul_Bergheim	all truck	108 hours	2048 km	£ 3000[1]
2_2 Istanbul-Luxemburg	truck	96 hours	1830 km	£ 2350
2_2.1Luxemburg_ Bergheim	rail	18 hours 20 minutes	176 km	£150

Source: Authors

Route transportation starts with the origin point of Ankara, and between Ankara and Istanbul road transportation is used in that leg, the distance is 500 km and it takes 7 hours 15 minutes (70 km/hours speed) adding 6 hours detention time total cost of leg 1 is $ 1280.

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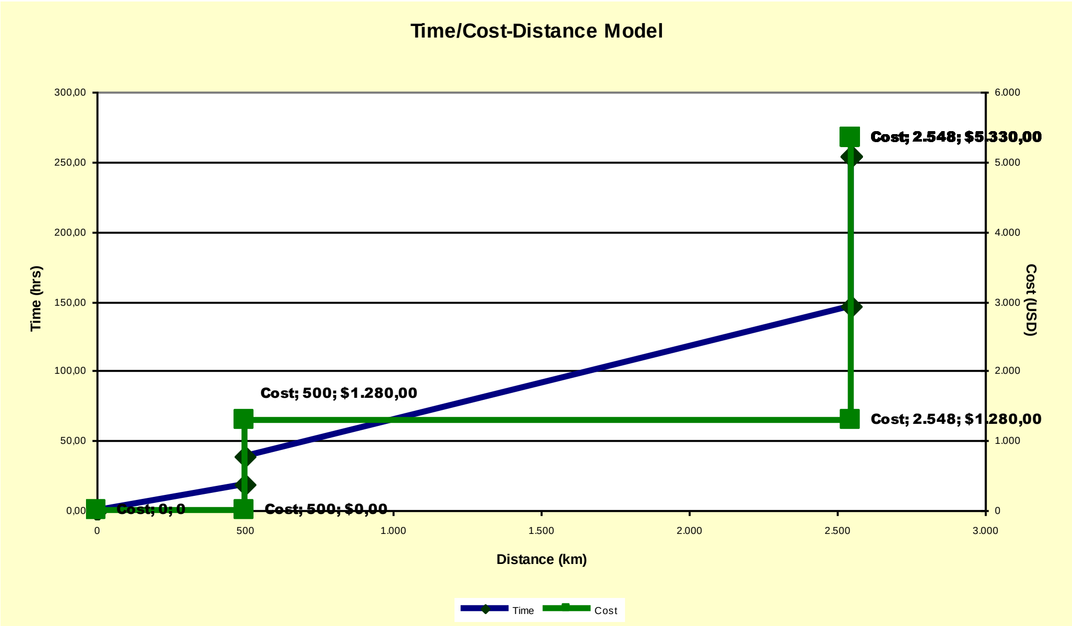
[*] (1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28 UTC)

http://www.distance-calculator.co.uk/distance-calculator.php#chosentown visited on 21 th May 2010

[1] freight offer which is given by Damco Land Side Service Department Executives, Fatih Yılmaz Karasu , Damco Hamburg Branch Pricing Department, Sales Executive, Dorien Warning in march

Inland transportation between Istanbul and Bergheim by all truck takes 108 hours (the speed is 70 km/hour) include detention and waiting times, the distance is 2058 km and cost is $ 4050. Beside this, when truck + rail is used the transportation takes 96 hours between Istanbul to Luxemburg (the speed is 70 km/hour) cost of $ 3172 and between Luxemburg and Bergheim transport by rail and it takes 8 hours 20 minutes (the speed is 30 km/hour) and adding approximately 10 hours for detention, transshipment with the cost of $ 202.

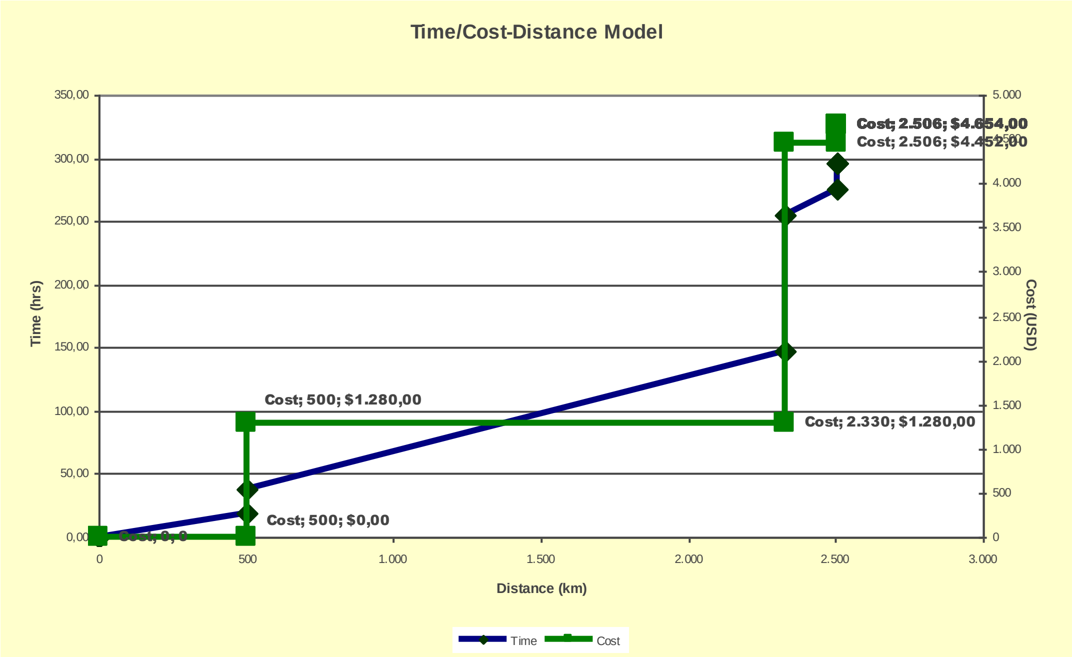
FIGURE 13
Time And Distance Cost Model Graphic For Ankara –Bergheim Via Istanbul All Truck



Source: Authors

The route’s length of 2548 km and it takes 254 hours by truck with the cost of $ 5300.

FIGURE 14
Time And Distance Cost Model Graphic For Ankara –Bergheim Via Istanbul By Truck + Rail



Source: Authors

The route's length is 2506 km and it takes 293 hours by truck +rail via Luxemburg with the cost of $ 4654

Routing Via Bremerhaven (Germany) Route 5

Route 5 is clarified with the schedules of Ankara _ Ambarlı _ Bremerhaven _ Bergheim via all truck and all rail alternatives. The route's length of 6450 km and it takes 955 hours by truck with the cost of $ 4248 and it takes 1000 hours by rail with the cost of $ 4024.

FIGURE 15
Routing Via Bremerhaven (Germany) Route 5 Map

Source: Authors

The main leg of the route is considered to be sea transport and port of Bremerheaven as the port of arrival. Beside this, multimodal choices such as truck and truck + rail transportation combinations are used in at destination and origin legs. The map figure is prepared by authors with Google map sources. But also all costs, transit times and distances of route's legs are shown detailed in table 8.

TABLE 8
Routing Via Bremerhaven (Germany) Cost And Transit Time Based

Leg	Mode	Transit Time	Distance Miles	Distance Km	Cost	Included *
1 Ankara _Istanbul	truck	8 hours		500 km	1640 TLR+VAT	
2Ambarlı Port Local Charges		30 hours			$283	FREE IN, ISPS;TCE; ODF
3Ambarlı_Bremerheaven	ship	16 days direct	3316 nm	5336 km	£400	BAS,CON,PRI,SER
BAF					£390	BAF
4 Bremerheaven Port Charge		34 hours			£ 32	DDF; PSI
Destination Handling Charge					£200	DHC
Custom Clerance					£ 50	FOR 3 HTS CODE
T 1 Document					£ 45	
5_1Bremerheaven_Bergheim	truck	17hours 52 min		527 km	£800	
Fuel Surcharge					£ 70	
Waiting Hours					£ 45 /per hour	
5_2Bremerheaven_Bergheim	rail	29hours 56 min		527 km	£700	

Source: Authors

Loading container on ships in Ambarlı port . For Bremerheaven ships, Ambarlı port's loading operation takes 20 hours approximately and adding detention 10 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Transportation from Ambarlı port to Bremerhaven port, total distance between these two ports is 6450 km and the direct service takes 16 days. Freight is $ 1066 (for 40 dc / container the commodity is food stuff. Unloading container from ship in Bremerhaven port with the cost is $ 445. For Ambarlı ships, Bremerheaven port's loading operation takes 22 hours approximately and adding detention 12 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Inland transportation between Bremerhaven and Bergheim is diversified with using different modes, in this routes truck and rail modes are used. Transportation from Bremerhaven to Bergheim by truck takes 7 hours 52 minutes, (the speed is 70 km/ hour) and adding approximately 10 hours for detention and waiting times, the distance is 527 km and cost is $ 1174. Beside this, when rail is used the transportation takes 17 hours 56 minutes with the cost of $ 950.

* see table 2 for place of sign

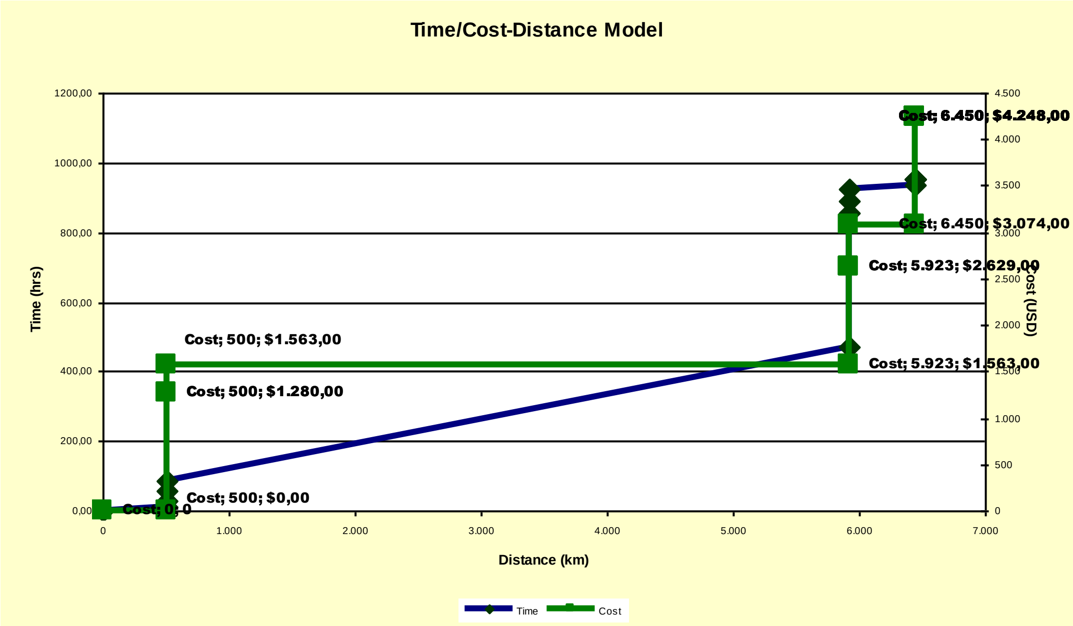
(1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28 UTC)

Maersk line Ambarlı port export local charges which included origin handling charge (OHC) , port security export (PSE), origin documentation fee (ODF) and temporary customs export (THC) .

http://www.distance-calculator.co.uk/distance-calculator.php#chosentown visited on 21 th May 2010
The sea freights includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI). http://www.maerskline.com/appmanager/ last visited on 31 th March 2010/ http:// www.mscturkey.com/tr last visited on 31 th March 2010

import local port charge included destination document fee (DDF), port security import (PSI) ,destination handling charge (DHC) ,customs and t1 document.

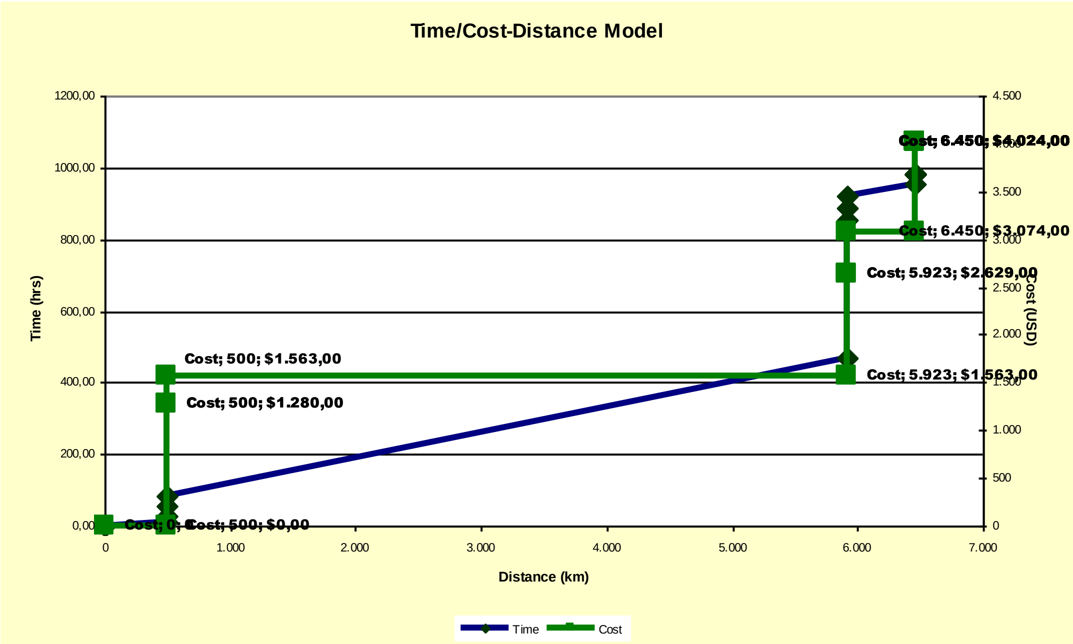
FIGURE 16
Time And Distance Cost Model Graphic For Ankara –Bergheim Via Bremerhaven By Truck



Source: Authors

The route's length of 6450 km and it takes 955 hours by truck with the cost of $ 4248.

FIGURE 17
Time And Distance Cost Model Graphic For Ankara –Bergheim Via Bremerhaven By Rail



Source: Authors

The route's length of 6450 km and it takes 1000 hours by rail with the cost of $ 4024.

Routing Via Genoa (Italy) Route 6

Route 2 is clarified with the schedules of Ankara _ Ambarlı _ Genoa _ Bergheim via ferry and all truck alternatives. The route's length of 3250 km and it takes 706 hours by truck with the cost of $ 5021.

FIGURE 18
Routing Via Genoa (Italy) Route 6 Map

Source: Authors

The main leg of the route is considered to be sea transport and port of Genoa is used as the port of arrival. Beside this, multimodal choices such as ferry and truck + transportation combinations are used in at destination and origin legs. The map figure is prepared by authors with Google map sources. But also all costs, transit times and distances of route's legs are shown detailed in table 9.

TABLE 9

Routing Via Genoa (Italy) Cost And Transit Time Based

Leg	Mode	Transit Time	Distance Miles	Distance Km	Cost	Included *
1 Ankara _Istanbul	truck	8 hours		500 km	1640 TLR +VAT	
2 Ambarlı Port Local Charges		30 hours			$283	FREE IN, ISPS;TCE; ODF
3Ambarlı_Genoa	ferry	11 days direct	1262 nm	2030 km	£850	BAS,CON,PRI,SER
BAF					£190	BAF
4 Genoa Port Charge		32 hours			£ 77	DDF; PSI
Destination Handling Charge					£150	DHC
Custom Clerance					£ 50	FOR 3 HTS CODE
T 1 Document					£ 45	
5Genoa_Bergheim	all truck	28 hours 30 minutes		740 km	£1200	

Source: Authors

Loading container on ships in Ambarlı port . For Genoa ships, Ambarlı port's loading operation takes 20 hours approximately and adding detention 10 hours which is average time of waiting time on the port, customs procedures and container gate in times included. The cost of leg 2 is $ 283 included Ambarlı port export local charges. Transportation from Ambarlı port to Genoa port, total distance between these two ports is 2030 km and the direct ferry service takes 11 days. Freight is $ 1404 (for 40 dc / container the commodity is food stuff. Unloading container from ship in Genoa port with the cost is $ 434. For Ambarlı ships, Genoa port's loading operation takes 20 hours approximately and adding detention 12 hours which is average time of waiting time on the port, customs procedures and container gate in times included. Transportation from Genoa to Bergheim by truck takes 18 hours 30 minutes, (the speed is 70 km/ hour) and adding approximately 10 hours for detention and waiting times, the distance is 740 km and cost is $ 1620.

* see table 2 for place of sign

(1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28 UTC)

Maersk line Ambarlı port export local charges which included origin handling charge (OHC) , port security export (PSE), origin documentation fee (ODF) and temporary customs export (THC) .

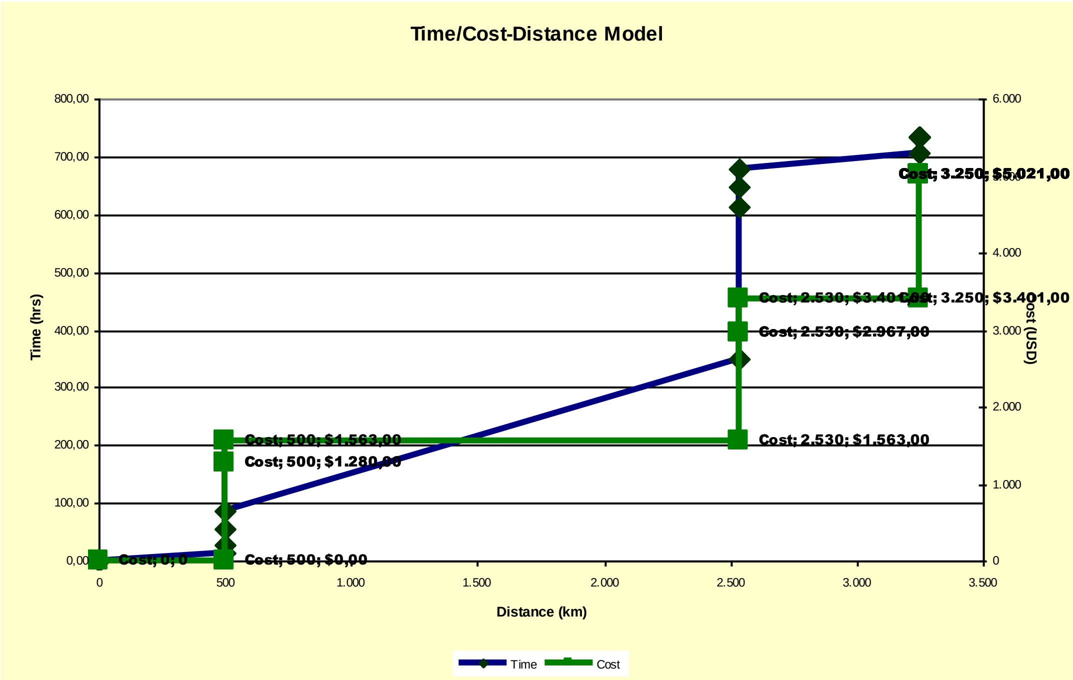
http://www.distance-calculator.co.uk/distance-calculator.php#chosentown visited on 21 th May 2010

The sea freights includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI). http://www.maerskline.com/appmanager/ last visited on 31 th March 2010/ http:// www.mscturkey.com/tr last visited on 31 th March 2010

import local port charge included destination document fee (DDF), port security import (PSI) ,destination handling charge (DHC) ,customs and t1 document.

FIGURE 19

Time And Distance Cost Model Graphic For Ankara –Bergheim Via Genoa By Truck



Source: Authors

The route’s length of 3250 km and it takes 706 hours by truck with the cost of $ 5021

EVALUATION OF THE ROUTES

When inland transportation is operated by truck, the transit times of schedules decreases, although its high speed and reliability, the cost increases. Sea transportation can be logical and cheaper when it is used long distance as intermediate leg of the transportation leg. It is also takes so much time because of transshipment. Using barge for inland transportation is the cheapest, hard to reach and also the long-timed when compare other modes. Using railway is in the middle of barge and truck when comparing cost and transit time based. All costs, transit times and distances of route’s are shown detailed in table 10.

TABLE 10

Comparing the Routes Between Ankara_Bergheim Total Cost And Transit Time Based

Route	Mode	Distance /Km	Time / Hours	Cost /$
Ankara-Ambarlı-Rotterdam-Bergheim	truck	3895 km	1177 hours	$3826[1]
Ankara-Ambarlı-Rotterdam-Bergheim	rail	3985 km	1208 hours	$3637
Ankara-Ambarlı-Hamburg-Bergheim	truck	6312 km	1294hours	$4092
Ankara-Ambarlı-Hamburg-Bergheim	truck+rail	6312 km	1282 hours	$4224
Ankara-Ambarlı-Antwerp-Bergheim	truck	5768 km	1343 hours	$3729
Ankara-Ambarlı-Antwerp-Bergheim	rail	5768 km	1348 hours	$3658
Ankara-Ambarlı-Antwerp-Bergheim	barge	5768 km	1369 hours	$3780
Ankara-Istanbul-Berheim	all truck	2582 km	254 hours	$5300
Ankara-Istanbul-Berheim	truck+rail	2506 km	289 hours	$4654
Ankara-Ambarlı-Bremerhaven-Bergheim	truck	6450 km	956 hours	$4248
Ankara-Ambarlı-Bremerhaven-Bergheim	rail	6450 km	1000 hours	$4024
Ankara-Ambarlı-Genoa-Bergheim	Ferry+truck	3250 km	706 hours	$5021

Source: Authors

If it is need to choose best routes between these routes, the fastest at the same time the most expensive route is Ankara-Istanbul-Bergheim all truck; The cheapest route is Ankara – Ambarlı – Rotterdam - Bergheim via truck.

The cost modal's one of the advantage is, these combinations can be a chance of point of view of planning logistics process, supplying customer needs, finding the best route, capacity, costs, transit times for efficient use in modes. Addition to these the transport cost modal can be adopted any given routes and various modes and modals. For instance the cost of legs can be adapted into different origin and destination.

CONCLUSION and FURTHER RESEARCH

This study represents a cost model for multimodal transport between Turkey and Germany by suggesting alternatives routes. Berestford's cost model is applied on the routes between Ankara and Bergheim for non perishable foodstuff (18 tonnes carried with equipment of 40 DC). Turkey, as a country in the developing phase of multimodal transport, must re-evaluate the main determinants in decision making in terms of mode selection and multimodality specifically and the role of the main parties involved in this process. This re-evaluation requires a detailed investigation of the current situation in terms of multimodal transport, and recognition of advantages and disadvantages.

Turkey as a country which is close to main international trade routes with its strategic location and increasing trade volumes can be considered as a potential country for the implementation of multimodal

[1] (1 £ = 1.35020 $, Live rates at 2010.04.03 13:45:28 UTC)

http://www.distance-calculator.co.uk/distance-calculator.php#chosentown visited on 21 th May 2010
The sea freights includes charges as bunker adjustment factor (BAF), currency adjustment factor (CAF), congestion (CON), security (SER), primaj (PRI). http://www.maerskline.com/appmanager/ last visited on 31 th March 2010/ http:// www.mscturkey.com/tr last visited on 31 th March 2010

transport services. Improving the infrastructure for the main transport modes and achieving the integration between modes will not only increase the use and the demand for these services but also will help Turkey to have a more active role in international transport corridors. This study aimed to provide a new and different perspective to the trade between Turkey and European countries by focusing on foodstuff exports to Germany. Although researches related to multimodal transportation in the domestic trade of Turkey has been conducted earlier, this study is the second application in the field after Denktas Sakar's study (Denktas Sakar, 2010) which investigates the possible international multimodal transportation routes by considering Turkey as the origin point.

As for further research, views of different parties such as shippers of the main commodity groups such as automotive parts, machineries, garments, furniture etc, main shipper associations, governmental bodies, logistics service providers in Turkey may be used to obtain a different perspective. Also investigating the views of road, rail transport companies providing the service from Ankara to Bergheim, representatives of shipping agencies at different ports in Germany and importer companies in Germany may be helpful to get an insight in terms of the destination leg of the transport system. A more detailed investigation of subjective factors in terms of each separate leg of the overall route may bring important outcomes in order to have an in-depth understanding of each leg. In terms of different methodological approaches, focus group studies and Delphi surveys can be used to investigate the main routing alternatives in detail. Moreover, environmental perspective such as CO2 emissions at road leg of the multimodal transport operations should be investigated which is one of the main concerns of the European Union countries. Environmental concerns also constitute the main motivation for the use of multimodal transport. Another important consideration to be discussed in the further research is the legal environment of the multimodal transport. The existence of different regulations and different parties in the multimodal transport, true definition of multimodal transport operators should be investigated and these may be evaluated together with the routes investigated in this study.

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THE EFFECT OF OIL PRICE VOLATILITY ON THE ISTANBUL STOCK EXCHANGE TRANSPORTATION INDEX

Murat Kıyılar[1], Serra Eren Sarıoğlu[2], Ebru Demirci[3]

Abstract — *There have been extensive research with various econometric models taking a broad perspective to present the relationship between oil price and a country's macro economy. The relevant literature mainly focuses on developed regions like North America and Europe and is primarily concerned about the country-wide macroeconomic indicators such as GDP / GNP or with a narrower view, the stock-market level in question. However, recent studies have revealed a relation between the movements in oil prices and current value of firms, which reflect the value of their anticipated future profits. Therefore, the present study with a novel approach examines the relationship between the oil price volatility and Transportation Index (XULAS) comprised of transportation firms listed in Istanbul Stock Exchange (ISE) of Turkey, a developing country. It uses monthly data from June 1997 to July 2010 with an econometric model to investigate the effect of oil price volatility on the XULAS covering the transportation industry, in which the movement of oil prices directly affects the financial performance of operating companies. The results are expected to enhance our understanding of the interaction between those variables and are of use to investors, managers and policy-makers.*

Keywords — *Oil price volatility, Stock returns, Transportation industry*

INTRODUCTION

Throughout the world history, oil has been one of the most crucial players in shaping the countries' economical and political developments. In the post-World War II era, the series of crude oil price shocks have affected the world economy. The OPEC oil embargo of 1973 increased the price of oil by $10 per barrel and created economic and social crises in the developing countries. The second oil price shock was in 1979 and led to global recession. The third was in 1990 after Iraq's invasion of Kuwait. The prices rised by $10 per barrel again. The oil prices have grown up from $12 to $24 per barrel in 1999 in the last oil shock.

Having in mind the importance of oil to the world economy, it is not surprising that there is a large body of literature studied the relationship between oil prices and macroeconomic variables such as economic growth, inflation, international debt and exchange rates. But in contrast, there exists a few papers that link oil prices to financial markets. Most of these papers deal with the data of the industrialized countries. Little research has been conducted on the effects of oil shocks in the developing stock markets. The contribution of this article is twofold. The main contribution to the literature is to study the impact of oil price changes on Turkish stock market, a developing financial market. As far as we are concerned, oil prices affect the industries with a relatively high proportion of their costs are oil-based inputs, especially Transportation sector. In this article, we conduct a detailed investigation of oil price effects to Transportation industry. This is the second contribution of the paper.

The remainder of this article is organized as follows. The next section discusses the importance of oil in the Turkish economy and different sectors in Turkey, especially the transportation sector. The following section provides a review of the literature. The next section describes methodology and data. The "Results" section presents and interprets the empirical results. The last section concludes the paper with a discussion of

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the main implications of the findings as well as outlining the study's limitations and making suggestions for further work.

OIL AND THE TURKISH ECONOMY

Oil and oil related products have very big importance for world economy and politics. Economic development and growth are depending on consumption and production of oil. Both producing and consuming countries are aware of the impact of the fluctuation of oil prices. The balance of demand and supply of oil has important impact on the price of oil. In recent years, higher oil prices led to significant redistribution of global income from oil importers to oil exporters.

Projected world oil consumption increases by 1.6 million barrels per day (bbl/d) in 2010. Countries outside the OECD, especially China, Saudi Arabia, and Brazil, represent most of the expected growth in the world oil consumption . Among the OECD countries, only the United States is expected to show significant increases in oil consumption of about 0.15 million bbl/d in both 2010 and 2011. Projected global oil consumption grows by another 1.5 million bbl/d in 2011 .

There has been a deep interest by researchers over recent years in the role of oil and other energy sources on financial markets. Energy prices, especially oil prices are likely to have important potential impact on the cost of factor inputs for many countries.

Globally, the 1970's were characterized by an increasing dependence of the economies on oil. Especially in 1973, there are large and unpredicted movements in the oil market and poor economic context especially in the USA. After big crisis, it is natural to investigate the potential links between oil prices and macroeconomic activities. In recent years, the big fluctuations of oil prices affect the oil importer countries' economies deeply. An oil price increase might also have a negative impact on consumption, investment and employment.

Turkey is not a major oil producer, its emerging role is an important oil transit country. This strategic situation makes increasingly important to world oil markets. Turkey is one of the importer of energy products in the world and also has a growing economy. Turkey's economic growth is highly industry oriented. There is a growing demand for energy in the results of Turkey's spectacular economic growth. The demand for energy comes from energy related sectors such as construction and transport. You can see the total consumption and import of Turkey for the years 2004-2009 on Tables 1 and 2. The increasing trend of oil consumption and imports declined in 2008 and 2009 because of the global crisis. The oil consumption is projected to increase in 2010. Turkey's total energy consumption depends on the oil, natural gas and electricity. Oil consumption is 44% of total energy consumption. It is expected that the oil price fluctuation in international markets might have an impact on the Turkish economy.

TABLE 1

Total Consumption of Petroleum Products of Turkey (Thousand Barrels Per Day)

2005	2006	2007	2008	2009
659.3343	677.5863	689.8055	677.6858	579.4767

Source: www.eia.doe.gov

TABLE 2

Total Imports of Refined Petroleum Products (Thousand Barrels Per Day)

2004	2005	2006	2007	2008
241.8585	242.3395	293.3172	319.1617	297.2767

Source: www.eia.doe.gov

It is expected that the potential for a negative oil price sensitivity to be greatest in industries with a relatively high proportion of their costs devoted to oil based inputs, such as Transport. Oil price changes affect the ability of firms to decrease the cost of inputs. These firms should hedge against the oil price risk. Industries are not homogeneous so oil price fluctuation can have different influences. We expect a negative oil return sensitivity in the non-oil related industries where in oil price changes directly impact on cost. There should be negative oil price sensitivity at the transportation industry.

Highway and Jet traffic have a rapid expansion since 1990's in the world. And also private automobile ownership has been rising. Transportation sector is one of the growing industries in Turkey. Development of the Turkish transportation industry has led to a surge in demand for oil products especially fuel oil. The fluctuation of oil prices causes increasing the cost of fuel oil.

Transportation Index (XULAS) is comprised of the stocks of Transportation industry. It consists of a few transportation companies. These companies are doing airline, transportation and logistics business. Transportation companies should take positions for hedging the oil price risk. Companies and investors should analyze oil price sensitivity of stock and index market returns. The aim of this paper is to analyze the oil sensitivity of the Turkish Transportation Stock market index returns.

LITERATURE

Although there has been a continuing interest by researchers in the impact that energy sources, especially oil, have on stock markets, the number of studies in this area is very limited. Besides, most of this limited papers work on the data of developed countries like US, UK, Canada and Japan. The number of studies dealing with developing countries is very restricted.

As we have mentioned before, oil prices started fluctuating in 1973. So this short time horizon leave little chance to researchers to have meaningful statistical inference about the effects of oil prices to economy.

One of the earlier studies performed by [4] investigates whether oil price risk effects the prices in the stock markets. Actually, the researchers provided a test of a multi-factor asset pricing model using innovations in a set of macroeconomic variables. Oil prices were chosen as one of the independent variables in the study. But they found no evidence that oil prices are one of the factors constituting the stock prices in US equity markets.

Reference [2] tests whether an oil price factor constitutes a systematic influence in the determination of prices in the equity markets of the US, Canada, Japan and UK.

Reference [9] analyzes the impact of oil price changes in Canada, Japan, UK and US. They show that all the markets respond negatively to oil shocks. But the magnitude of the impact is substantially different across the four markets. The evidence suggests that the US and Canadian stock markets are rational: the reaction of stock prices to oil shocks can be completely accounted for by their impact on current and expected future real cash flows alone. In contrast, the evidence for Japan and UK is puzzling. In both countries, the researchers are unable to explain the effects of oil price shocks on stock returns using changes in future cash flows and/or financial variables.

While [9] uses quarterly data, [8] considers daily data on the oil futures market and the stock market, and estimates a vector autoregressive model in order to determine the effect of oil shocks to futures and spot markets of US. The researchers find an evidence of a connection between oil futures returns and oil stock returns and stock prices are negatively impacted by rises in oil and gas prices. Reference [11], using the same methodolgy of [8] and including US industrial production and short interest rates to the model, separates positive form negative oil shocks. Both shocks affect aggregate stock returns but positive oil shocks are of large importance, whereas negative ones have little or no effect.

Reference [7] investigates the sensitivity of Australian industry equity returns to an oil price factor over the period 1983-1996. The researchers find significant positive oil price sensitivity in the Oil and Gas and Diversified Resources industries. Similarly they find negative oil price sensitivity in the Paper and Packaging, and Transport industries.

Reference [12] provides a detailed analysis of the relationship between oil prices and equity values in the Canadian oil and gas sector, using monthly data covering the period from the final quarter of 1983 to the final quarter of 1999. [12] reports a significant positive relationship between the oil and gas equity index and the price of crude oil.

Reference [10] finds that expected changes in the oil price are able to predict relative sector performance in US.

Reference [5] tests whether changes in oil prices predict stock returns. The researchers use data of 48 countries, a world market index and price series of several types of oil. Stock returns tend to be lower after oil price increases and higher if oil prices decline in the previous month. They use thirty-year sample of monthly data for developed stock markets but the time horizon was shorte in emerging markets.

Reference [6] investigates the relationship between the price of crude oil and equity values in the oil and gas sector using data relating to the UK. The evidence indicates that the relationship is always positive, often highly significant and reflects the direct impact of volatility in the crude oil on share values within the sector.

Reference [3] using a multifactor arbitrage pricing model, finds strong evidence that oil price risk impacts returns of emerging stock markets.

Reference [1] uses developed countries data (Japan, Norway, Sweden, the UK and the US) to present an empirical study of volatility spillover from oil prices to stock markets within an asymmetric BEKK model.

They find strong evidence of volatility spillover for all stock markets but the Swedish one, where only weak evidence is found. News impact surfaces show that, slthough statictically significant, the volatility spillovers are quantitatively small. The stock market's own shocks are more prominent than oil shocks.

DATA AND METHODOLOGY

The aim of this research is to find the impact of oil price volatility to the Transportation sector. As a matter of fact, the Brent crude oil prices are used to determine the oil price volatility. For the Transportation sector we use the Transportation Index (XULAS) in Istanbul Stock Exchange. The sample period for the XULAS index and Brent crude oil price is monthly and covers the period July, 30 1997 to July, 30 2010 resulting in 163 observations. The reason why starting from 1997 is that available return data XULAS index is beginning from July 1997. In Figure 1, you can see the trend of XULAS returns and Brent crude oil returns.

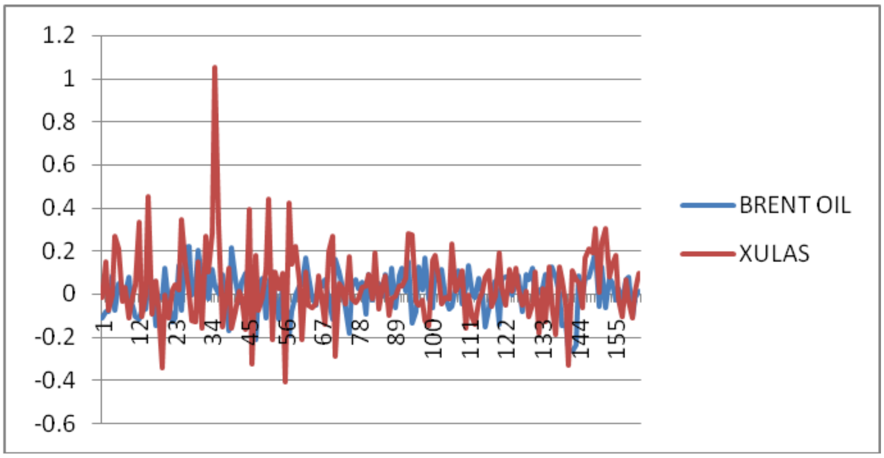

FIGURE 1
The Trend of XULAS Returns and Brent Crude Oil Returns

RESULTS

In this paper, ARCH and GARCH models are used in order to calculate the volatility of Brent crude oil. Before ARCH and GARCH models, we first test if Brent crude oil has unit root which in turn to determine whether we need to estimate the equations in the first differences instead of levels. There are two different methods for testing stationarity. One of them is to graph the correlogram of the coefficient of autocorrelation of the series. The second method is to test ADF unit root test statistics value for series. In this paper, we test ADF statistics values for Brent crude oil prices at level and first differences. As can be seen from Table 3, we conclude that Brent oil series is no stationary at the level but at the first difference. Absolute ADF test statistics value is greater than test critical values.

TABLE 3
ADF Unit Root Test Statistics

Level			First Difference		
L	**Constant**	**Trend&Constant**	**L**	**Constant**	**Trend&Constant**
5	-1.7408*	-4.1713*	5	-8.3365**	-8.3115**

* Critical Values for %5 are; 2.8793 and 3.4711 and for %1 are; 3.4381 and 4.0116
**Critical Values for %5 are; 2.8793 and 3.4379 and for %1 are; 3.4711 and 2.8711

Brent crude oil series is stationary in the first difference at the 5% and 1% level. Therefore we conduct the analysis in terms of oil price changes.

Until a decade ago the focus of most macroeconometric and financial time series modeling centered on the conditional first moments, with any temporal dependencies in the higher order moments treated as a nuisance. The increased importance played by risk and uncertainty considerations in modern economic theory, however, has necessitated the development of new econometric time series techniques that allow for the modeling of time varying variances and covariances. Given the apparent lack of any structural dynamic economic theory explaining the variation in higher order moments, particularly instrumental in this development has been the autoregressive conditional heteroskedastic (ARCH) class of models introduced by Engle (1982). ARCH and GARCH models are important for many issues in macroeconomics and finance, such as irreversible investments, option pricing, the term structure of interest rates, and general dynamic asset pricing relationships. Also, from the perspective of econometric inference, the loss in asymptotic efficiency from neglected heteroskedasticity may be arbitrarily large and, when evaluating economic forecasts, a much more accurate estimate of the forecast error uncertainty is generally available by conditioning on the current information set.

In Figure 2, there exists big fluctuation and volatility clustering at the Brent crude oil returns. The big differences follow big movements and small differences follow small movements. This is the sign of volatility.

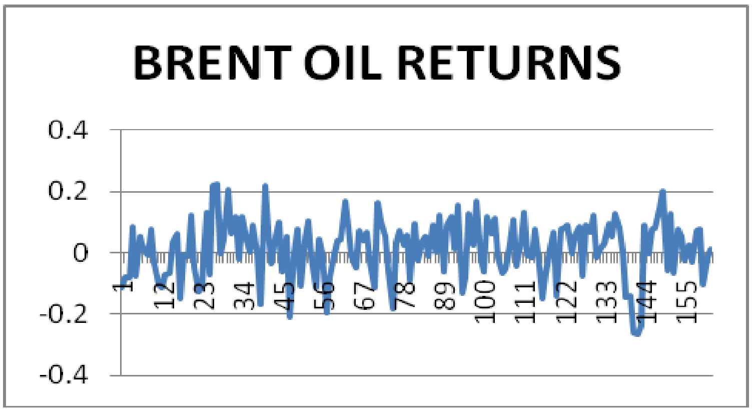

FIGURE 2
The Trend of Brent Oil Return

After analyzing the unit root test we should estimate the ARMA models that best fit the Brent crude oil series. As you see from Table 4, AR(1) model is chosen according to Akaike Criteria Information. Besides coefficient of c and AR(1) is significant.

TABLE 4
AR (1) Model Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.354039	0.611097	0.579350	0.0002
AR(1)	0.392758	0.072841	5.392009	0.0000

R-squared	0.154587	Mean dependent var	0.339938
Adjusted R-squared	0.149270	S.D. dependent var	5.104791
S.E. of regression	4.708406	Akaike info criterion	5.948920
Sum squared resid	3524.885	Schwarz criterion	5.987199
Log likelihood	-476.8881	Hannan-Quinn criter.	5.964463
F-statistic	29.07376	Durbin-Watson stat	2.083794
Prob(F-statistic)	0.000000		

We test the ARCH effect with the ARCH-LM test. We reject the null hypothesis,

$$H_0 = \beta_1 = \beta_2 = ...\beta_n = 0$$

There is ARCH effect at the Brent Crude Oil.

TABLE 5
Heteroskedasticity Test: ARCH

F-statistic	7.710737	Prob. F(1,159)	0.0061
Obs*R-squared	7.446603	Prob. Chi-Square(1)	0.0064

In order to eliminate the ARCH effect we should choose the best ARCH-GARCH model. After trials of the ARCH and GARCH models, we chose the best fit model for Brent crude oil GARCH (1,1) model according to Akaike Information Criteria. Model results can be seen from Table 6.

TABLE 6
GARCH(1,1) Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.002663	0.228145	0.011671	0.9907
AR(1)	0.141832	0.088375	1.604887	0.1085
Variance Equation				
C	0.121305	0.185797	0.652893	0.5138
RESID(-1)^2	0.178621	0.082134	2.174742	0.0296
GARCH(-1)	0.846337	0.074372	11.37983	0.0000

R-squared	0.088185	Mean dependent var	0.339938
Adjusted R-squared	0.064805	S.D. dependent var	5.104791
S.E. of regression	4.936613	Akaike info criterion	5.438744
Sum squared resid	3801.743	Schwarz criterion	5.534440
Log likelihood	-432.8189	Hannan-Quinn criter.	5.477600
F-statistic	3.771831	Durbin-Watson stat	1.501441
Prob(F-statistic)	0.005877		

The ARCH LM test for GARCH(1,1) can be seen from Table 7. There is no ARCH effect in the series.

TABLE 7
Heteroskedasticity Test: ARCH for GARCH(1,1)

F-statistic	0.888575	Prob. F(5,151)	0.4904
Obs*R-squared	4.487379	Prob. Chi-Square(5)	0.4816

Afterwards we form the GARCH(1,1) series for every month.

In order to determine the relationship between oil price volatility and transportation index return, a regression analysis is employed:

$$R_{it} = \alpha + \beta_{it}(Oil\,\mathrm{Pr}.Volatility)$$

R_{it} =Return on Transportation index in month t

The equation found is as follows:

R_{it}= 0,00014+0,033β_{it}

As can be seen from the equation, there is a positive relation between oil price volatility and index returns. But the results of the test imply that the relationship is not significant. Also the R^2 value is very low: % 0,0011.

When a correlation analysis is applied to the data series, a correlation coefficient of 0,034 is found at 10 % significance level.

CONCLUSION

Energy prices in general and oil prices in particular are likely to have an important affect on the costs of many companies. Oil prices affect the industries with a relatively high proportion of their costs are oil-based inputs, especially Oil and Gas, Paper and Packaging and Transportation sectors. In this paper, we investigate the sensitivity of Turkish transportation industry index returns to an oil price volatility over the period 1997-2007.

The oil price volatility is modeled by GARCH(1,1). In order to find the relation between oil price volatility and transportation index we conduct a regression and a correlation analysis. The evidence suggests that there is no significant relation between the variables. The correlation coefficient is found to be 0,034 with a positive sign. Actually, the negative relation between oil price volatility and transportation index is expected. There are many reasons of the insignificant relation between the variables. Firstly, XULAS involves restricted number of transportation firms. Only 4 firms can not explain the relationship between the variables. When analyzing sensitivity of energy price changes to the transportation sector, transportation index is not sufficient to indicate the effect of energy price fluctuation. The impact of oil price changes on equity prices depend on the firms' ability to hedge the price risk without changing goods and services price for customer. Second, different variables can impact industry returns in disparate ways. Moreover, the stock market's own shocks, which are related to other factors of uncertainty than the oil price, are more effective than the oil price shocks.

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PERFORMANCE EVALUATION OF TRANSPORTATION WEBSITES BY USING FUZZY AHP

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Abstract *— Effective website design is critical to the success of electronic commerce and digital government. Considerable efforts have been undertaken to evaluate and improve website designs, generating a host of design guidance, methods and modeling tools. In this study selected Turkish transportation firms' websites, which can be evaluated as shopping websites, will be evaluated by using multi-criteria decision making techniques. Because of imprecise nature of evaluation fuzzification will be performed on values of criteria.*

Keywords — Website, Performance Evaluation, Fuzzy AHP

INTRODUCTION

E-business is reaching technological maturity due to the growing penetration of broadband connections to the Internet [1]. In recent years, the Internet has become a new channel for the commercialization of products conventionally sold through traditional outlets; according to the Forrester Report, the volume of US online retailing will grow from $172 billion in 2005 to $329 billion in 2010. Electronic commerce (e-commerce) requires little additional investment by companies (a website is sufficient) and facilitates access to markets previously considered as out of reach [2].

As companies have become more effective in their use of websites, they have become more complex. For some organizations, they serve as repositories of information for various stakeholders and the public. For others, websites also offer transaction capabilities, providing an additional mechanism from which to serve customers. Since websites serve as an important point of contact for most companies, assessing their effectiveness or quality of the website is important as a way to understand whether the company is providing the type and quality of information and interaction to satisfy website users. This is especially true for companies selling goods and services on their websites. Customers must be satisfied with their experience with the website or they will not return. Thus, the assessment of website quality has become a priority for companies [3].

In this study, determining the best transportation website is chosen as research object. We aim to compare transportation website by using Fuzzy AHP. The framework is applied to measure the performance of transportation websites as a real world case study.

The paper is organized as follows. Section 2 describes the details of the proposed evaluation framework and the methods used. To validate our model and to examine its effectiveness, we evaluate the performance of transportation websites in Section 3. Finally some concluding remarks are given in the last section.

EVALUATION FRAMEWORK FOR BUSINESS WEBSITES

During the past decades, companies made large investments in the implementation of information systems with the expectation of productivity gains, competitiveness enhancement, and the reduction of market, administrative and operational costs [4,5]. However, such claims have not been validated by empirical data. Therefore, researchers have made efforts to propose a better way of evaluating information systems. These efforts can be divided into two categories. One is to develop methods for evaluating information systems, and the other is to identify factors affecting information system success[6].

Website evaluation measures have been proposed in various contexts in recent years. We use Tsai et al.'s criteria set for website evaluation [7]. These criteria can be seen in Table 1.

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TABLE 1
Web Design Evaluation Criteria [7]

Criteria Set	Criterion	Definition
Visual Design (VD)	Attractiveness (ATT)	This criterion consists of whether web pages are fun to read and help visitor promote their excitement, such as through graphics, online games, cartoons, screensavers, software downloads, and Q&As
	Personalization (PER)	This criterion includes an individualized interface, effective one-to-one information, and customized service. Customized content of the website can provide a user with the relevant and up-to-date information that will address his specific needs.
Content	Relevancy (REL)	This criterion includes relevant depth and scope and completeness of information. Different parts of the website should be designed to meet the needs of different group of visitors, such as travelers, researchers, students, and local citizens.
	Richness (RIC)	This criterion refers to detailed level and scope of information content. That is, formations contained on the website are rich in content.
	Currency (CUR)	This criterion refers to up-to-date information. Last update/review dates are a critical way of notifying users of the currency of content.
Navigation (N)	Navigability (NAV)	This criterion measures how easy it is to navigate around the site, how easy it is to return to the home page of the site, how easy it is to find relevant information, how many links are required to get from one point in a site to another and what search tools the site provides.
	Speed (SPD)	This criterion refers to quick connection and delivery, minimal use of large graphics and bright colors, easy access to links, and website loading speed.
	Links (LINK)	This criterion refers to availability of links to other government organizations, different national parks, eco-protection, tourism and travel, and other related websites.
Other Features (OF)	Security (SEC)	This criterion deals with how a website proves to be trustworthy for customers. A confident website should assure the secrecy of its users' personal and private data as well as prevent the content of a message from being tampered with.
	Responsiveness (RES)	This criterion deals with the provision of information on FAQs and prompts assistance for solving problems. Various service functions, such as complaint management systems, should be provided.

FUZZY AHP METHODOLOGY

To deal with vagueness of human thought, Zadeh [8] first introduced the fuzzy set theory, which was oriented to the rationality of uncertainty due to imprecision or vagueness. A major contribution of fuzzy set theory is its capability of representing vague data. The theory also allows mathematical operators and programming to apply to the fuzzy domain. A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function, which assigns to each object a grade of membership ranging between zero and one. A tilde "~" will be placed above a symbol if the symbol represents a fuzzy set.

Therefore, $\tilde{p}$, $\tilde{r}$, $\tilde{n}$ are all fuzzy sets. The membership functions for these fuzzy sets will be denoted by $\mu(x|\tilde{p})$ and $\mu(x|\tilde{n})$ respectively. A triangular fuzzy number (TFN), $\tilde{M}$, is shown in Fig. 1. A TFN is denoted simply as $\left(\frac{m_1}{m_2}, \frac{m_2}{m_3}\right)$ or (m_1, m_2, m_3). The parameters m_1, m_2 and m_3 respectively denote the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event [9].

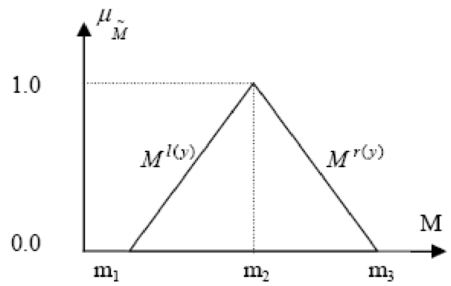

FIGURE 1
A triangular fuzzy number

The analytic hierarchy process (AHP) is one of the extensively used multi-criteria decision-making methods. One of the main advantages of this method is the relative ease with which it handles multiple criteria. In addition to this, AHP is easier to understand and it can effectively handle both qualitative and quantitative data. The use of AHP does not involve cumbersome mathematics. AHP involves the principles of decomposition, pairwise comparisons, and priority vector generation and synthesis. Though the purpose of AHP is to capture the expert's knowledge, the conventional AHP still cannot reflect the human thinking style. Therefore, fuzzy AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems. In the fuzzy-AHP procedure, the pairwise comparisons in the judgment matrix are fuzzy numbers that are modified by the designer's emphasis [9].

In the following, first the outlines of the extent analysis method on fuzzy AHP are given and then the method is applied to website evaluation problem. Let

$$x = \{x_1, x_2, ...,x_n\} \quad (1)$$

be an object set, and

$$U = \{u_1, u_2, ...,u_n\} \quad (2)$$

be a goal set.

According to the method of Chang's extent analysis [10,11], each object is taken and extent analysis for each goal is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M^{1}_{g_i}, M^{2}_{g_i}, ..., M^{m}_{g_i} \quad i = 1,2,...,n \quad (3)$$

where all the $M^{j}_{g_i}$ (j 1,2,...,m) are triangular fuzzy numbers. The value of fuzzy synthetic extent with respect to i*th* object is defined as:

$$S_i = \sum_{j=1}^{m} M^{j}_{g_i} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M^{j}_{g_i} \right]^{-1} \quad (4)$$

The degree of possibility of $M_1 \geq M_2$ is defined as:

$$V(M_1 \geq M_2) = \underset{x \geq y}{SUP} \ [\min(\mu M_1 (x), \mu M_2 (y))] \quad (5)$$

When a pair (x,y) exists such that $x \geq y$ and μM_1 (x) = μM_2 (y), then we have $V(M_1 \geq M_2)=1$. Since M_1 and M_2 are convex fuzzy numbers we have that:

$$V (M_1 \geq M_2) =1 \ if \ m_1 \geq m_2 \quad (6)$$

$$V (M_1 \geq M_2) = hgt (M_1 \cap M_2)$$
$$= \mu M_1 (d) \quad (7)$$

where d is the ordinate of the highest intersection point D between μM_1 and μM_2 . When $M_1 = (l_1,m_1,u_1)$ and $M_2 = (l_2,m_2,u_2)$, the ordinate of D is given by equation (8):

$$V (M_2 \geq M_1) = hgt (M_1 \cap M_2)$$
$$= \frac{l_1 - u_1}{(m_2 - u_2) - (m_1 - u_1)} \quad (8)$$

To compare M_1 and M_2, we need both the values of $V (M_1 \geq M_2)$ and $V (M_2 \geq M_1)$. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i (i= 1,2,...,k) can be defined by:

$V(M \geq M_1, M_2, \ldots\ldots, M_k) = V(M \geq M_1)$
and $V(M \geq M_2)$ and...and $V(M \geq M_k)$ (9)
$= \min V(M \geq M_i),\ i = 1,2,\ldots.,k$
Assume that:
$d'(A_i) = \min V(S_i \geq S_k)$ (10)
For $k = 1,2,\ldots,n$; $k \neq i$. Then the weight vector is given by:

$$W' = (d'(A_1), d'(A_2),,\ldots, d'(A_n))^T \quad (11)$$

where A_i (i=1,2,...,n) are n elements. Via normalization, the normalized weight vectors are:

$$W = (d(A_1), d(A_2),,\ldots, d(A_n))^T \quad (12)$$

where W is a non-fuzzy number.

A REAL WORLD APPLICATION

Websites of four cargo companies operating in Turkey are considered. The companies and their websites are as following:

- UPS Cargo (www.ups.com.tr),
- DHL Cargo (www.dhl.com.tr),
- Yurtiçi Cargo (www.yurticikargo.com),
- Aras Cargo (www.arascargo.com.tr).

The websites are evaluated by four experts who are working in web design. The linguistic variables in Table 2 are used by decision makers in the evaluation phase.

TABLE 2
Linguistic Terms and Corresponding Fuzzy Numbers

Linguistic term	Very Very Good (VVG)	Very Good (VG)	Good (G)	Weak (W)	Equal (E)
Fuzzy number	(7/2,4,9/2)	(5/2,3,7/2)	(3/2,2,5/2)	(2/3,1,3/2)	(1,1,1)

Table 3. Evaluation of Main Criteria

	VD	C	N	OF
VD	E	G	G	G
C		E	G	G
N			E	W
OF				E

Table 4. Evaluation of sub criteria of Visual Design

	ATT	PER
ATT	E	G
PER		E

Table 5. Evaluation of sub criteria of Content

	REL	RIC	CUR
REL	E	G	
RIC		E	G
CUR	VG		E

Table 6. Evaluation of sub criteria of Navigation

	NAV	LINK	SPD
NAV	E	G	
LINK		E	
SPD	VG	VG	E

Table 7. Evaluation of sub criteria of Other Features

	SEC	RES
SEC	E	G
RES		E

Decision makers evaluated the main criteria in Table 3. The weights of the main criteria, which are Visual Design, Content, Navigation, Other Features, are calculated as (0.535; 0.385; 0.040; 0.040) respectively.

The evaluation of sub criteria of Visual Design is on Table 4. The weights of the sub criteria which are, Attractiveness and Personalization, are calculated as (1; 0) respectively. The evaluation of sub criteria of Content is on Table 5. The weights of the sub criteria which are, Relevancy, Richness, Currency, are calculated as (0.244; 0.287; 0.468) respectively. The evaluation of sub criteria of Navigation is on Table 6. The weights of the sub criteria which are, Navigability, Speed, Links, are calculated as (0; 0; 1) respectively. The evaluation of sub criteria of Other Features is on Table 7. The weights of the sub criteria which are, Security, Responsiveness are calculated as (1; 0) respectively.

The pair-wise comparisons of alternatives according to the sub-criteria are listed in Tables 8-17.

Tablo 8. Evaluation alternatives according to Attractiveness

	UPS	DHL	Yİ	ARAS
UPS	E		G	G
DHL	G	E	G	G
Yİ			E	G
ARAS				E

Table 9. Evaluation of alternatives according to Personalization

	UPS	DHL	Yİ	ARAS
UPS	E	G	G	G
DHL		E	W	G
Yİ			E	G
ARAS				E

Table 10. Evaluation of alternatives according to Richness

	UPS	DHL	Yİ	ARAS
UPS	E	W	W	W
DHL		E	W	G
Yİ			E	W
ARAS				E

Table 11. Evaluation of alternatives according to Currency

	UPS	DHL	Yİ	ARAS
UPS	E	E		G
DHL		E	W	
Yİ	G		E	G
ARAS		G		E

Table 12. Evaluation of alternatives according to Relevancy

	UPS	DHL	Yİ	ARAS
UPS	E	W	W	W
DHL		E	W	W
Yİ			E	W
ARAS				E

Table 13. Evaluation of alternatives according to Navigability

	UPS	DHL	Yİ	ARAS
UPS	E	W	W	G
DHL		E	W	
Yİ			E	G
ARAS		G		E

Table 14. Evaluation of alternatives according to Links

	UPS	DHL	Yİ	ARAS
UPS	E	W	W	E
DHL		E	E	E
Yİ			E	W
ARAS				E

Table 15. Evaluation of alternatives according to Speed

	UPS	DHL	Yİ	ARAS
UPS	E			W
DHL	G	E	W	
Yİ	G		E	W
ARAS		G		E

Table 16. Evaluation of alternatives according to Responsiveness

	UPS	DHL	Yİ	ARAS
UPS	E	W	G	VG
DHL		E	G	
Yİ			E	
ARAS		VG	G	E

Table 17. Evaluation of alternatives according to Security

	UPS	DHL	Yİ	ARAS
UPS	E	W	W	
DHL		E	W	G
Yİ			E	W
ARAS	W			E

The comparison of alternatives according to criteria can be seen in Table 8-17. And the results of calculations reveal the score of each alternative respectively in Table 18.

TABLE 18
Scores of Alternatives

	Attractiveness	*Personalization*	*Richness*	*Currency*	*Relevancy*	*Navigability*	*Links*	*Speed*	*Responsiveness*	*Security*
UPS	0.344	0.518	0.246	0.249	0.25	0.377	0.25	0.145	0.495	0.374
DHL	0.506	0.265	0.141	0.141	0.25	0.034	0.25	0.264	0.066	0.374
YURTİCİ	0.150	0.178	0.347	0.347	0.25	0.251	0.25	0.296	0	0
ARAS	0	0.039	0.263	0.263	0.25	0.337	0.25	0.296	0.439	0.252

TABLE 19
Summary of Priority Weights

Sub-attributes of visual design

	ATT	PER	**priority weights of alternatives**
alternatives	1	0	
UPS	0.344	0.518	**0.344**
DHL	0.506	0.265	**0.506**
Yİ	0.150	0.178	**0.150**
ARAS	0	0.039	**0**

Sub-attributes of content

	REL	RIC	CUR	**priority weights of alternatives**
alternatives	0.244	0.287	0.468	
UPS	0.25	0.246	0.249	**0.248**
DHL	0.25	0.302	0.141	**0.214**
Yİ	0.25	0.2456	0.347	**0.294**
ARAS	0.25	0.207	0.263	**0.244**

Sub-attributes of navigation

	NAV	LINK	SPD	**priority weights of alternatives**
Alternatives	0	0	1	
UPS	0.377	0.25	0.145	**0.145**
DHL	0.034	0.25	0.264	**0.264**
Yİ	0.251	0.25	0.296	**0.296**
ARAS	0.338	0.25	0.296	**0.296**

Sub-attributes of other features

	SEC	RES	**priority weights of alternatives**
Alternatives	1	0	
UPS	0	0.495	**0**
DHL	0.374	0.066	**0.378**
Yİ	0.374	0	**0.374**
ARAS	0.252	0.439	**0.252**

TABLE 20
Overall Scores of The Alternatives

	VD	C	N	OF	**Scores of the Alternatives**
weights	0.535	0.385	0.040	0.040	
alternatives					
UPS	0.344	0.248	0.145	0	**0.285**
DHL	0.506	0.214	0.264	0.374	**0.379**
Yİ	0.150	0.294	0.296	0.374	**0.220**
ARAS	0	0.244	0.296	0.253	**0.116**

According to the results in Table 20, the ranking of websites is as DHL > UPS > Yİ > ARAS.

CONCLUSIONS

The volume of e-trade is expanding rapidly. The most important source of e-trade is the website. The competition forces firms to move to the e-trade and compete also in this field. In this study, four cargo firms operating in Turkey are considered and their websites are compared. The decision makers in this process were selected among the experts of the subject and Fuzzy AHP is the tool that had been used with pair-wise comparisons. Linguistic variables enabled experts to conduct fuzzy evaluations. In future studies fuzzy analytic network process (ANP) can be used in comparison of e-trade websites.

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KEY SUCCESS FACTORS IN IMPLEMENTATION OF ENTERPRISE RESOURCE PLANNING (ERP) SYSTEMS FOR MULTI-NATIONAL COMPANIES

İsmail Karakış[1]

Abstract — *Enterprise resource planning (ERP) systems are software packages that enable the companies to have more real time visibility and manage their activities in an integrated manner. The implementation of such system is a complex exercise for the companies since it requires change management, and technology innovation. This paper investigates the key success factors in implementing ERP systems such as training, communication, knowledge transfer, organizational structure, organizational culture, and national differences that are mainly valid for ERP implementation in particularly global and multi-national companies. The findings of the study identify the factors stated above as key success factors. Moreover, it highlights some interesting and different aspects of organizational elements and national differences in terms of impacting ERP systems implementations.*

Keywords — Enterprise resource planning (ERP), key success factors, multi-national organizations, new technology implementation

INTRODUCTION

The enterprise resource planning (ERP) system is integrated software that consists of several module applications that enable organizations to plan, execute and control or briefly manage the activities and resources [1]. ERP is a generic term for any integrated computing system. It handles the key functional areas of a company such as finance, procurement, inventory management, production, sales and marketing [2]. ERP systems began in 1960s as material requirements planning (MRP) and became manufacturing resources planning (MRP II) in 1970s and finally during 1980s transformed to today's ERP since major activities of companies are merged within the same system. Because of this capability in terms of integrating and managing different functionalities, nowadays, ERP systems are considered as a system that can deliver strategic competitive advantages [1].

However, ERP adoption or implementation is really a complex exercise in technology innovation and organizational change management [2]. Different companies have been encountering problems from early ages of implementations. Those various problems cause the implementation projects failure. There are several studies that have tried to identify the critical success factors in ERP implementation projects. These key success factors help an organization identify the important issues that have significant impacts through the implementation process. Although there are number of both empirical and non-empirical studies conducted to determine key success factors, it is clear that different studies highlighted different sets of factors [1]. More than that, there are a number of studies about failure factors for ERP as well and it can be pointed that the factors that contribute to the success of ERP are not the same as the factors that contribute to failures. Hence, companies should be focusing on different sets of key factors for success and avoiding another set of factors not to fail [3]. This implies that there is no general agreement on such key success factors [1], [2], [3].

In this study, it is focused on key success factors in implementation of ERP system from adoption of a new technology within a company, particularly a multi-national one. However, differently, it is investigated to reveal such factors for a widely used ERP software application called "SAP ECC" for that there is not much of research done specifically [3], [4]. The study focuses on multi-national companies in different industries. Due to this type of the companies, it is supposed that almost all components of SAP ECC application are

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being used in a highly integrated manner which is useful in order to generalize the key success factors. Besides this, since the company has many facilities in many different countries and/or regions, it is a kind of opportunity to point out some special issues and/or challenges (e.g. multi-nationality, organizational culture, communication, etc) for which there is a lack of studies from literature perspective [5], [6], [7].

AIM AND FOCUS OF THE STUDY

The purpose of the study is to investigate the key success factors through a systematic literature review during ERP application software SAP ECC implementation for especially multi-national companies.

Gargeya and Brady [3] mention the 11 key factors for successful ERP implementations in the literature, as below:

- ERP teamwork and composition
- Change management program and culture
- Top management support
- Business plan and vision
- Business process re-engineering and minimum customization
- Effective communication
- Project management
- Software development, testing, and trouble shooting
- Monitoring and evaluation of performance
- Project champion
- Appropriate business and IT technology legacy systems

ERP system implementation is indeed very good example of new technology adoption or implementation. It has a very strong relation with the business processes of the company, therefore it can be considered as a kind of transformation. The effective implementation of an ERP system requires change management strategies that are related to organizational culture. This change management includes the training and education activities of the organizations. ERP systems implementation projects are opportunity for the companies in terms of process improvement, process innovation, and process re-engineering [1], [2], [3], [11], [13].

Training is really important for helping the end users understand and perceive the system; this factor becomes more important because if these people are not able to use the system on the first day of go-live, then the implementation would be considered as a failed project although there would be no technical issues. The user's ability to understand ERP knowledge and involvement influences the performance of their accepting and using the ERP system through technology acceptance model [9], [10], [12]. Training is a key factor for especially SAP implementations as well [3]. This is due to complex appearance of interface of SAP although it is more user-friendly indeed but needs more training at the beginning stages in order for the company to increase the effective usage [22]. This can be named as a kind of "social factor" that requires cooperation among different parties within a company [8]. Training is more critical in emerging countries in terms of lack of well-educated personnel for ERP implementations [14]. Hence;

- Training is a key success factor in implementing ERP systems for multi-national companies.

Communication at all levels of the company is another key success factor. This communication should be clear, effective and formal. In order to achieve this kind of communication, open and honest communication policies should be defined and all different kinds of communication tools (e.g. web, e-mail, teleconference, etc.) should be utilized [1], [3], [7], [12]. Ineffective communication within the company is considered as one of the most critical risks for ERP implementations [11]. Stronger communication skills are real drivers for SAP implementations [13]. In the light of these;

- Communication is a key success factor in implementing ERP systems for multi-national companies.

Process changes and process innovations could be taking place during the process design phases of the ERP systems implementations. More than that, re-engineering could be applied to the suitable processes. For all those improvements and changes, knowledge management is surely a key concept which is depending on the organizational attributes of the companies. Especially communicated, tacit, visualized, documented, and process based knowledge among the end users and consultants is essential for ERP success [15], [18], [19]. Such a knowledge management is improving the process innovation capability of the company which implies a successful design phase [16]. More effective knowledge transfer during implementation leads to organizational process fit to ERP [17]. Therefore, the study advocates;

- Knowledge management is a key success factor in implementing ERP systems for multi-national companies.

Another key success factor is organizational characteristics [1]. For instance, organizational structure of a company has an impact on the success of ERP adoption based on recent studies. While organizations whose structures are machine bureaucracy or professional bureaucracy support staff have a higher degree of fit to ERP, adhocracy or divisionalized form have a lower degree of fit to ERP systems [20]. Organizational culture is another valid aspect recently. When the ERP system conflicts with the company's culture, resistance behavior will be coming in place, the system will be rejected or sabotaged. Therefore, there is a strong relation between the success of the projects and organizational culture because culture is important for innovative activities [21], [23]. This paper advocates the following propositions as well;

- Organizational structure has an impact on the success in implementing ERP systems for multi-national companies.
- Organizational culture has an impact on the success in implementing ERP systems for multi-national companies.

Besides the company culture itself, national culture is another significant factor for ERP implementation which is a kind of technology adaptation and/or business process change [1]. ERP system provides multi-national organizations with information and coordination of supply chain functions. In terms of national differences, there are six categories; culture and language, government/corporate politics, management style, government regulations, time zone, and labor skills. These different national attributes impact on entering data to the system, resistance to change, communication styles, and way of workings which are important for the implementations [6]. Such national differences become more crucial in case of multi-national projects [7]. This key success factor is surely valid for SAP implementations as well [5]. Therefore;

- National differences have an impact on the success in implementing ERP systems for multi-national companies.

In the light of the literature review, this paper focuses on the evidences for both theoretical key success factors and recent ones likewise organizational culture, and national differences. In fact, many researches addressed and modeled the ERP success factors, however both DeLone and McLean information system (IS) success evaluation model which is a casual one that uses cause and effect logic is not clearly referring this aspect. Gable, Sedera and Chan's ERP success model highlights the organizational impact for during the implementation phases as well as the post-implementation period however this is not emphasizing either the multi-national perspective or different cultural attributes [24], [25], [26].

Organizational impact in terms of culture and national differences can be highlighted that although the same ERP system (i.e. same technology) applied to different facilities of the same company which implies same organizational culture; the implementation process, challenges, and issues would be different. Thus, key success factors would be miscellaneous, and success is naturally affected by both organizational culture and national differences.

METHODOLOGY

A comprehensive literature review was conducted in terms of articles from journals mainly between 2000 and 2010 about critical success factors in implementing ERP systems for the organizations. Based on this literature review, structured and informal interviews were carried out with different parties that involved the ERP implementation projects in different industries likewise consumer business, oil & gas, manufacturing, and healthcare. The individual correspondents of the mentioned interactions greatly vary; project leads and managers, process owners, information technology business analysts, and SAP consultants at different levels of seniority. The question list used as a framework during the interviews is stated as follows:

- What are the key factors that enable the key achievements?
- What are the key challenges of the project?
- Do you think that training is an important success factor in implementing ERP systems?
- Do you think that communication is an important success factor in implementing ERP systems?
- What are the main communication policies and tools used in the project?
- Do you think that knowledge management is an important success factor in implementing ERP systems?
- Do you think that organizational culture is an important success factor in implementing ERP systems?
- Do you think that organizational structure is an important success factor in implementing ERP systems?
- Do you think that national differences are important success factors in implementing ERP systems?
- Do you think that top management commitment is an important success factor in implementing ERP systems?
- Do you think that change management is an important success factor in implementing ERP systems?
- Do you think that project management is an important success factor in implementing ERP systems?
- Do you think that software development, technical support and testing are important success factors in implementing ERP systems?
- In the case of ranking these different success factors, which one would be the 1st important success factor? Which one would be the last important success factor?
- Do you think that master data management is an important success factor in implementing ERP systems?
- Is there a separate Master Data team established in the project?
- Is closure workshop or meeting conducted after the project completion?
- What are the lessons learned from the project?

FINDINGS OF THE STUDY

The discussions and interviews revealed the several obvious points regarding each of the propositions stated before. First of all, one of the key success items that almost all the parties agree on was the communication through all the different parties which includes the knowledge transfer between those parties. This implies the knowledge transfer among those parties. For instance, SAP consultants would inform all relevant parties regarding the applicable functionalities/solutions. Particularly, for the multi-national companies, the business process owners in one site, country, region or market place communicated to colleagues in another regarding any process improvements, even potential opportunities. More than that, it can be clearly highlighted that the communication method would be formal communication (e.g. emails, teleconferences, etc). This point makes the project management more effective, mainly from basic principles, gate keeping, open issues tracking, and documentation perspectives.

Secondly, common view is such an effective communication helped business users' involvement to the new process and system design which was in other words, a kind of training of the users about the system. It is said that this involvement encouraged the users in terms of accepting this new technology.

Thirdly, one important and different aspect for the multi-national projects, the core dedicated project teams including SAP consultants, and business side are multi-cultural teams. It is noted that multi-cultural teams are an advantage to manage the cultural differences of different nations. Moreover, cultural diversity is usually supposed to be a factor that generates new ideas and opportunities.

Fourthly, surely management commitment, visibility and clarity of project scope and planning are the other items. These are all inevitable for successful implementations. The project team organization would really be fitting to business organization chart of the company and this provides the effective use of organizational culture especially for accepting the new technology (e.g. SAP ECC, RFID and barcode technologies), applying the process changes, and process innovations. Such an initiative is a genuine desire for harmonization of business processes accordingly which is one of the most important and recent target achievements for the multi-national firms. At that point, training comes into the picture as an enabler to accomplish these. A highlighting point for training is that there has to be sufficient involvement for trainings. Moreover, establishing a "can do" culture is another agreed idea which is directly related to national differences in general. On the other hand, insufficient involvement for training is significantly risky to enable a successful ERP system; the risk here for the multi-nationals is the lack of such involvements because of national attributes and/or attitudes of the people. It is said that more time could be spent to sensitive cultural issues since it affected communication, learning, planning, resistance to change, etc. The work hours, public holidays, and time zones are a few examples of this difference.

Finally, it is inevitable in order for a company to have a stable successful ERP that carrying on learning and getting more from the system. In order to achieve this, arranging forums and/or platforms for the people to encourage the information sharing and knowledge transfer is a useful approach. The purpose of those platforms should be using more capabilities of SAP ECC and exploring new tools. Regarding the improvements of ERP systems, measurements of the benefits from the ERP system should be identified as "key performance indicators".

CONCLUSION

It is obvious from the results of the study that training is really a key success factor in implementation of ERP systems that includes SAP ERP projects [3], [14], [22]. More than that, it can be basically stated that better trained users mean less failure risky implementations [9], [10], [12]. Training is not only a critical success factor for achieving successful go-live, but also one of the most crucial areas in terms of future improvements during post go-live phases. Therefore, first proposition is supported.

For the second proposition about communication, the study results are supporting that the effective communication is another key success factor for ERP systems implementations. Formal communication is more likely essential during project implementation phase [1], [3], [7], [11], [12]. The results of the study prove that communication is also important for especially SAP implementations in practice [13].

This research paper supports that knowledge management is another key success factor for ERP implementation projects. This factor is highly integrated with the communication factor [15], [18], [19]. Especially knowledge transfer is positively affecting the projects during process design phases [16], [17]. As a result, this knowledge transfer encourages the business people to accept the new technology and ERP system [12]. It is determined that knowledge management is not only useful during design and implementation but also a useful and essential principle for future improvements in post go-live periods.

Fourth proposition is about organizational structure and it is supported as well. Organizational structure is another key factor that has an impact on ERP implementations within a company [1]. The organizational structures of the multi-national companies reviewed are mainly machine bureaucracy so they are more capable to fit ERP systems due to the literature [20].

Besides these, project team organization chart is in line with the company business organization structure which is thought to have a positive effect on the usage of organizational culture especially for accepting the new technology. Companies can achieve some required innovations in processes and adopting totally new technologies like RFID and barcode technology simultaneously [22], [23]. This implies that the results support fifth proposition as well. Regarding the organizational culture, a different aspect is realized for these multi-national companies. There is a clear agreement about having a multi-cultural and multi-national project team including SAP consultants, and business people was a real advantage in terms of managing the cultural differences [6]. This interesting point indicates that the study supports the sixth proposition about national differences impacting the ERP systems implementations. For instance, a high technology country in Asia would be very motivated for process innovation and technology change acceptance while another emerging Asian country would have a high level of resistance to change.

In summary, training, communication, knowledge transfer, organizational structure and culture are some of the key success factors that have an impact on ERP system implementations as well as national attributes of the countries. Surely organizational characteristics and national elements become more crucial when ERP implementations take place in such multi-national companies.

The study asserts that although same ERP system (i.e. same technology) is applied or adopted across the many countries for the same company that has same organizational structure and culture, the implementation process would not be the same. Rather than organizational culture differences, this is due to national differences which affect way of working, perception of work life, communication, and perception of technology.

Moreover, especially for ERP implementations of multi-national companies, there are a few further key points that should be significantly important for the success of the project.

The main and basic one is Project Management & Governance which is very crucial for the projects, particularly roll-out approached ones. In such projects, there is a global or regional template that should be followed up by the all countries. However, the big challenge is that there are usually deviations from this template inevitably. For instance, template has to be changed due to the market conditions and/or statutory requirements. Besides, technology and human resources can force to change the template because the solutions offered by the template could not be applicable. Therefore, project management & governance is important to manage the deviations from the template due to different reasons including organizational culture and national differences.

Related to the previous item, another point is Change Management including the escalation procedure, a big challenge for the such projects. Resistance to change is very dependent on the culture and national differences. Because of that reason, change management can be stated as one of the key success factors for the ERP projects of the multi-nationals. It can be advised that ERP implementation projects should not be considered as only a type of IT projects. They should be considered and treated as Transformation Projects from both business and IT point of view.

Another item is more related to the technical side; Master Data. Management of master data is generally not assumed to be an important area however it is definitely very crucial. It can be advised that a seperate master data team should be set up for the project and this team is responsible for all activities related to master data (e.g. data preparation, cleansing, uploading, etc). More than that, even for the medium or small sized projects, a business process should be designed regarding the master data management likewise new product code creation, new brand creation or the Bill of Materials (BOM)/Recipes modification.

Lastly, it is advised to conduct a closure workshop after the project has completed. In this workshop, there could be discussions regarding the different aspects of the projects. For example, what achieved, what gone worse than expected, what are the lessons learned, what will be the future improvements could be the main topics of such a workshop.

LIMITATIONS AND FUTURE RESEARCH

There are some limitations of the study. First, it could be difficult to make general statements based on the contents of the previous studies and this study [1]. Secondly, although it was aimed to make interviews and discussions with a participation of numerous people, the comments are still the ideas of this specific audience. Lastly, the results of the study may not be valid for all industries which make it possible that the findings may be slightly varying due to the industry and/or company specific conditions. Further research is needed to investigate the impact of cultural differences of the countries for ERP system applications since it is observed that there is a lack of study regarding this area.

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AN INFORMATION THEORETIC APPROACH TO RFID-SECURITY PROBLEMS IN SUPPLY NETWORKS

Ulrich Tamm[1], *Ela Sibel Bayrak Meydanoğlu*[2]

Abstract — *Counterfeit trade is a severe problem for many industries worldwide. The use of Radio Frequency Identification (RFID) technology is an important technological measure to combat counterfeit trade. In the relevant literature a number of RFID anti-counterfeiting techniques are illustrated. Cryptographic techniques serve as a basis to some of these anti-counterfeiting techniques. The paper aims to contribute to the RFID-security discussion by providing recent information theoretic methods - network coding and identification codes – and their possible applications for security problems in supply networks. These techniques are especially useful in situations where traditional cryptographic tools are not applicable for RFID security – identification codes are superior to hash functions when errors can occur, and network codes may be applied instead of one-way functions. This last approach to RFID security will be particularly discussed in this paper with an emphasis on the detection of the location of a fraud in the supply chain.*

Keywords — *Counterfeiting, RFID Technology, Product Authentication, Network Coding, Identification Codes*

INTRODUCTION

Counterfeiting is a global problem that has negative impacts on companies, countries where counterfeiting takes places and harms consumers in many ways. Companies, whose goods are faked, face unjustified liability claims, loss of goodwill and revenue. Counterfeiting discourages investment in research and development. Counterfeit products put the safety and health of consumers at risk because of inferior product quality. Counterfeiters do not pay taxes, have poor working conditions and often use forced child labor. Earnings from counterfeiting are often used to finance other illegal activities such as terrorist activities, drug trafficking [1], [2], [3]. Product authentication plays an important role to combat counterfeiting and detect counterfeit products. It enables to determine whether a given product is genuine or counterfeit [2]. Various measures such as the use of holograms, invisible ultraviolet ink exist for product authentication [4]. RFID-based product authentication is also an important technological measure for checking the originality of a product that moves in a supply network.

In this paper after the illustration of possible attacks against RFID-based product authentication in supply networks, existing RFID product authentication techniques are discussed briefly. Subsequently it is illustrated how network coding and identification codes can be applied for product authentication in supply networks. The paper finishes with conclusion part.

COUNTERFEITING PROBLEM IN SUPPLY NETWORKS

Figure 1 shows a simple supply network. The manufacturer is linked to raw material suppliers, distributors and some direct sales customers. The flow of goods is from the manufacturer to distributors and then to wholesalers. The goods then flow from wholesalers to retailers and then to consumers [5]. Up to consumer each actor in a network can be the entry point of the counterfeit product. To realize a secure network each actor in a supply network has to verify the authenticity of the products on hand. To understand whether a given product is genuine or counterfeit, the insertion of a security feature into the product and the authentication of this feature are essential. RFID tags can be used for this purpose. Even though some of the presented techniques below (e.g. authentication based on product specific feature) support to bind the feature

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and the product for authentication, through a RFID product authentication predominantly the security feature is authenticated and not the product itself [2]. For the authentication of products physical status verifications – verification of the authenticity by checking ingredients of products, verification of packages for broken packing, broken seals etc. – can be applied [4]. These verifications are out of the scope of this paper.

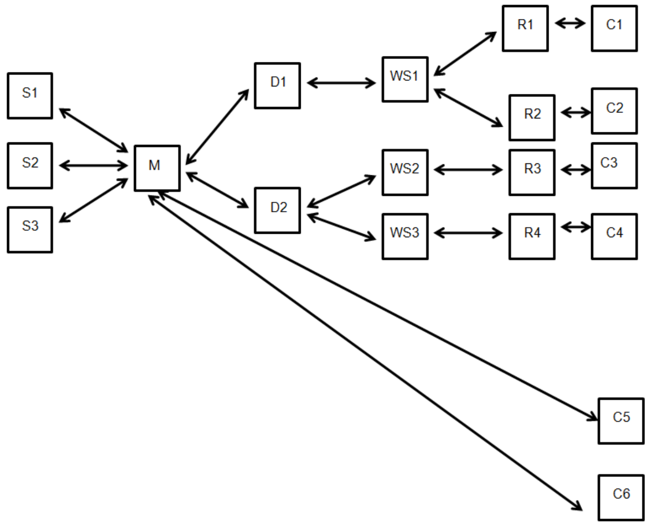

FIGURE. 1
A Simple Supply Network [5].

Any actor of a supply network can put a counterfeit product in the network through the following attacks:

Tag cloning: is the copying the information of one tag to another [6].

Tag removal and reapplication: The application of genuine security features from (mostly discarded) genuine products to counterfeit products is called removal and reapplication attacks [3].

RFID-BASED PRODUCT AUTHENTICATION TECHNIQUES

The RFID-based product authentication techniques are categorized into four classes depending on what the authentication is based on. The first and the second techniques authenticate the products without tag authentication [3], [7]. The third and the fourth techniques authenticate the tag or the data the tag stores [7]:

Unique Serial Numbering: This technique is the simplest RFID product authentication technique. It relies on assigning a serial number (product ID) in a random way from a large numbering space, writing it to the RFID tag and storing the number in a secure online server. When the product ID is checked, e.g. in a store, a reader retrieves the ID, sends it to a service offered by the manufacturer (or an IT provider) which looks up the number in the server and returns the result to the reader. The absence of the product's ID in the server would serve as indication of counterfeit. The success of this technique relies on keeping the list secret from counterfeiters while providing needed access for it to licit actors. Tag cloning is the weakness of this technique. However, cloned tags can be detected by various methods (e.g. by the use of tamper-evident tags). This technique can be implemented in RFID enabled supply chains with little additional cost [3], [7].

Plausibility checks based on track and trace: Track and trace enable to generate and store dynamic profiles of individual products as they move through the supply network [7]. In a track and trace system information on a product's location (location can be a geographic location as well as the location or the step in a process, such as in the distribution or sold to customer [2]) and the corresponding time, possibly together with the information on the owner, its status etc., are recorded and stored for further processing [3]. Product specific records are used then for heuristic plausibility checks. As the system allows to know the location of a product, clones can be found as being in wrong locations [2]. For example, a product with a serial number registered for sale in Switzerland is suspicious if offered in an American store at the same time [7]. As track and trace systems are used in supply networks also for other purposes (e.g. for deriving a product's history, organizing product recalls) track and trace based product authentication can be cost-efficient for supply networks. However, generating and gathering track and trace profiles can be hard in supply networks because of the reluctance of the parties to share information [2], [7].

Authentication based on product specific features: This technique enables a cryptographic way to bind the RFID tag and the product that it authenticates. The authentication is based on writing on the tag memory a digital signature that combines the tag ID number and specific feature (e.g. precise weight) of the product that is to be authenticated. Features can be physical or chemical properties that identify the product and can be verified. The choosen feature is measured as a part of the authentication. If the feature used in the tag's signature matches the measured feature, the tag-product pair is original. This technique needs a public-key stored on an online database. If an offline authentication is desired, then the public-key is stored on the tag. But this decreases the level of security. Physically verification of each unit as a part of authentication is the disadvantage of this technique [7]. This technique detains illicit actors from removing a tag from a legitimate product and reapplying it to a counterfeit product [3].

Secure authentication: This approach considers the use of cryptographic tags for product authentication and anti-counterfeiting. The main motivation is to increase cloning resistance. RFID tags can be protected from cloning by the use of read-protected secrets residing on tags [2]. In the relevant literature various technical solutions with varying complexity are proposed. These solutions base on various protocols such as lightweight hash-based challenge-response protocols, symmetric and asymmetric encryption-based protocols, protocols using physical unclonable functions (PUF) and public key based digital signatures [7]. Disadvantage of this approach is the increasing of the tag costs as a result of the integration of the required cryptographic unit in RFID tags. The application of network coding and identification codes for product authentication, which is discussed below, contributes a new approach to secure authentication.

Among the presented techniques unique serial numbering as well as track and trace based plausibility checking are cost-efficient product authentication techniques. Reasons of the cost-efficiency of these techniques are [7]:

- They need only low-cost tags and support simple authenticity checks.
- As they are used also in other supply chain applications, authentication is not the only application for the hardware costs of these techniques

Based on the discussion above it can be said that the use of unique serial numbering as well as track and trace based plausibility checking is convenient for consumer goods and other low-cost products, the other cryptographic techniques can be applied for more expensive products [7].

NETWORK CODING AND IDENTIFICATION CODES

In this section we are going to provide two ideas from information theory, which might be useful for RFID tag authentication. The first one, identification codes, will only briefly be mentioned, since they are useful only in the presence of noise, which might be not a necessary assumption in most cases. The second one, network coding, however, might turn out to be a useful tool in the future. This very hot topic, analysing how information can be distributed through a network, to our knowledge has not been discussed yet in the RFID context, although the underlying infrastructure of a supply chain, of course, is a network.

Identification codes: The theory of identification in the presence of noise had been developed in [8]. The underlying model is the same as Shannon's model for the transmission of information over a noisy channel: a bit is flipped from 0 to 1 or from 1 to 0 with a small probability **e**. Then a central role is played by the entropy $h(e) = -e.\log(e) - (1-e).\log(1-e)$. Namely, exponentially many - approximately $2^{n.h(e)}$ - messages can be reliably (i.e.,with arbitrarily small probability of confusing the messages) transmitted over the channel using block codes of n bits. In [8], the authors now relaxed Shannon's model to the identification case, in which the exact decoding of the message is not important, but the question "Is this the message (or item) I am interested in?" has to be answered. Their central result was that again the entropy is the important parameter, but with n bits now doubly exponentially many – approximately 2 to the power $2^{n.h(e)}$ - messages or items can be identified. In other words, given a number m of messages, about log (m) bits are required to reliably decode the message, whereas only log(log(m)) bits are required to identify the message.

Such identifation codes automatically provide an authentication mechanism. They just answer the question “Is this the item I am looking for?” and do not give any further information about the item. Since they are very short, devices with a very limited storage space like RFIDs are ideal for application. As mentioned before, the presence of noise is essential. Especially, when noise comes into play, codes base on hashing will not work well any more. Noise will automatically come into play, when the distance to the reader device is large. A setting, where this might occur, is a misplacemnt of an object. In this case it can be searched for within a distance the reader will allow. With high probability then the object can be identified.

Network coding: The theory of network coding has been developed only in the last decade, for a recent book on the topic by the leading expert, see [9]. The main discovery was that encoding the messages in the nodes of an information network can improve the throughput. Since the internet and other information networks are based on routers, which simply forward (without coding) the arriving information to the successors of the respective node in the network, a lot of attention was drawn to the topic – even the Scientific American became interested [10]. We shall motivate the benefits with the standard example from literature – the butterfly network.

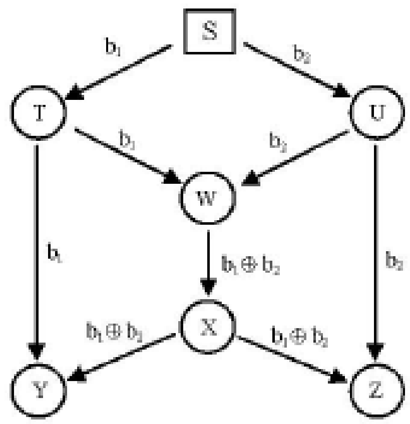

FIGURE 2: The Butterfly Network [9]

The situation here is that a sender wants to transmit the two messages b_1 and b_2 to the two receivers Y and Z each. Since there is a bottleneck on the edge between W and Z, in a transport network it would not be possible to transport b_1 and b_2 at the same time. So, either this would cause a delay by transporting them subsequently or the capacity of this edge were to increase. In an information network, where b_1 and b_2 are digital messages, it is simply possible to encode them into one message b_1+b_2 as in Figure 2. The receivers then could simply decode, for instance, Y can calculate $b_2= (b_1+b_2)-b_1$. Of course, the addition can be carried out in any field, for instance modulo a prime number – as indicated in Figure 2 by the circle around the “+”.

Soon it turned out that the improvement of throughput was not the only advantage of network coding. Especially, security aspects became apparent. Coding of information in the nodes of a network could protect the information against eavesdropping and even link failures. Microsoft launched its content distribution system Avalanche, which is based on network coding. This and several further applications are listed in [11]. We could not find in [11] or other papers any application related to RFID security, which was our motivation to discuss this topic here in some detail.

The fundamental difference between a transport network and an information network is that messages in an information network are immaterial and can hence be copied or combined to a new message. This would not be possible with goods in a transport network. Now observe that the goods and the RFID tags attached to them in a supply chain are distributed via a transport network as in Figure 1, whereas the messages on the RFIDs are distributed via an information network.

For our purposes, the improvement of throughput is not an essential feature. Security aspects are more important. One of these aspects is also evident in Figure 2. Observe that the encoding in node W yields a new message b_1+b_2, which does not reveal enough information on the single messages b_1 and b_2 to an eavesdropper. So without the single messages, which hence act as a secret key for the other message, the information is useless for a third party. So the encoding can also be regarded as an encryption procedure.

This can be applied to RFID security by encrypting sensible information in the nodes of the underlying network via a network code. Via the methods provided so far in the literature (e.g. [10],[11]) further protection can be guaranteed against link failures, which correspond to the case that an RFID tag would be lost – for instance, by accidental or intentional removal. The information on the RFID tag to be kept secret might also be an authentication code or the part of it for the respective receiver.

So far, we saw how the existing theory on network coding can be applied to RFID security. This concerns primarily secrecy aspects and only secondarily, via encrypting relevant information, authenticity aspects. In the sequel we shall sketch how network coding can further be applied to authentify the products to be transported via information on the RFID tags. In order to do so, we first need some clarity about the infrastructure:

(1) *The Network*: Authentication is a protection against fraud. So, it has to be clarified, in which places fraud can occur. This can be in the nodes, usually representing the depots of the supply chain, or in the edges, which represent the roads between these depots. So if, for instance, an employee of a post office would steal or replace a parcel, this fraud would occur in a node of the network. The same action by a truck driver would result in a fraud in an edge of the network. Protection can be provided against either kind of fraud or against both kinds simultaneously. In order to design the authentication code, the correct scenario should be considered. For instance, when leaving the depots, the trucks may be sealed such that fraud in the edges is unlikely, or, in the other direction, the emlpoyees may be considered as reliable, such that fraud in the nodes is irrelevant. By replacing every node by an edge (between the incoming and the outgoing point, for instance), every network may be extended to a network in which only frauds in the edges should be considered.

(2) *Synchronization:* In the butterfly network in Figure 2 it is essential that the two messages arrive in node W at the same time. So, the encoder in a node has to know which informations he must combine into a codeword. The incoming informations hence must be synchronized – either they arrive at the same time or the encoder knows which parts he has to wait for. If this is not the case, some additional information must be provided. In Microsoft's Avalanche system the previous codes are attached to the message. This, however, may be too space-intensive for RFIDs. However, a local computer in the nodes may help – see (3).

(3) *Local Storage and Computation:* Since RFIDs have very much limited storage space and computational power, local computers placed in the nodes of the network may be necessary to serve as an assistance. Information may also be stored in such local computers in order to later trace back the path from the receiver to the sender. Further it is understood that, in order to apply network coding procedures, the devices in the nodes of the network will be able to read from and write to the RFIDs, i.e, it must be possible to overwrite the contents of an RFID in any node of the network.

(4) *Information vs. Transport:* We saw already that the fundamental difference between a transport and an information network is that information can be copied or coded to a new message. Our application is in some sense in between an information and a transport network. To see this, observe what will happen in node W in Figure 1. If two parcels will arrive tagged with RFIDs whose contents is b_1 and b_2, respectively, then the information would be combined to b_1+b_2. This new message will be written to both RFID tags. Hence, two copies – one for each parcel – of the

new message will leave the node W in direction X, contrasting to a pure information network, where only one copy would be necessary.

(5) *THE RFIDs:* As mentioned under (3) it must be possible to read from and write to the RFIDs. Further, cloning must be impossible, which could be guaranteed by a unique code as a serial number which cannot be changed. Further, the RFIDs must be attached in such a way to the goods that they cannot be removed without this being observed.

With this scenario in mind, one might think about the possible kinds of fraud. A simple theft of a good can be detected by counting the parcels. Hence a parcel must be replaced by a counterfeit. By (5) we assume that the attached RFID cannot be removed and not be cloned, which means that the counterfeit parcel must be provided with a counterfeit RFID distinguishable from the original one. Further, the counterfeit RFID must be of some quality such that the fraud cannot be immediately detected by a reader device.

An authentication should usually serve the detection of a counterfeit. This may occur (a) immediately in the node following the fraudulent edge, (b) at a specified receiver, or (c) at a subset of all the receivers. If the fraud is detected at the receiving end one might further try to find out (d) the location of the fraud.

Network coding can immediately be applied to the cases (b) and (c), where the fraud is detected at the receiving end. If a counterfeit had taken place, the message on the RFID cannot be the one it should be. To compare it with the correct message there are three possibilities: one might ask the sender, one might compare the messages with those having arrived at the other receivers (case (c)), or one might provide the correct message through another network code, for instance, an error-correcting code as sketched before. This last possibility is, of course, in the spirit of cryptology, where an authentication code consists of the correct message and some manipulation of this message, which cannot be corrupted. Usually in cryptology this is guaranteed via one-way functions. The computation of these one-way functions, however, is too complex for RFID devices. The security via a network code would stem from the fact that information from one node is distributed to all his successors. So if fraud takes place on an edge to one of these successors the information may still be reconstructed from the other edges.

After detecting the error, it has to be found out where the fraud has taken place – case (d) above. This must have occured on one of the edges on the path from the sender to the receiver whose good and respective RFID are counterfeits. The network code may already reveal some information. Consider, for instance, the example in Figure 2 and assume that the RFID arriving at Y was a counterfeit and that exactly one edge was corrupted. Y should be in possession of b_1 and b_2. If b_1 is not received correctly the fraud must have taken place on the edges (S,T) or (T,Y). Otherwise, we further check if Y and Z received the same message from W. If this is the case, then the fraud must have taken place before node W – on (T,W) or (U,W). If the messages from W to Y and Z, respectively, are different, then the fraud took place after W – on (W,X) or (X,Y). So, an investigator from the police or an insurance company already has some information about the location. The exact location cannot be found by a simple network code. The difficulty is that a counterfeit RFID would influence all messages on the edges following the one where the counterfeit took place. To obtain further infomation one would have to store the messages on the incomig RFIDs on local computers in the nodes. However, here we see a lot of perspectives for future research.

So, network coding can be applied to detect counterfeits at the receiving end and to obtain some information about the location of the fraud. The strongest protection would be an immediate detection of fraud at the ending node of the edge where the fraud occured – case (a) above. In this case network coding might help only in nodes with more than one incoming edges, since some information about the correct message that should arrive via the corrupted edge might be contained in the messages arriving via the other incoming edges.

CONCLUSION

In this paper, we wanted to draw the attention on infomation theoretic methods which might be useful

for authentication via RFIDs, since they are applicable in situations, where the standard tools for authentication codes – hash functions and asymmetric cryptosystems based on one-way functions – are problematic. Hash functions are not applicable if errors can occur during the transmission. In this case identification codes may be an interesting alternative. The computation of a one-way function with an RFID processor is too complex in order to guarantee a sufficient degree of security. As an alternative, at least for a supply chain described by a network we suggest network coding as a proper alternative. Security is here obtained by distributing the information on an RFID to all the successors of a node. We saw that network coding can easily be used to detect a counterfeit at the receiving end and also to obtain information about the location where the fraud took place. There is a lot of perspective for further research, since the codes have to be designed separately for every network, also taking into account aspects like time synchronization and local storage and computation in the nodes of the network. To our knowledge identification codes and network coding have not been applied to RFID security and other problems related to supply chains, so far. Indeed, information theory is usually studied in electrical and communication engineering. For identification codes even in this area applications are hardly known. RFIDs and other storage devices with limited memory may be a very natural environment. Completely different is the situation with network coding. Since the pioneering paper published by Ahlswede, Cai, Li and Yeung [12] only in the year 2000 a lot of applications have been found. These are surveyed, for instance in [10], [11]. Besides communication problems, the most notable application is distributed storage: the whole topic became very popular after Microsoft launched their peer-to-peer Avalanche system for content distribution, see [13], [14]. Authentication problems in this context had already been adressed [15], however, these are again based on traditional cryptography. With this paper, we hope to initiate a discussion about the possible application of network coding to RFID security in transport networks like supply chains. Our first emphasis is on the location of fraud in the supply chain. Further applications will surely follow, but one has to be careful with the restrictions given by the supply chain and by the RFIDs themselves.

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FUZZY ANALYTIC NETWORK PROCESS APPROACH FOR SHOPPING CENTER LOCATION SELECTION PROBLEM

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Abstract *— The shopping center location selection problem has been critical issue for investors in fast-growing retail markets for a long time. In the presence of many alternatives and selection criteria, the problem becomes a multiple-criteria decision making (MCDM) shopping center location selection problem. Therefore, the investors have utilized various methods to successfully carry out this difficult and time-consuming process. In this work, one of the most used MCDM methods, the Analytical Network Process (ANP) is introduced to present a performance analysis on the shopping center location selection problem. Furthermore, we utilize a fuzzy extension of ANP which uses uncertain human preferences as input information in the decision-making process due to the fact that a fuzzy logic method providing more accuracy on judgments. The resulting fuzzy ANP (FANP) enhances the potential of the conventional ANP for dealing with imprecise and uncertain human comparison judgments.*

Keywords — Analytic network process, fuzzy logic, multiple-criteria decision making, shopping center selection.

INTRODUCTION

Evaluating shopping center location selection alternatives is a typical multiple-criteria decision making (MCDM) problem in the presence of a set of quantitative and qualitative evaluation criteria. So, in this work, we utilized analytic network process (ANP) method, because it has been widely used for determining the best satisfying alternative from a set of possible options. The ANP method is used because, in the world of the decision making, as a holistic approach, the ANP method developed by T.L. Saaty [1] is needed if all criteria and alternatives involved are connected in a network system accepting various dependencies.

Furthermore, if compared the ANP with the analytic hierarchy process (AHP) developed by T.L. Saaty [2], the AHP is not suitable for decision problems that cannot be hierarchically structured because they involve the interactions and dependencies in higher or lower level elements. In other words, ANP incorporates feedback and interdependent relationships among decision criteria and alternatives [1]. This provides a more accurate approach for modeling complex decision environment [3, 4].

In addition, a decision maker`s requirements on evaluating a set of alternatives in a MCDM problem always contain ambiguity and multiplicity of meaning. Furthermore, it is also recognized that human assesment on qualitative attributes is always subjective and thus imprecise. Therefore, conventional ANP seems to be inadequate to capture decision maker`s requirements explicitly.

So, in this work, in order to model this kind of uncertainity in human preference, fuzzy sets could be incorporated with the pairwise comparison as an extension of ANP. This fuzzy ANP (FANP) approach allows us a more accurate description for shopping center location selection problem.

RELATED LITERATURE

In literature, a number of studies have been realized in various fields using the ANP and its fuzzy extension, fuzzy ANP since first introduced. Some of them are presented here; Hamalainen and Seppalainen [5] presented ANP-based framework for a nuclear power plant licensing problem in Finland. They used the pairwise comparison process with the consistency index to determine the weightings of the alternatives. ANP is also used to incorporate product lifecycle in replacement decisions [6]. Meade and Presley [7] used the ANP method for R&D project selection. Agarwal and Shankar [8] presented a framework for selecting the trust-building environment in e-enabled supply chain. Lee and Kim [9] proposed an integration model by integrating the ANP and goal programming for interdependent information system project selection.

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Yurdakul [4] used the ANP method to measure long-term performance of a manufacturing company. Carnahan *et al.* [10] also used fuzzy ratings for multi-attribute decision making. Buyukozkan *et al.* [11] used fuzzy ANP to prioritize design requirements by taking into account the degree of the interdependence between the customer needs and design requirements and the inner dependence among them. Mikhailov and Singh [12] used fuzzy ANP and its application to the development of decision support systems.

PROPOSED APPROACH

In this section, first fuzzy logic is introduced; second fuzzy ANP-based approach and its steps are presented.

Fuzzy logic

The key idea of fuzzy set theory is that an element has a degree of membership in a fuzzy set [13, 14]. A fuzzy set is defined by a membership function (all the information about a fuzzy set is described by its membership function). The membership function maps elements (crisp inputs) in the universe of discourse (interval that contains all the possible input values) to elements (degrees of membership) within a certain interval, which is usually [0, 1]. Then, the degree of membership specifies the extent to which a given element belongs to a set or is related to a concept. Finally, if the value lies within the interval [0, 1], the element has a certain degree of membership (it belongs partially to the fuzzy set). A fuzzy set, then, contains elements that have different degrees of membership in it. In this study, the triangular fuzzy numbers (TFNs), $\tilde{1}$ to $\tilde{9}$, are used to represent subjective pairwise comparisons of selection process (equal to extremely preferred) in order to capture the vagueness (table 1). A fuzzy number is a special fuzzy set $F = \{(x, \mu_F(x)), x \in R\}$, where x takes it values on the real line, $R: -\infty < x < +\infty$ and $\mu_F(x)$ is a continuous mapping from R to the closed interval [0, 1]. A triangular fuzzy number denoted as $\tilde{M} = (l, m, u)$, where $l \le m \le u$, has the following triangular type membership function:

$$\mu_F(x) = \begin{cases} 0 & x<l \\ x-l \big/ m-l & l \le x \le m \\ u-x \big/ u-m & m \le x \le u \\ 0 & x>u \end{cases}$$

In conventional ANP, the pairwise comparison is made using a ratio scale. A frequently used scale is the nine-point scale [15] which shows the participants` judgments or preferences. Even though the discrete scale of 1-9 has the advantages of simplicity and easiness for use, it does not take into account the uncertainty associated with the mapping of one’s perception or judgment to a number. The TFNs are utilized to improve the conventional nine-point scaling scheme of the ANP.

Fuzzy ANP-based approach

ANP represents relationships in a form of network but does not require as strict as hierarchical structure and therefore allows for more complex interrelationships among the decision levels and attributes. The overall objective is to find out the best shopping center location alternative. The determinants, dimensions and attribute-enablers used for evaluating a set of location alternatives are determined based on the needs and expectations of the investor. That’s why that they may differ from an investor to another. They are also so critical elements in determining the best alternative, because they directly affect to determine the ultimate alternative out of the available options. After constructing flexible hierarchy, the decision maker is asked to compare the elements at a given level on a pairwise basis to estimate their relative importance in relation to the element at the immediate proceeding level.

Next, the proposed approach is presented step-by-step:

Step I. Model construction and problem structuring: The top most elements in the hierarchy of determinants are decomposed into dimensions and attribute-enablers. The decision model development requires identification of dimensions and attribute-enablers at each level and the definition of their interrelationships. The ultimate objective of hierarchy is to identify alternatives that are significant for finding out best shopping center location alternative.

Step II. Building pairwise comparison matrices between component/attributes levels: By using TFNs, the decision-maker(s) are asked to respond to a series of pairwise comparisons with respect to an upper level "control" criterion. These are conducted with respect to their relevance importance towards the control criterion. In the case of interdependencies, components in the same level are viewed as controlling components for each other. Levels may also be interdependent. The TFNs are used to indicate the relative strength of each pair of elements in the same hierarchy. Then, the fuzzy judgment matrix, $\tilde{A}$ ($\tilde{a}_{ij}$) via pair wise comparison is constructed as given below;

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & .. & .. & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & .. & .. & \tilde{a}_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \tilde{a}_{n1} & \tilde{a}_{n2} & .. & .. & 1 \end{bmatrix}$$

where,

$\tilde{a}_{ij} = 1$, if i is <u>equal</u> j , and $\tilde{a}_{ij} = \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$ or $\tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1}$, if i is <u>not equal</u> j.

When scoring is conducted for a pair, a reciprocal value is automatically assigned to the reverse comparison within the matrix. That is, if $\tilde{a}_{ij}$ is a matrix value assigned to the relationship of component i to component j , then $\tilde{a}_{ij}$ is equal to $1/\tilde{a}_{ij}$. Alternatively, by defining the interval of confidence level α , the triangular fuzzy number can be characterized using the following equation (Eq.1):

$$\forall \alpha \in [0,1]$$
$$\tilde{M}_\alpha = [l^\alpha, u^\alpha] = [(m-l)\alpha + l, -(u-m)\alpha + u] \tag{1}$$

Some main operations for positive fuzzy numbers are described by the interval of confidence, by Kaufmann and Gupta [16] as given below:

$$\forall m_L, m_R, n_L, n_R \in R^+, \tilde{M}_\alpha = [m_L^\alpha, m_R^\alpha], \tilde{N}_\alpha = [n_L^\alpha, n_R^\alpha], \alpha \in [0,1]$$

$$\tilde{M} \oplus \tilde{N} = [m_L^\alpha + n_L^\alpha, m_R^\alpha + n_R^\alpha] \quad \tilde{M} \Theta \tilde{N} = [m_L^\alpha - n_L^\alpha, m_R^\alpha - n_R^\alpha]$$

$$\tilde{M} \otimes \tilde{N} = [m_L^\alpha n_L^\alpha, m_R^\alpha n_R^\alpha] \quad \tilde{M} / \tilde{N} = [m_L^\alpha / n_L^\alpha, m_R^\alpha / n_R^\alpha]$$

While α is fixed, the following judgment matrix can be obtained after setting the index of optimism, μ, in order to estimate the degree of satisfaction. The eigenvector is calculated by fixing the μ value and identifying the maximal eigenvalue.

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{21}^{\alpha} & .. & .. & \tilde{a}_{1n}^{\alpha} \\ \tilde{a}_{21}^{\alpha} & 1 & .. & .. & \tilde{a}_{2n}^{\alpha} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \tilde{a}_{n1}^{\alpha} & \tilde{a}_{n2}^{\alpha} & .. & .. & 1 \end{bmatrix}$$

$\alpha - cut$ is known to incorporate the experts or decision maker(s) confidence over his/her preference or the judgments. Degree of satisfaction for the judgment matrix is estimated by the index of optimism μ determined by the decision maker. The larger value of index μ indicates the higher degree of optimism. The index of optimism is a linear convex combination [17] as defined in the following equation (Eq.2):

$$a_{ij}^{\alpha} = \mu a_{iju}^{\alpha} + (1-\mu) a_{ijl}^{\alpha}, \ \forall \mu \in [0,1] \qquad (2)$$

Once the pairwise comparisons are completed, the local priority vector w (also referred as e-Vector) is computed using (Eq.3) as the unique solution:

$$Aw = \lambda_{\max} w \qquad (3)$$

where, $\lambda_{\max}$ is the largest eigenvalue of A

Step III. Calculating consistency ratio (CR) for each pairwise comparison matrix: After constructing all required pairwise judgment matrices between component/attributes levels, for each, the consistency ratio (CR) should be calculated.

The deviation from consistency, the measure of inconsistency is called the consistency index (CI) and calculated using the following equation (Eq.4):

$$CI = \frac{\lambda_{\max} - n}{n-1}, \text{ where } n \text{ is matrix size} \qquad (4)$$

The CR is used to estimate directly the consistency of pairwise comparisons, and computed by dividing the *CI* by a value obtained from a table of Random Consistency Index *(RI)*, the average index for randomly generated weights [2], as shown in (Eq.5).

$$CR = \frac{CI}{RI} \qquad (5)$$

If the *CR* less than 0.10, the comparisons are acceptable, otherwise not.

Step IV. Pairwise comparison matrices of inter-dependencies: In order to reflect the interdependencies in network, pairwise comparisons among all the attribute-enablers are constructed and their consistency ratios are calculated as we previously defined in *Step II* and *Step III*.

Step V. Super-matrix formation and analysis: The super-matrix formation allows a resolution of the effects of interdependence that exists between the elements of the system. The super-matrix is a partitioned matrix, where each sub-matrix is composed of a set of relationships between two levels in the graphical model. Three types of relationships may be encountered in this model; (1) independence from succeeding components, (2) interdependence among components, (3) interdependence between levels of components. Raising the super-matrix to the power *2k+1*, where *k* is an arbitrary large number, allows convergence of the interdependent relationships between the two levels being compared. The super-matrix is converged for getting a long-term stable set of weights.

Step VI. Selection of the shopping center location alternative: The equation of *desirability index,* D_{ia} for alternative i and determinant a is calculated using the following equation (Eq.6):

$$D_{ia} = \sum_{j=1}^{J} \sum_{k=1}^{K_{ja}} P_{ja} A_{kja}^{D} A_{kja}^{I} S_{ikja} \qquad (6)$$

Step VII. Calculation of Shopping Center Location Selection Weighted Index (SCLSWI): To finalize the analysis of the selection, SCLSWI is calculated for each alternative. The SCLSWI value is the product of the desirability index, D_{ia} for each alternative. Then, the SCLSWI values are normalized to prioritize the alternatives to determine the one with highest value.

In this section, we applied the proposed approach to a real-life example as follows: First, the ANP network diagram using Super Decision Software is given (FIGURE 1).

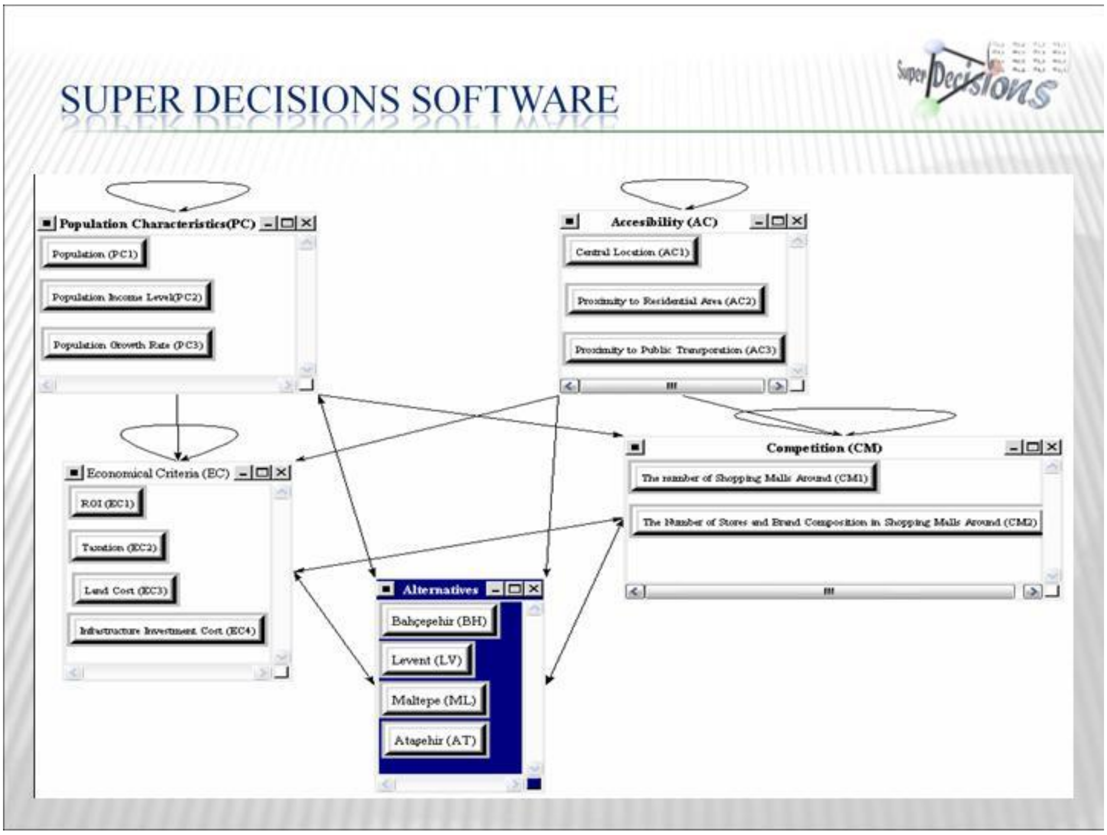

FIGURE 1
ANP Network Structure Represented in Super Decisions Software

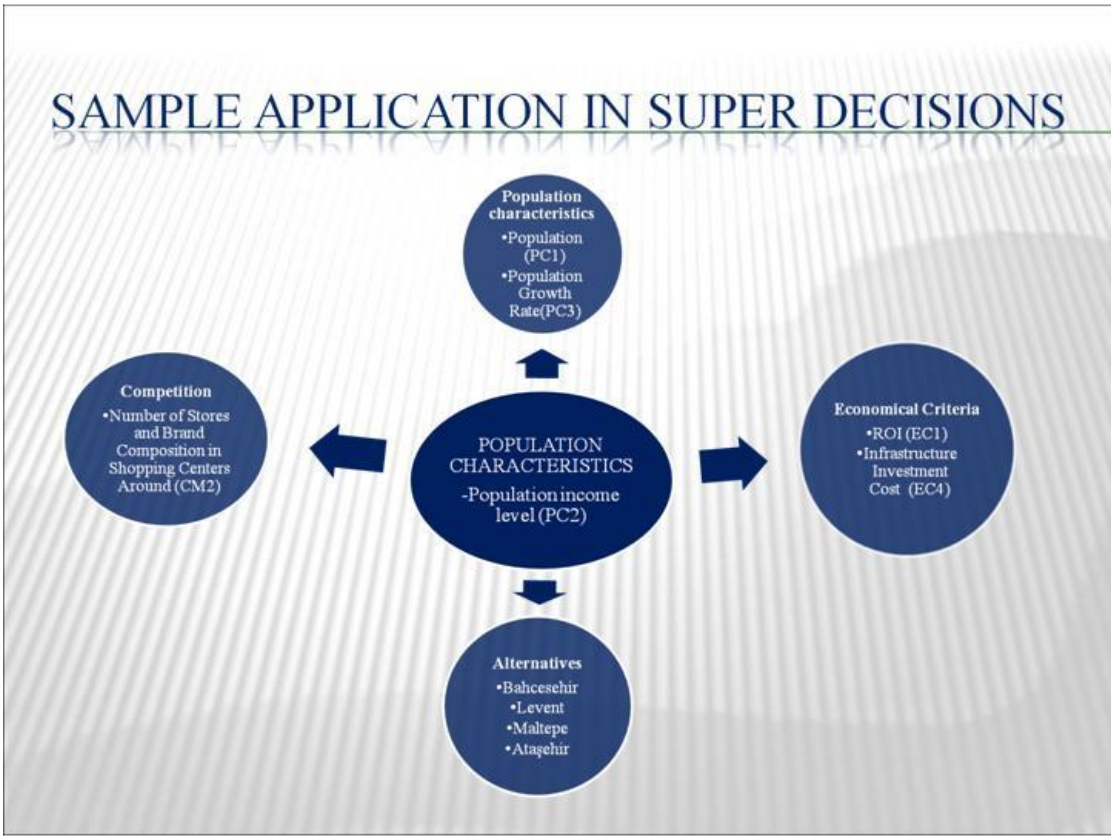

FIGURE 2
Sample Application in Super Decisions

CONCLUSION

The shopping center location selection as a MCDM problem has been critical issue for investors in fast-growing retail markets for a long time. In addition, it is difficult and time-consuming process to evaluate potential alternatives in terms of a set of evaluation criteria. Therefore, in this study, we used the ANP integrated with fuzzy logic. Because fuzzy ANP (FANP) uses uncertain human preferences as input information in the decision-making process due to the fact that a fuzzy logic method providing more accuracy on judgments. The resulting fuzzy ANP (FANP) enhances the potential of the conventional ANP for dealing with imprecise and uncertain.

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LOCATIONAL DECISION MAKING OF A LOGISTICS CENTER FOR TURKISH CLOTHING INDUSTRY

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Abstract *— The textile and clothing sectors can be seen as a supply chain consisting of a number of discrete activities. The supply chain from sourcing of raw materials to distribution and marketing must be well organized as an integrated production network. Logistics is a very important strategy to get competitive advantages like time, cost and customer satisfaction. This paper presents a locational decision making of a logistics center for Turkish Clothing Industry in Marmara Region in Turkey. A numerical study with a questionnaire survey database aimed at the clothing industry of Turkey was conducted and Analytic Hierarchy Process (AHP) was used to evaluate the questionaire results.*

Keywords — Analytic Hierarchy Process, site selection, logistics center

INTRODUCTION

Logistics, in its most basic definition, is the efficient flow and storage of goods from their point of origin to the point of consumption. It is the part of the supply chain process that plans, implements and controls the flow of goods. It can also be seen as the management of inventory, in rest or in motion. Logistics is also defined as a business planning framework for the management of material, service, information and capital flows. It includes the increasingly complex information, communication and control systems required in today's business environment [1].

The clothing sector is both a labor-intensive, low wage industry and a dynamic, innovative sector, depending on which market segments one focuses upon. In the high-quality fashion market, the industry is characterized by modern technology, relatively well-paid workers and designers and a high degree of flexibility. The competitive advantage of firms in this market segment is related to the ability to produce designs that capture tastes and preferences, and even better – influence such tastes and preferences – in addition to cost effectiveness. The core functions of firms servicing this market segment are largely located in developed countries and often in limited geographical areas or clusters within these countries [2]. The other major market segment is mass production of lower-quality and/or standard products. Manufacturers for this market segment are largely found in developing countries, often in export processing zones and/or under so-called outward processing agreements with major importers. In the low to middle priced market, the role of the retailer has become increasingly prominent in the organization of the supply chain [3].

The supply chain of the clothing sector has very distinctive processes. Different supply methods, push and pull logistics as well as the non replenishment approaches especially for the fast fashion sector are affecting processes in the supply chain. In addition, the depth and range of assortments such as different sizes, colors, and cuts of a collection requires very efficient and optimized logistics. Furthermore time efficiency is one of the key factors for this industry to provide a competitive advantage. Logistics is a very important strategy to get competitive advantages like time, cost and customer satisfaction. This paper presents a locational decision making of a logistics center for Turkish Clothing Industry in Marmara Region in Turkey. A numerical study with a questionnaire survey database aimed at the clothing industry of Turkey was conducted and Analytic Hierarchy Process (AHP) was used to evaluate the questionaire results.

LITERATURE REVIEW

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Sheu [4] presented a hybrid neuro-fuzzy methodology to identify appropriate global logistics (GL) operational modes used for global supply chain management. The proposed methodological framework included three main developmental phases: (1) establishment of a GL strategic hierarchy, (2) formulation of GL-mode identification rules, and (3) development of a GL-mode choice model. By integrating advanced multi-criteria decision-making (MCDM) techniques including fuzzy analytical hierarchy process (Fuzzy-AHP), Fuzzy MCDM, and the technique for order preference by similarity to an ideal solution (TOPSIS), six types of global logistics and operational modes coupled with corresponding fuzzy-based multi-criteria decision-making rules were specified in the second phase. Using the specified fuzzy decision-making rules as the input database, an adaptive neuro-fuzzy inference system (ANFIS) was then developed in the third phase to identify proper GL modes for the implementation of global supply chain management. A numerical study with a questionnaire survey database aimed at the information technology (IT) industries of Taiwan was conducted to illustrate the applicability of the proposed method.

Chen et al.considered the planning of a multi-product, multi-period, and multi-echelon supply chain network that consists of several existing plants at fixed places, some warehouses and distribution centers at undetermined locations, and a number of given customer zones. The supply chain planning model was constructed as a multi-objective mixed-integer linear program (MILP) to satisfy several conflict objectives, such as minimizing the total cost, raising the decision robustness in various product demand scenarios, lifting the local incentives, and reducing the total transport time. For the purpose of creating a compensatory solution among all participants of the supply chain, a two-phase fuzzy decision-making method was presented and, by means of application of it to a numerical example, was proven effective in providing a compromised solution in an uncertain multi-echelon supply chain network [5].

Tudela et al. [6] compared the outcome of Cost Benefit Analysis and a Multi-Criteria method when applied to a transport project. The Analytic Hierarchy Process was used, utilising two approaches to derive the weights. Results showed that the outcome of the Multi-Criteria method didn’t match the one suggested by the Cost Benefit Analysis, but it match the final decision by the authority. An important conclusion has to do with the relevance of incorporating other aspects into the assessment, apart from the economic ones. Furthermore, public opinion should be taken into account explicitly into the decision making, providing accurate and timely information about projects.

A freight village is defined as a specific area where all the activities relating to transport, logistics and goods distribution –both for national and international transit –are carried out by various operators. In order to encourage intermodal transport for goods handling, a Logistics Center should preferably be served by a variety of transport modes (roads, rail, sea, inland waterways, air) [7]. UNECE has defined the freight transport as a geographical grouping of independent companies and bodies which are dealing with freight transport (for example, freight forwarders, shippers, transport operators, customs) and with accompanying services (for example, storage, maintenance and repair), including at least a terminal [8].

Tsamboulas and Kapros [9] presented a method and models for assessing the financial viability of a new Freight village financed by private and public investments. The financial evaluation model constituted an integrated part of a wider planning methodology, with four distinct phases, namely (a) site selection and traffic forecasts, (b) definition of services offered and corresponding dimensions, (c) estimation of investment and operation costs and (d) evaluation of investments. The paper presented the overall methodology, and presented analytically the evaluation method with the corresponding model. An application of developed methodology and models is done for the case of a Freight village in Northern Greece, demonstrating its potential to application for similar cases.

Ozdemir [10] studied a research project involving logistics firms in Istanbul designed to investigate the strengths and weaknesses of Istanbul in its quest to become as a logistics center serving a wider region beyond Turkey. The results of the interviews and survey have shown that, logistics activity in the Marmara region (and Istanbul in particular) is mainly the result of economic activities taking place in a national context, rather than the result of logistics node operations at a regional or global level.

As mentioned above there are many types of studies related to the logistics such as global logistics operational modes, the planning of supply chain network, transportation and warehousing management, transport project, performance measures and logistics center. The concept of flow has become particularly important in logistics and freight distribution. From a simple question of capacity, the issues of timing, frequency and punctuality are now of significant relevance in freight movements since they are part of supply chain management strategies. In particular, transport terminals and freight distribution centers have been the major elements permitting improvements in the efficiency and throughput of commodity chains from global production networks to local distribution.

This paper presents a locational decision making of a logistics center for Turkish Clothing Industry in Marmara Region in Turkey. The research design for this study consisted of a case study form of methodology involving 55 Turkish clothing manufacturers. 32 of companies have manufacturing facilities and 23 of them use sub-contracting based firms for their manufacturing facilities. The method of collecting data during these studies was face-to-face interviews with management teams at their workplace. A numerical study with a questionnaire survey database was conducted and Analytic Hierarchy Process (AHP) was used to evaluate the questionaire results.

METHODOLOGY

The Analytic Hierarchy Process (AHP) for decision-making is a theory of relative measurement based on paired comparisons used to derive normalized absolute scales of numbers whose elements are then used as priorities [11,12]. Matrices of pairwise comparisons are formed either by providing judgments to estimate dominance using absolute numbers from the 1 to 9 fundamental scale of the AHP, or by directly constructing the pairwise dominance ratios using actual measurements. The AHP can be applied to both tangible and intangible criteria based on the judgments of knowledgeable and expert people, although how to get measures for intangibles is its main concern. The weighting and adding synthesis process applied in the hierarchical structure of the AHP combines multidimensional scales of measurement into a single “uni-dimensional” scale of priorities [13].

The Analytic Hierarchy Process is a powerful and understandable methodology that allows groups or individuals to combine qualitative and quantitative factors in decision making process. It is a Multi Criteria Decision Making method for complicated and unstructured problems. Also, it is an approach that uses a hierarchical model having levels of goal, criteria, possible sub-criteria, and alternatives. AHP captures priorities from paired comparison judgments of the elements of the decision with respect to each of their parent criteria [14].

As the evaluation scale, the Saaty’s scale of 1-9 will be used as shown in Table 1.

TABLE 1
The Fundamental Scale for Making Judgements

1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Between Very Strong and Extreme
9	Extreme

RESULTS

In this study we prepared a detailed analysis of a clothing logistics center location selection. First, a geographical evaluation of Turkish clothing sector was investigated to select the region for a logistics center. According to the data gathered from TurkStat (Turkish Statistical Institute) [15,16] it was seen that 59% of the clothing firms were founded in Marmara Region and 49% of the clothing firms were also established in Istanbul. As a result, it was decided to select Marmara Region for a logistics center establishment.

In North Marmara Region, three sites Tuzla, Hadimkoy and Gumusyaka were selected to analyze the benefits they could provide if a logistics center to be developed (Figure 1) [17,18]. These three sites were preferred by Istanbul Metropolitain Planning department in order to establish a logistics center because they all three places have good transportation advantages (port, airport, highway and RO-LA, RO-RO connections). Hadimkoy is very near to widely used Ataturk Airport, Ambarli Port, highway and railway. Gumusyaka and Tuzla also have the advantageous of being very close to the port, airport, highway connection and railway connection.

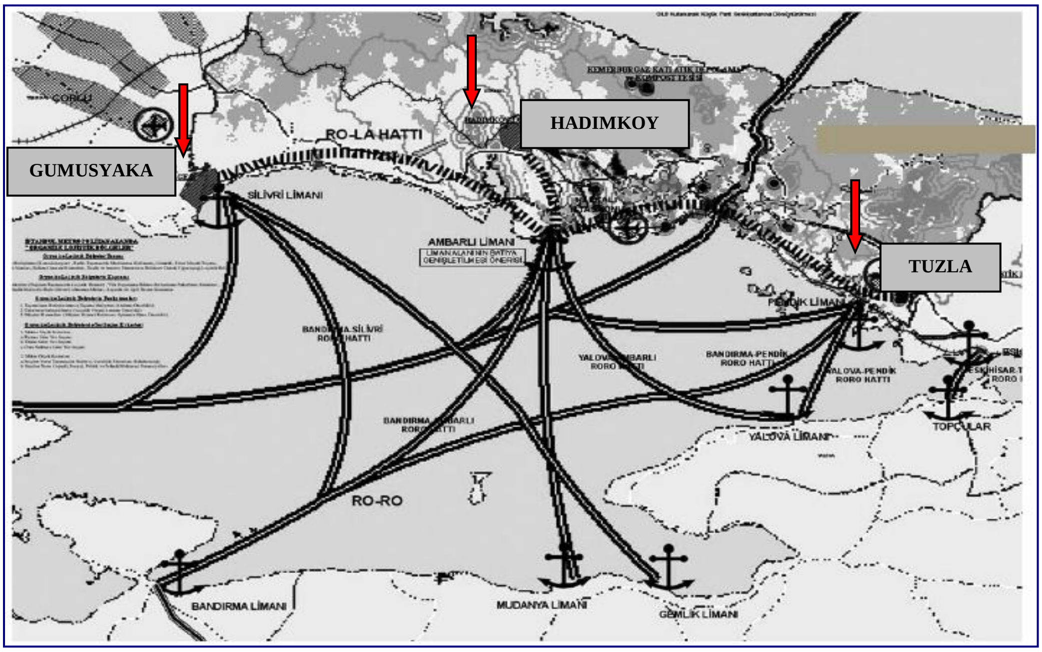

FIGURE. 1
Clothing Logistics Center Candidate Places.

Table 2 shows the site selection criteria that were developed as a result of intensive researches in literature and individual discussions with logistics sector professionals. For the study, next step will be to evaluate the below criteria for the best logistics center placement for the Turkish Clothing Industry.

TABLE 2
Clothing Logistics Center Site Selection Criteria

	SITE SELECTION CRITERIA
	PHYSICAL ANALYSIS
1	Land size
2	Expansion of Physical Facilities
3	The Geological Status (as in the earthquake zone)
	LOCATION ANALYSIS
1	Promotion opportunities in the region
2	Proximity to Supply Point
	INFRASTRUCTURE SERVICES
1	Communication infrastructure
2	Electricity, Gas and Water Networks
3	Sewage and waste treatment plants
	TRANSPORTATION OPPORTUNITIES
1	Proximity to the motorway
2	Proximity to the airport
	LABOR FORCE SUPPLY
1	Labor supply
2	Labor cost
	FIXED COST AND CAPITAL SUPPLY
1	Cost of land
2	Construction costs
3	Cost of usage

Figure 2 shows the Hierarchical model for site selection of a clothing logistics center. The goal of the study is site selection for a clothing logistics center and alternative places are Hadimkoy, Tuzla and Gumusyaka.

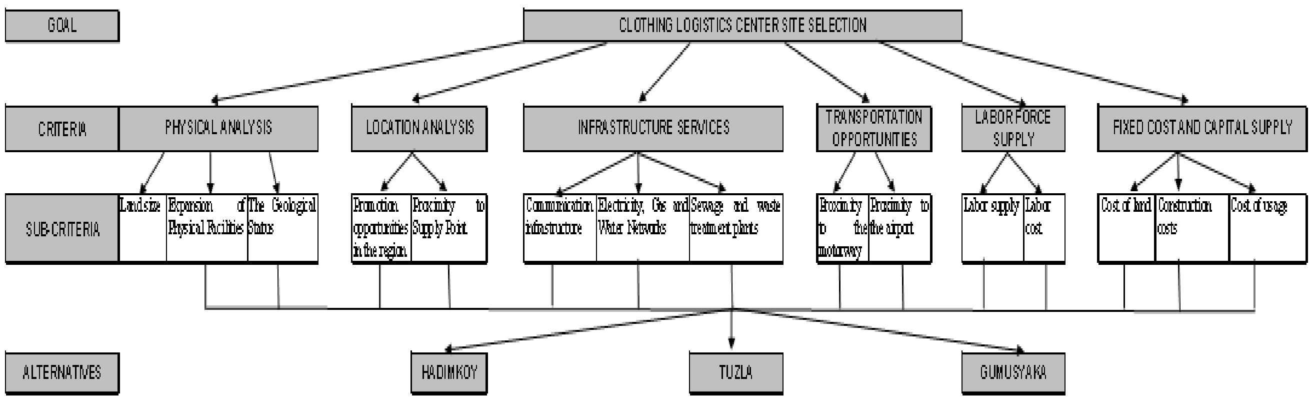

FIGURE. 2
Hierarchical Model for Site Selection Clothing Logistics Center.

Figure 3 and Figure 4 show the site selection criteria weights of apparel manufacturers and apparel firms that use sub-contractors. When site selection model is evaluated in terms of apparel manufacturs and apparel firms using sub-contractor firms, it is seen that the most important criteria is fixed cost and capital supply with

28% and 32% share. As a result of evaluation, second the labor force supply and third transportation opportunities come.

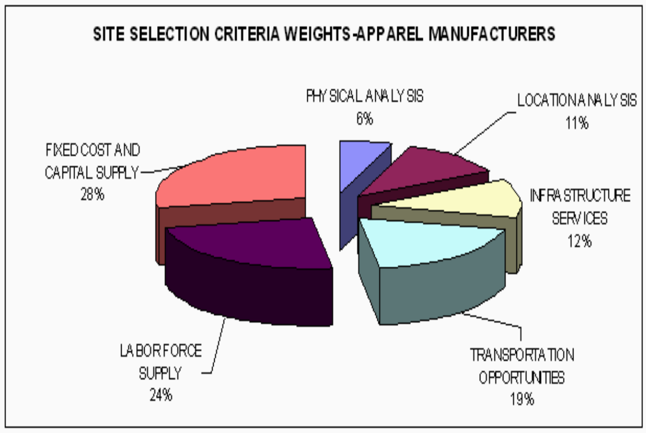

FIGURE. 3
Site Selection Criteria Weights of Apparel Manufacturers.

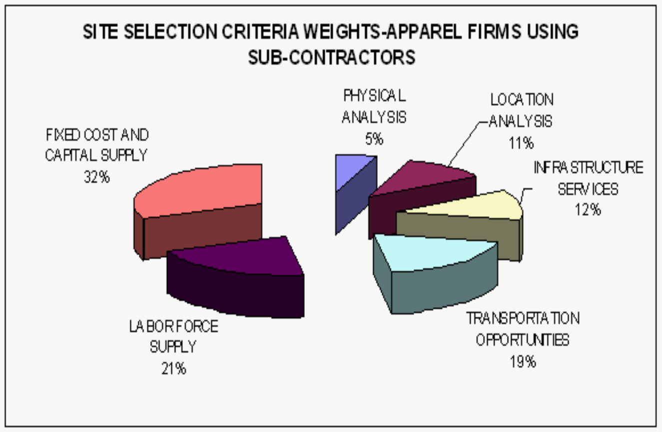

FIGURE. 4
Site Selection Criteria Weights of Apparel Firms using Sub-Contractors.

Figure 5 shows the results of site selection criteria for apparel manufacturers.When site selection model was evaluated in terms of apparel manufacturs Hadimkoy came in the first place with 34,8%. Gumusyaka was selected in the second place with 34,5% and Tuzla was in the third row with 30,6%. Striking result here was that, Gümüşyaka and Hadimkoy get almost equal weights. Apparel manufacturers disapproved building a clothing logistics center in Tuzla and they were evaluated Hadimkoy and Gumusyaka at the same level because apparel manufacturing is mostly concentrated in Europian part of the country. Apparel manufacturers gave high scores to the labor force supply and fixed cost and capital supply criteria. Especially, Gumusyaka and Hadimkoy were decided appropriate in terms of labor cost and cost of usage.

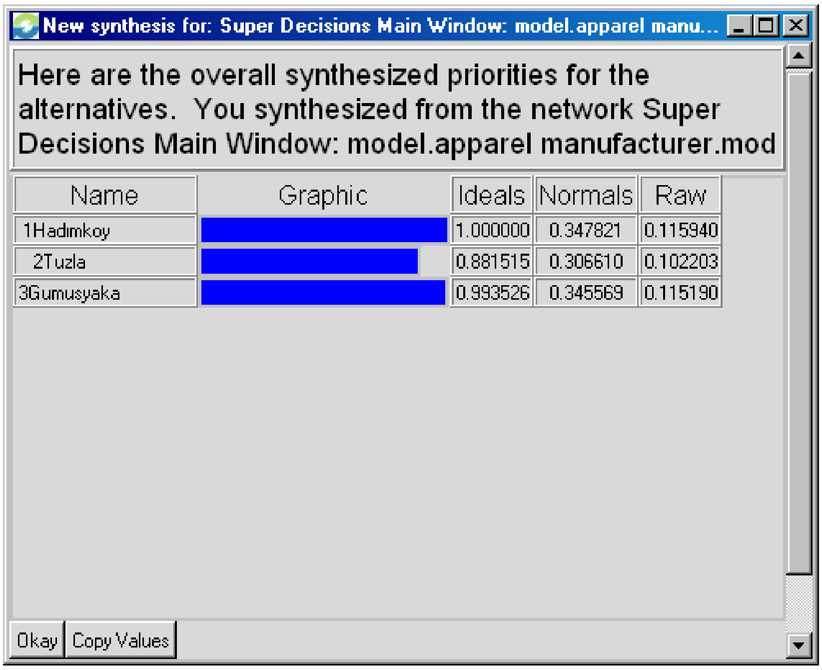

FIGURE. 5
The Result of Clothing Logistics Center Site Selection Decision of Apparel Manufacturers.

Figure 6 shows the results of site selection criteria for apparel manufacturers.When site selection model was evaluated in terms of apparel firms that use sub-contractors Hadimkoy came in the first place with 37,2%. Gumusyaka was located in the second place with 31,2% and Tuzla was in the third row with 31,6%. Apparel manufacturers who use outsourcing (sub-contractor) companies preferred Hadimkoy as a first place for a logistics center establishment because this region is a busy area in terms of transportation opportunities and labor force supply and the concentration of garment manufacturers is also high. Moreover, widely used Ambarli Port and Ataturk Airport are very near to Hadimkoy. Since these firms outsource their production Hadimkoy were evaluated very positively by the companies and Tuzla and Gumusyaka were evaluated equally important by the companies.

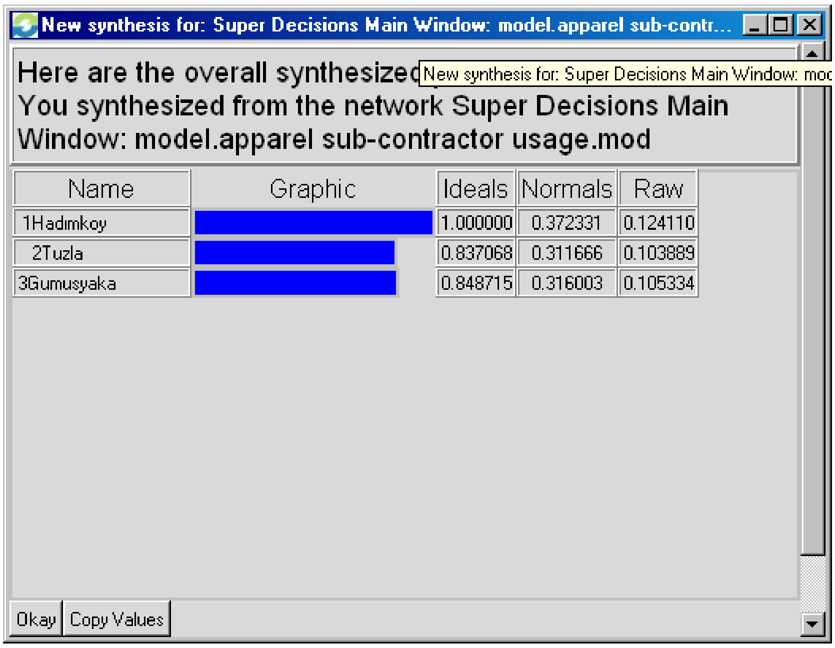

FIGURE. 6
The Result of Clothing Logistics Center Site Selection Decision of Apparel Firms that Use Sub-Contractors.

CONCLUSION

The objective of this research was to find the best place for a logistics center for clothing industry. A case study methodology was selected and an AHP based questionnaire was applied to 55 clothing companies located in Marmara Region in Turkey. Clothing firms were evaluated and classified according to their manufacturing facilities. 32 firms have their own manufacturing facilities and 23 firms outsource their facilities to sub-contactor firms.

Although, all of three places have good transportation opportunities like being very close to the port, airport, highway and railway, results showed that Hadimkoy was preferred as the first place to establish a clothing logistics center by all of the apparel companies. Hadimkoy is a busy area in terms of transportation opportunities and labor force supply and most of the garment manufacturers are located in this area. Also Turkey’s biggest airport (Ataturk Airport) and high-capacity port (Ambarli Port) are very close to the Hadimkoy. Apparel manufacturers disapproved building a clothing logistics center in Tuzla and they gave high scores to Hadimkoy and Gumusyaka because apparel manufacturers are mostly concentrated in Europian part of the country. Apparel firms that use sub-contractors evaluated Tuzla and Gumusyaka equally because they outsource their production facilities and only concentrate on marketing, branding and retailing activities. Hadimkoy is a commercially intensive place so this is the best choice for establishing a logistics center.

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DETERMINING THE LOCATION AND CAPACITIES OF THE WAREHOUSES OF KIZILAY EMERGENCY AND OPERATIONS MANAGEMENT CENTER

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Abstract *— This study is implemented in the logistic department of KIZILAY Emergency and Operations Management Center (AFOM). The aim of the project is to determine the location and capacity of warehouses to transport first aid materials to the population affected by the earthquake, as quickly as possible. In the study, northeast region of Turkey is selected as the pilot area, and firstly the fault lines in that region are examined and scenarios, that show the possible damages caused by earthquakes in various magnitudes and intensities, are created. Secondly, the demand of each town is determined according to these earthquake scenarios. Based on the demands and the distance between the demand and supply points, a p-center facility location model is proposed. The problem is solved with different budget and facility number constraints to obtain alternative solutions for the pilot area.*

Keywords —p-median facility location problem, emergency logistics and earthquake scenarios

INTRODUCTION

The frequency of occurrence of disasters in Turkey clearly reveals the fact of the importance of disaster management and emergency logistics in our country. Considering the climate, geological structure of our country and past disaster data, the probability of occurrence of a natural disaster is quite high enough. Every year, the economic loss caused by all natural disasters is 3% of the gross national product. According to the past disaster data among all natural disasters the 90% of loss of life and property is resulted from earthquakes. The 96% of Turkey is seismic hazard zone (Akdağ, 2002). In the last sixty years, Turkey is the fifth among all countries with respect to the loss of life as a result of earthquakes. Logistics is not only the transportation of commodities to the demand points, but also the system that consists of the procurement and stocking levels. Since the logistic systems include the steps from the procurement level to the last mile distribution of materials the functions of it should be considered as a whole. Facility location problem is a logistic function which is affected from many factors related to logistic network design. There are basic differences between commercial and emergency logistic planning. Therefore, there is a need to develop different methods to solve relief logistic problems. The main objective of emergency logistic systems is to transport the rescue team and aid materials to the affected regions as quickly as possible whereas in commercial logistic systems the basic aim is usually the minimum transportation cost. Unlike commercial systems, there is uncertainty relevant to demand, supply and network availability in emergency logistics. The logistic activities are categorized into four groups: mitigation (pre-disaster phase), preparedness (pre-disaster phase), response (post-disaster phase) and recovery (post-disaster phase). The facility location problem is a strategic level decision and related to preparedness phase.

AIM AND SCOPE OF THE STUDY

The current capacity and location of warehouses were determined in 1940. However, the population and geological structure of many regions have changed. In spite of this change, the required revisions have not been applied. The location and capacity of warehouses should be revised according to today's requirements. Therefore, we deal with the problem of selecting the optimum warehouse locations and capacities to achieve a satisfactory level of readiness to respond to earthquakes. Since the surface area of Turkey is wide and there is a limited time, the northeastern area is selected as a pilot region and the problem is formulated as p-center facility location model. Then, various earthquake scenarios are generated to produce alternative solutions. The proposed methodology can be applied for a broader study which includes all the regions.

CURRENT SYSTEM ANALYSIS AND DEFINITION OF THE PROBLEM

There is currently one emergency logistic center in Erzurum and five local warehouses (Trabzon, Rize, Erzincan, Ağrı and Van) in the selected pilot region. The current capacities of the warehouses can provide aid materials for 60000 people. As it is stated before, there is change in population growth. The objective of Kızılay is to be ready to the worst case scenarios. According to the results of the earthquake scenario analysis, the number of people whose demand should be satisfied is 156510. It is obvious that the current capacity is insufficient to satisfy the current demand. Therefore, the location and stock level of each warehouse should be analyzed and if there is a need for a change, it should be revised. The main problem with emergency logistics is the uncertainty of the disasters. Consequently, the location and capacity of local and central warehouses are decided based on geographical structure and the disaster maps which are constituted according to past disaster data. Besides, another factor is the variability of the type and damage effect of disasters since the population, structure and economy of regions are different. The main difficulties to deal with relief logistic problems are supply and demand uncertainty, network vulnerability and need for quick response. The current regional and local warehouses are given in Appendix1.

LITERATURE REVIEW

Although there is a wide literature related to facility location problems for commercial logistic systems, researches have been studying on facility location problems for stochastic environments such as natural and man-made disasters, epidemic illnesses and terrorist attacks since 1990. Barbarosoğlu et al., (2002) develop an interactive approach for hierarchical analysis of helicopter logistics in disaster relief operations. They propose a mixed integer mathematical model and an iterative heuristic approach based on two level hierarchical multi criteria decomposition method and light beam search interactive approach. Barbarosoğlu and Arda (2004) develop a two stage stochastic programming model to make an emergency transportation plan of first-aid materials and rescue teams to the disaster affected areas. Özdamar et al., (2004) model a dynamic time based transportation problem for macro level emergency logistic planning. The aim of their study is to transport the aid materials from the main supply locations to the local distribution centers in a disaster region and transport wounded people from affected areas to the permanent or temporary health care centers. Balcık and Beamon (2006) construct a logistic network design model to minimize unsatisfied demand and maximize operation efficiency. They deal with the demand uncertainty with probabilistic scenario approach. Yi and Özdamar (2007) proposed a dynamic mixed integer multi-commodity network flow model which threats vehicles as integer commodity flows rather than binary variables to minimize delay and unsatisfied demand. Jia et al., (2007) construct a three different facility location models to locate medical service facilities for large-scale disasters considering different coverage levels and facility qualities. Balcık and Beamon (2008) proposed a method for equitable supply allocation among demand points. They consider different demand characterizations and supply criticality in resource allocation.

PROPOSED METHODOLOGY

Previous studies which are mentioned above are analyzed in detail and the problem is constructed as a p-center facility location model with respect to the aim of the project and the system structure.

Single Resource P-center Facility Location Formulation

The problem is modeled as a p-center facility location mathematical model with single resource and various capacity levels. The aid-materials are transported to the disaster victims, from the closest facility; this is the reason of considering a single resource model. The notations which are used in the model are listed in below.

Model indices

$i =$ Demand points $(i = 1, 2, 3, \dots, 152)$
$j_n =$ Potential warehouse locations $(j_n = 1, 2, 3, 4, 5)$
$j_c =$ Current warehouse locations $(j_c = 6, 7, 8, \dots 11)$
s = scenarios $(s = 1, 2, 3, \dots, 15)$
m = capacity levels $(m = 1, 2, 3)$
k = types of commodities $(k = 1, 2, 3, 4, 5)$

Model parameters

P = the maximum number of warehouse that can be constructed
$Cap_{j,m}$ = m capacitated warehouse j
$dist_{i,j}$ = distance between demand point i and warehouse j
D_i = demand of node i
C = total budget
$F_{j,m}$ = the cost of opening m capacitated warehouse j
j = warehouse set $\{ j_n \cup j_c \}$

Decision variables

$$Y_{j,m} = \begin{cases} 1 & \text{if } m \text{ capacitated warehouse j is opened} \\ 0 & \text{otherwise} \end{cases}$$

$$Z_{i,j} = \begin{cases} 1 & \text{if demand node } i \text{ is assigned to warehouse } j \\ 0 & \text{otherwise} \end{cases}$$

Objective function

$$\text{Min } Z = \left(\max_{i,j}\left(dist_{i,j} Z_{i,j}\right)\right) \quad (1)$$

Constraints

$$\sum_j \sum_m Y_{j,m} = P \quad (2)$$

$$\sum_j Z_{i,j} = 1 \quad \forall \ i \quad (3)$$

$$\sum_i D_i \ Z_{i,j} \le \sum_m Cap_{j,m} \ Y_{j,m} \quad \forall \ j \quad (4)$$

$$\sum_m Y_{j,m} \le 1 \quad \forall \ j_n \in j \quad (5)$$

$$\sum_m Y_{j,m} = 1 \quad \forall \ j_c \in j \quad (6)$$

$$Y_{j,m} = \{0,1\} \quad \forall \ j,m \qquad Z_{i,j} = \{0,1\} \quad \forall \ i,j \quad (7)$$

Constraint (1) minimizes the furthest distance between a warehouse and a demand location in the pilot area. Constraint (2) limits the number of warehouses to be constructed (at most P depots can be constructed). Constraint (3) ensures to assign each demand location to a single warehouse. Constraint (4) ensures the flow preservation and constraint (5)-(6) ensures the capacity level restrictions for each warehouse. Constraint (7) indicates the binary variables. The objective function of the model is nonlinear. Therefore, constraint (8) is added to the model and the objective function is reformulated to get rid of the nonlinearity in the objective function. Linearization constraint (8) and the new objective function (1') are stated as:

$$\text{Min } Z = L \qquad (1')$$

$$\left(\left(d_{i,j} Z_{i,j} \right) \right) < L \qquad \forall \; i,j \qquad (8)$$

Different capacity levels for warehouses leads to different warehouse opening cost. Therefore, the budget constraint is integrated to the model to analyze the alternative solutions under different budget restrictions.

$$\sum_m \sum_j F_{j,m} Y_{j,m} \leq C \qquad (9)$$

MODEL INPUTS

Warehouse Capacity Levels

The capacity levels of current warehouses are determined based on past data whereas the capacity of candidate warehouses is determined according to the population of counties. We firstly determine the satisfied demand quantity (in terms of people) from a cubic meter of the warehouse by considering the northeastern central warehouse located at Erzurum. The current capacity of Erzurum warehouse is 25000 m^3 and it can satisfy the demand of 35000 people. In other words, in 1 m^3 of the warehouse, there are commodities to satisfy the demand of 1.4 people. In this study, it is assumed that in 1 m^3 of the warehouse, there are aid-materials to satisfy the demand of 1.2 people. We consider three capacity levels (5000 m^3, 10000 m^3, 15000 m^3) for each candidate warehouse location. Table 1-2 represent the current and candidate warehouse locations respectively. Table 3 indicates the capacity levels of warehouses and the total satisfied demand with respect to each capacity level. The reason of considering different capacities for the current and alternative warehouses is to respond to the various demand requirements. By this means, the effect of capacity increment for the current warehouses is observed. The candidate facility locations which are suggested by emergency operations management center (AFOM) are Hakkari, Yüksekova, Giresun, Artvin and Kars. The location selection criteria of candidate warehouses are determined based on the population, transportation, well educated and qualified medical people and rescue teams. Although there is a candidate warehouse location in Hakkari, Yüksekova, which is a county of Hakkari, is also considered as another candidate facility location since the transportation is obstructed by frequent snowstorms in winter.

TABLE 1
CURRENT WAREHOUSE LOCATIONS

	Current Warehouse Locations				
Warehouse Index	1	2	3	4	5
Counties	Erzurum	Trabzon	Rize	Erzincan	Ağrı

TABLE 2
CANDIDATE WAREHOUSE LOCATIONS

	CANDIDATE WAREHOUSE LOCATIONS					
WAREHOUSE INDEX	6	7	8	9	10	11
COUNTIES	VAN	HAKKARI	YÜKSEKOVA	GIRESUN	ARTVIN	KARS

TABLE 3
CAPACITY LEVELS FOR WAREHOUSES

CAPACITY LEVEL	WAREHOUSE CAPACITY (M3)	TOTAL SATISFIED DEMAND (PEOPLE)
1	5000	6000
2	10000	12000
3	15000	18000

The capacity of current warehouses is decided according to past data and suggestions of AFOM specialist. The total capacity of current warehouses can provide aid materials for 60000 people. The capacities on the basis of cities: for Erzurum the capacity is 35000 people, for the other cities (Trabzon, Rize, Erzincan and Van) it is 5000 people. The total demand in the studied pilot region is 156510 people which indicate clearly the lack of inventory to satisfy the total demand. Table 4 indicates the current and additional capacities of the current warehouses.

Distances between Counties

The real highway distances between 152 counties and each candidate/current warehouse is calculated by the help of Sony Map. An illustration of this calculation is given in Appendix 2 and Appendix 3.

Facility Opening and Operating Costs

To calculate the yearly warehouse costs, firstly the warehouse opening costs, labor costs, stock keeping costs, cycle times and depot utilization times are determined. Considering the prices decided by Ministry of public works and settlement in 2007, the cost of opening a depot is 230 TL per m^2. In this study, the smallest capacity is assumed to be 5000 m^3 which requires 1000 m^2 space. Therefore, the cost opening the smallest warehouse is 230000 TL. Assuming the utilization time of a depot is approximately 20 years, yearly installation cost of a 5000 m^3 depot is calculated as 11500 TL. There are five workers in a 5000 m^3 depot and monthly salary of a worker is 600 TL. Hence, yearly labor cost is 36000 TL. To determine the yearly inventory cost, unit cost of each different aid-materials and the required quantity per 5000 m^3 are calculated.

TABLE 4
CAPACITY OF THE CURRENT WAREHOUSES

CURRENT WAREHOUSES	CURRENT CAPACITY (M^3)	SATISFIED DEMAND (PEOPLE)	ADDITIONAL CAPACITY (M^3)	SATISFIED DEMAND (PEOPLE)	ADDITIONAL CAPACITY (M^3)	SATISFIED DEMAND (PEOPLE)
6	42000	35000	10000	41000	10000	47000
7	6000	5000	10000	11000	15000	23000
8	6000	5000	10000	11000	15000	23000
9	6000	5000	10000	11000	15000	23000
10	6000	5000	10000	11000	15000	23000
11	6000	5000	10000	11000	15000	23000
TOTAL		60000		96000		162000

According to the calculations, there are a tent for per 5 people, a blanket for each person, a sleeping bag for per 4 people, a heating stove for per 10 people and a kitchen set for per 10 people in the warehouse. By taking into these ratios into account, unit cost and quantity for each type of commodity is given in Table 5.

TABLE 5
UNIT COST AND QUANTITY FOR EACH TYPE OF AID-MATERIAL

	UNIT COST	UNIT / 5000 M3	COST
TENT	1067	1200	1280400
BLANKET	16	6000	96000
HEATING STOVE	69	600	41400
SLEEPING BAG	109	1500	163500
KITCHEN SET	49	600	29400

The total inventory cost of all aid-materials in a 5000 m^3 depot is 1610700 TL. As a result of discussions with AFOM, the inventory turnover ratio is determined as 5 years, the yearly turnover ratio is 20% and yearly stock keeping cost is determined as 10% of the total cost. To reflect these rations to the total cost, yearly inventory cost is calculated. Each depot uses one forklift for 10 years. The cost of a forklift is 40000 TL. The yearly total cost of a 5000 m^3 warehouse is listed in Table 6. The Table 7 represents the total yearly cost of warehouses in different capacity levels.

TABLE 6
TOTAL YEARLY COST OF A 5000 M3 WAREHOUSE

	SPACE	FORKLIFT	LABOR	INVENTORY	TOTAL
COSTS	11500	4000	36000	483210	534710

Earthquake Scenarios

The effect of a disaster depends on the magnitude and the epicenter of a disaster. As a result of this uncertainty emergency scenarios are widely used in literature. In this study, earthquake scenarios are created to deal with uncertainty. There are many factors to affect the intensity of an earthquake such as earthquake magnitude, the distance from the epicenter of an earthquake, ground structure and source mechanism.

TABLE 7
TOTAL YEARLY COST OF A 5000 M3 WAREHOUSES IN DIFFERENT CAPACITY LEVELS

WAREHOUSE SPACE	COST
5000 M3	534710
10000 M3	1069420
15000 M3	1604130

The main reason of creating earthquake scenarios is to estimate the demand of each region with respect to the epicenter of the earthquake and the level of damage on its neighboring counties. Formulations based on past disaster data can provide us to find the acceleration on the neighborhood of the earthquake and this information helps us to find the intensity of the earthquake (Tüysüz, 2003). Earthquake waves decreases when the distance increases. This is called ‘decrement’. Decrement is the estimation of a seismic wave at a given point by evaluating the properties of the earthquake waves at the source point and the followed path from the source (Tüysüz, 2003). In this study, the decrement relations on the faults are determined based on a formulation. Firstly a desired fault is selected and an earthquake magnitude is assigned among possible magnitudes to this fault. Secondly, after this fault creates the earthquake with the specified magnitude, the effect of it on the neighboring counties are observed. While creating scenarios, we assumed the independence of scenarios. The objective of Kızılay is to be ready for the worst case scenario. Thus, past earthquakes for the pilot region are investigated and it is observed that the magnitude of the biggest earthquake is 7.9. We considered the worst case to satisfy all the demand in all scenarios. Thus we assumed that the magnitude (magnitude of surface wave) of the earthquake is 7.5 for all scenarios. Geographical information systems

(GIP) are a tool to create disaster scenarios in developed countries. However, there is no such a tool in our country for the studied pilot region. Therefore, we develop a procedure to create scenarios. The steps of the procedure are: a) Determining the active faults for the northeastern region, b) Producing earthquake scenarios in different intensities and magnitudes on each fault, c) Determining the population of each county for the year 2007, d) Determining the damage ratios and disaster affected people for each county

Determining Active Faults for Northeastern Region

The active faults for the pilot region are determined according to the Turkey Earthquake Map which is prepared by a commercial consultant company called 'Sayısal Grafik'. The active faults of the pilot region are represented in Appendix 4.

Creating Earthquake Scenarios with 7.5 Magnitude

We assumed that there is only one broken fault in each scenario with the magnitude of 7.5 with five different intensities. Besides, the faults which are longer than 25 km are solely taken into account whereas the ones smaller than 25 km are considered together. The maximum intensities which can be caused by an earthquake are calculated with the formula proposed by Erdik and Eren(1983) (formula: $I = 0.34 + 1.54\ M – 1.24\ LnR$). The formula is used to determine the required distance in terms of km (R) to change the average intensity at the construction area at a given surface wave magnitude (M). Table 8 represents the relationship between intensity, earthquake magnitude and distance under different intensities. After the calculation of the distances, a specific fault is selected by using Sayısal Grafik software. Then, for each of the selected fault the impact of the created disaster scenario on neighboring counties in terms of damage percentage is observed for each of the specified distance values which are mentioned above. Appendix 6 indicates an example of the calculation on the map for an earthquake scenario.

Population of Counties for Year 2007 in the Pilot Area

The current population of counties is unknown. However, the rate of yearly increase in the population with respect to counties and cities are known. Using the past population data of 1990 and 2000, the rate of increase on the population per 10 years is calculated. Then, with the help of interpolation, the population in 2007 is estimated.

TABLE 8
RELATIONSHIP BETWEEN I, M AND R

AVERAGE INTENSITY (I)	SURFACE WAVE MAGNITUDE (M)	DISTANCE (R)
6	7,5	4,59
7	7,5	10,28
8	7,5	23
9	7,5	51,6
10	7,5	116

Damage Ratios and Affected People for Each Scenario on The Basis of Counties

Intensity of an earthquake is determined according to the impact of the disaster on constructions, people and nature. The damage impact changes with respect to the magnitude distance of an earthquake, focal depth of an earthquake, geology, local surface structure and strength of buildings. Consequently, damage estimation of counties which are affected in different intensity levels is calculated based on the ratios relevant to the specified intensity. Table 9 indicates the percentage of being highly destroyed with respect to various earthquake intensities (Erdik and Eren, 1983). For each county in the scenario, we multiply the affection percentage for each county obtained from Turkey Earthquake Map, damage ratio related to the specified intensity in the scenario and population of the county to estimate the demand (affected population) for each damage level (low, medium, high damage levels). 15 scenarios are created in total.

TABLE 9
DAMAGE RATIOS

INTENSITY (MSK)	PERCENTAGE OF BEING SERIOUSLY DAMAGED(%)
VI	0.04
VII	0.91
VIII	2.82
IX	15.70
X	33.06

SOLUTION OF THE MODEL

Alternative solutions are obtained under various budget constraints and different number of warehouses.

Model Outputs

The problem is solved for two different objectives by using CPLEX. The first objective is solving the model to revise the capacities of current facilities without opening a new warehouse. The second one is solving the problem to determine the location and capacity of candidate warehouses and to update the capacity of current warehouses with the aim of minimum cost under different capacity and warehouse number restrictions. The reason of not considering any budget and depot number constraints in the first objective is to find the optimum solution and evaluate the total cost without any restriction. When the problem is solved with the aim of first objective, the capacity of all current warehouses are assigned to the third level and the objective function is found to be 349,5 km which refers to the maximum distance between the warehouses and the demand points. Table 10 indicates the required budget to revise the capacities and the updated capacity levels.

TABLE 10
THE SOLUTION OF THE MODEL WITH RESPECT TO THE FIRST OBJECTIVE

BUDGET (TL)	MAXIMUM NUMBER OF WAREHOUSES	CAPACITY LEVELS FOR THE CURRENT AND POTENTIAL WAREHOUSES											OBJECTIVE FUNCTION VALUE (KM)
		1	2	3	4	5	6	7	8	9	10	11	
14.842.700	-	-	-	-	-	-	3	3	3	3	3	3	349,5

When the problem is solved according to the second objective, budget and warehouse number constraints are considered. Since satisfying all the demand from a single source is not realistic and affect the systems performance poorly, we set a threshold value (2 warehouses) for the minimum number of warehouses. Besides, we consider an upper bound for the maximum number of warehouses (11 warehouses) as a result of discussions with AFOM. The minimum and maximum budgets that can be used are 10.000.000 TL and 160.000.000 TL respectively. The result of the model under various budget and warehouse number constraints is given in Table 11.

TABLE 11
EVALUATIONS OF MODEL SOLUTIONS

BUDGET CONSTRAINT (TL)	WAREHOUSE NUMBER	CAPACITY LEVELS FOR THE CURRENT AND CANDIDATE WAREHOUSES											OBJECTIVE FUNCTION VALUE (KM)
		1	2	3	4	5	6	7	8	9	10	11	
16.000.000	5	3	3	3	3	3	3	3	3	3	3	3	190,4
	4	3	3	-	3	3	3	3	3	3	3	3	194,7
	3	-	3	-	3	3	3	3	3	3	3	3	204,7
	2	3	-	-	-	3	3	3	3	3	3	3	230,2
14.000.000	5	3	3	1	3	3	3	1	3	3	3	3	190,4
	4	3	2	-	2	3	3	1	3	3	3	3	194,7
	3	3	-	-	3	3	3	1	3	3	3	3	204,7
	2	3	-	-	-	3	3	3	3	3	3	3	230,2
12.000.000	5	3	3	1	1	3	3	1	3	3	3	3	190,4
	4	3	3	-	2	3	3	1	3	3	3	3	194,7
	3	3	-	-	3	3	3	1	3	3	3	3	204,7
	2	3	-	-	-	3	3	3	3	3	3	3	230,2
10.000.000	5	2	1	1	1	3	3	1	3	2	3	3	230,2
	4	1	3	-	1	3	3	1	3	3	3	2	206,3
	3	3	3	-	-	3	3	2	3	3	2	2	206,3
	2	-	3	-	-	3	3	3	3	3	3	3	230,2

Evaluation of Model Outputs

Table 12 indicates the satisfied demand in terms of people and the objective function of the model (maximum distance) and total cost obtained from each alternative solution. An alternative solution that opens a candidate warehouse is better than the ones which only consider current warehouses. Because, required budget to increase the capacity of a current warehouse is higher than the cost of opening a new facility in some of the alternatives. Besides, since the main objective of the model is to minimize the maximum distance between warehouses and demand locations, opening a new warehouse close to a demand region clearly provide a shorter distance. Consequently, we only consider the alternative solutions which consider both the current and candidate warehouse locations. If the maximum number of warehouse is increased, the maximum distance reduces and the satisfied demand increases. However, the required budget also increases. Therefore, both the total cost and distance criteria must be considered to select the best decision. The primary objective in the system is to reduce the furthest distance between a demand point and the warehouse that serves to that demand point. In that respect, the alternative solutions groups with the constraint of five additional warehouses are the best since the distance is shorter than the other alternative solution groups. The objective functions of the first three solutions have the same objective function value which is 190,4 km. As a result, we can select any of these three alternatives. Since the total demand of the system is 156510 people, we need to select the alternative which can satisfy all the demand with the minimum cost. The third alternative solution in the group is the best decision since it satisfies the demand of 186000 people with the minimum distance. The required total budget is 12.000.000 TL for this option. Although Kızılay is an aid agency, there is a limited financial support. Consequently, the alternative solution with the minimum total cost (10.000.000 TL) should also be considered. With this budget constraint (10.000.000 TL) the alternative solutions with 3 and 4 candidate warehouses satisfy the demand of the system. Nevertheless, the alternative with 3 warehouse number is better since the satisfied demand is higher. The alternative solutions are also evaluated with respect to two criteria: the quantity of satisfied demand and transportation time. Total demand of the system is 156,510 people. The current system can satisfy the demand of 60,000 people. With the first selected alternative the satisfied demand is 186,000 people whereas with the second one it is 168,000. Accordingly, with the first selected alternative the demand satisfaction of the system increases 80% whereas with the second selected one it only increases 69%. Table 13-14 indicates the improvement of the system performance in terms of the satisfied demand percentage for both the current and the suggested alternatives.

TABLE 12
INTEGRATED ALTERNATIVE SOLUTIONS

Warehouse Number	Total Cost	Satisfied Demand (people)	Maximum Distance
5	16.000.000 14.000.000 **12.000.000** 10.000.000	222000 198000 **186000** 167000	190,4 190,4 **190,4** 230,2
4	16.000.000 14.000.000 12.000.000 10.000.000	204000 180000 186000 162000	194,7 194,7 194,7 206,3
3	16.000.000 14.000.000 12.000.000 **10.000.000**	186000 174000 174000 **168000**	204,7 204,7 204,7 **206,3**
2	16.000.000 14.000.000 12.000.000 10.000.000	168000 168000 168000 168000	230,2 230,2 230,2 230,2

TABLE 13
SYSTEM PERFORMANCE with RESPECT TO DEMAND SATISFACTION

	Demand (people)	Satisfied Demand (people)	Demand Satisfaction Ratio (%)	Performance Improvement ratio (%)
Current System	156.510	60.000	38	*
Proposed Alternative 1	156.510	186.000	118	80
Proposed Alternative 2	156.510	168.000	107	69

The furthest distance to the warehouses is 349.5 km in the current system. In the first proposed alternative, it is 190.4 km and in the second one it is 290.3 km. If it is assumed that the speed of a truck is 45 km/hour, the transportation time which is needed to arrive to the furthest location takes 7.76 hours in the current system, and it takes 4.23 hours in the first proposed alternative and 5.28 in the second proposed alternative. Therefore, the improvement ratios on the system performance with respect to transportation time are 45.48% and 25.51% respectively.

TABLE 14

SYSTEM PERFORMANCE with RESPECT TO TRANSPORTATION TIMES

	Furthest Distance (km)	Transportation Time (hour)	Performance Improvement ratio (%)
Current System	349,5	7,76	*
Proposed Alternative 1	190,4	4,23	45
Proposed Alternative 2	206,3	5,78	26

CONCLUSION

This study is conducted for Emergency Operations Center (AFOM) Logistic Department to decide the location and capacities of warehouses to satisfy the demand with the minimum cost and transportation time. In this study, the emergency logistics and current system is analyzed in detail and the system structure is summarized briefly. The literature is reviewed widely for the studied problem and a two-stage- solution procedure is developed. In the first stage, a mathematical model is developed to select the location of warehouses and the model parameters are stated. Since there is an uncertainty in the studied system, earthquake scenarios are developed in the second stage. The proposed alternative solutions are compared with the current system to evaluate the improvements on the system performance with respect to transportation time and cost criteria. Since natural disasters occur very often in our country and cause serious damages, this study comes into prominence. With the solutions of this study, all of the demand of disaster affected people can be satisfied with the shortest transportation time. Thus, the loss of life and damage effect can be reduced in an emergency situation. Despite the study is conducted for a pilot region, the proposed solution method can be applied for a broader region. In this study, vulnerability of supply is not considered and a single transportation mode is assumed. Further studies can consider multiple transportation cost and supply vulnerability in the mathematical model.

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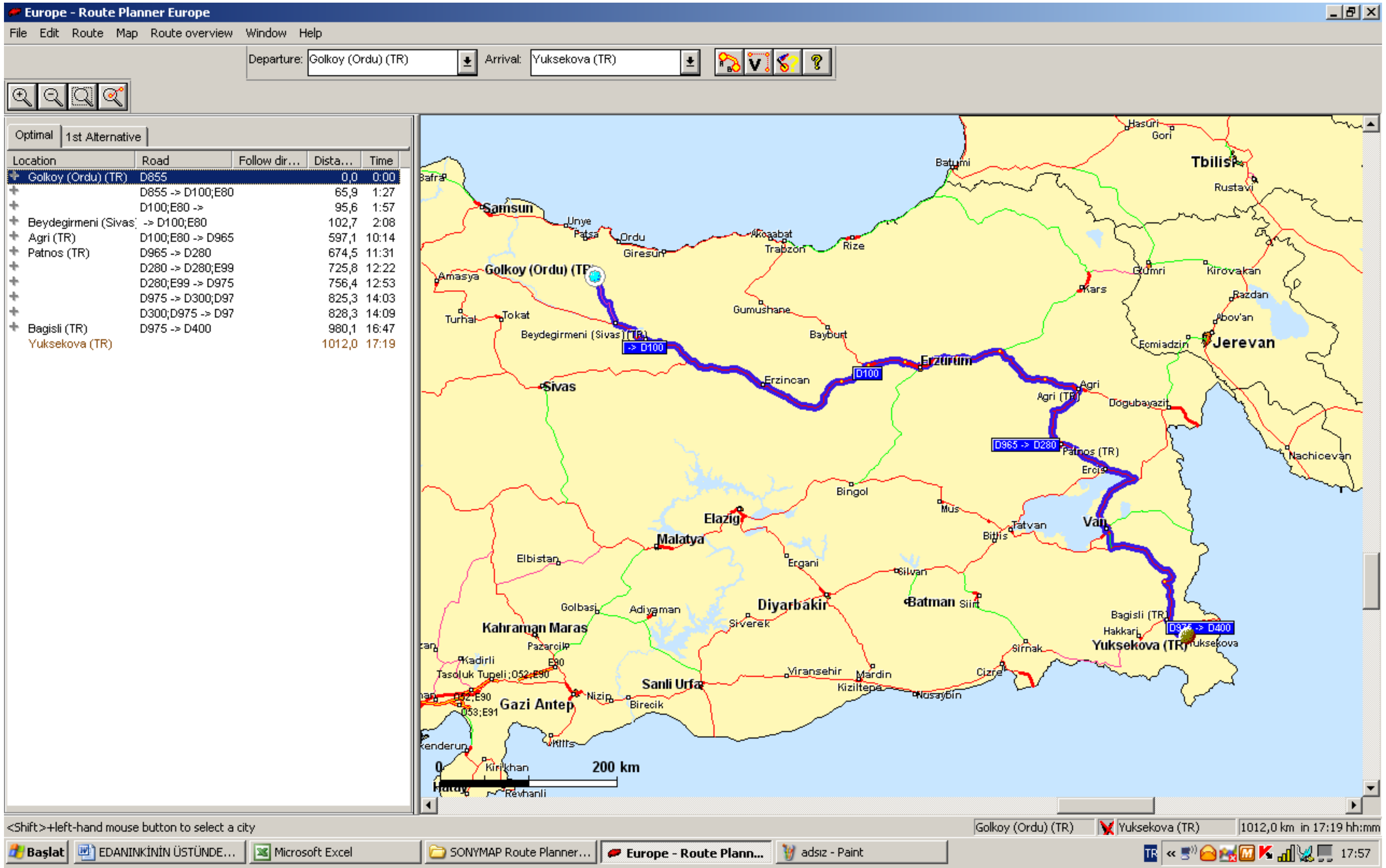
APPENDIX

Appendix 1: Regional and Local Logistic Centers of Kızılay

7 Regional Logistic Centers
10 Local Logistic Centers adet

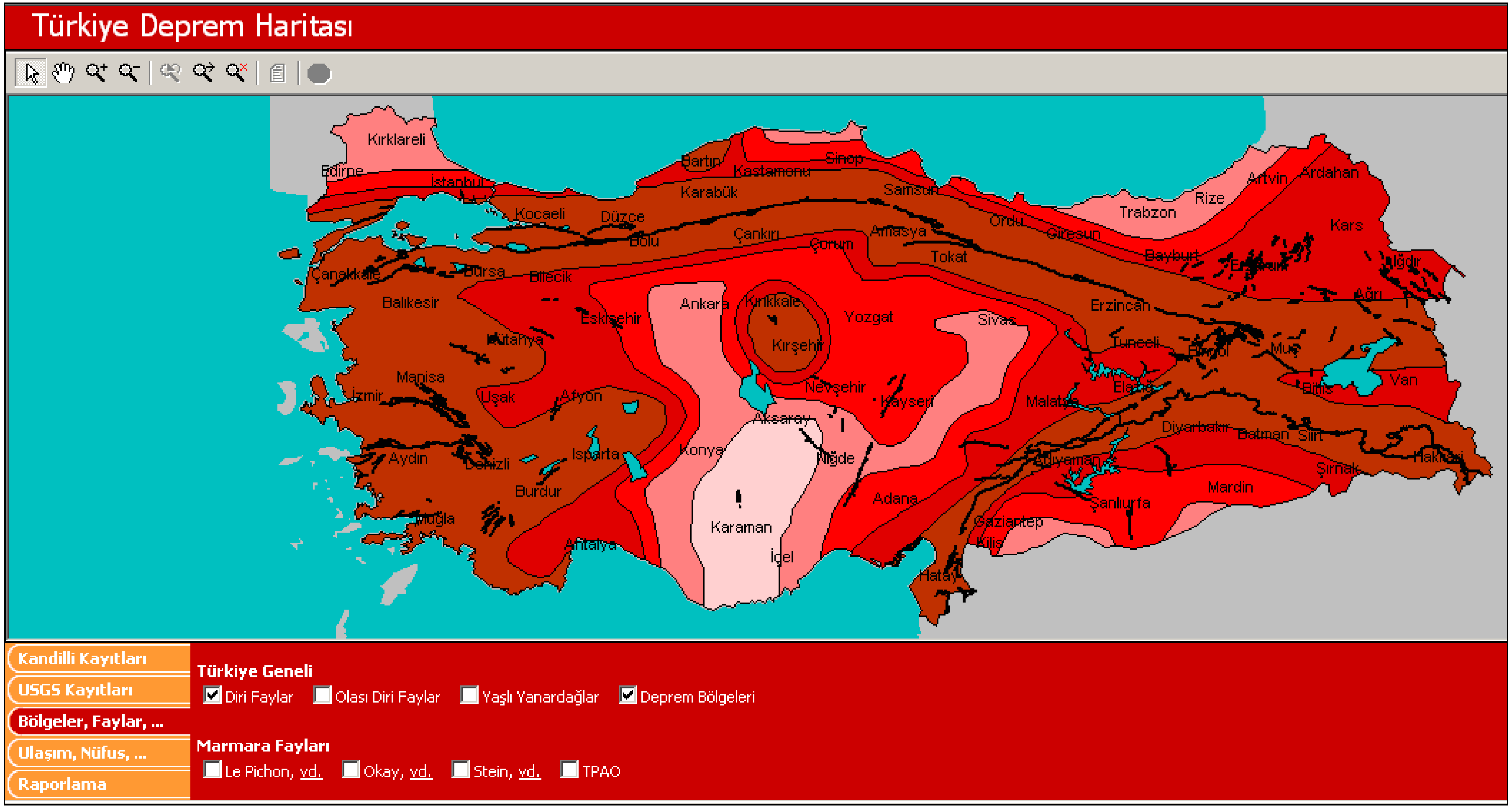
Appendix 2: **The highway Distance between Gölköy and Yüksekova**



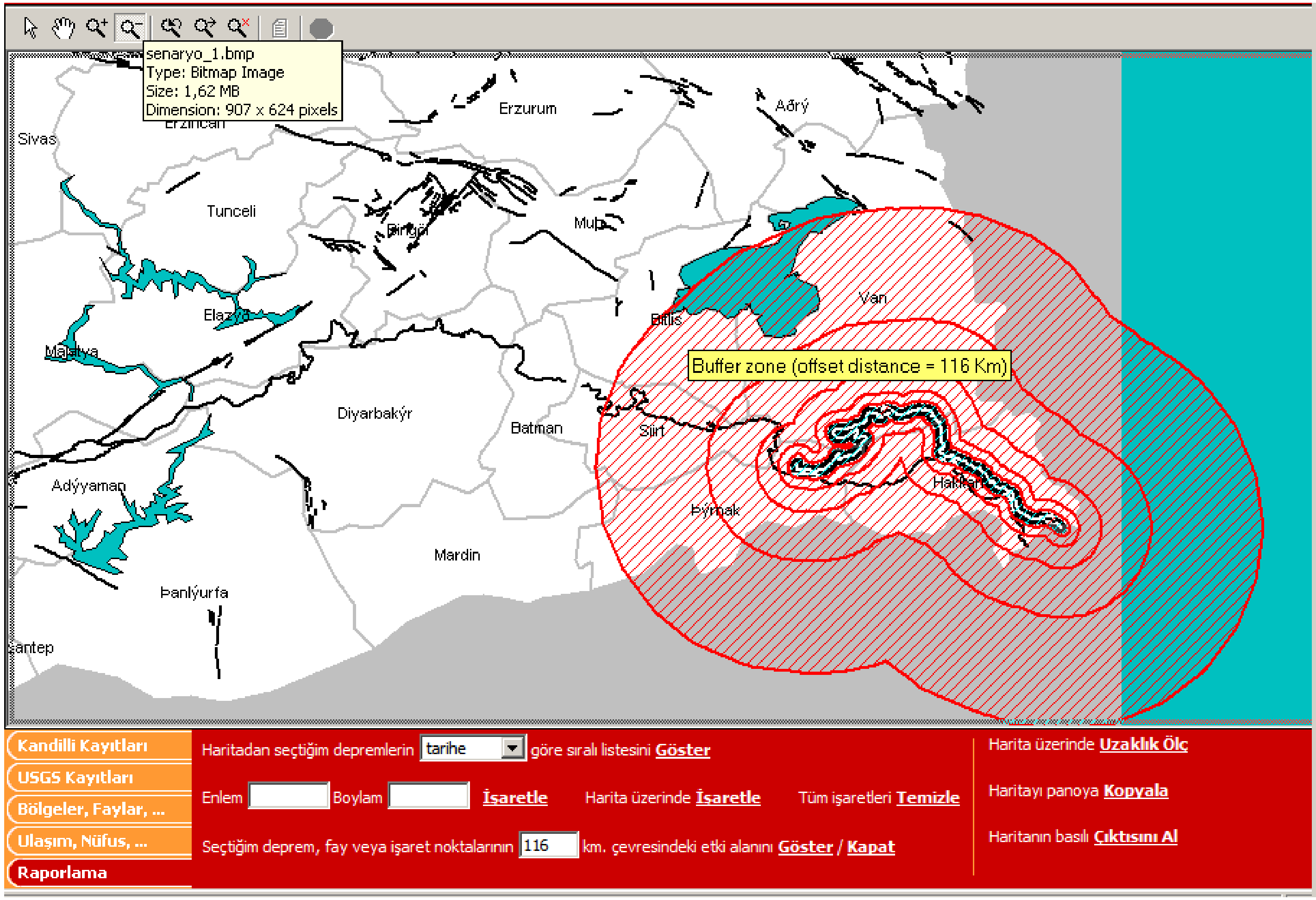
Appendix 3: **Distances between Current/Candidate Warehouses and Demand Locations (km) (a small example)**

		ADAY TESİSLER (j)										
TALEP (I)	KM	ERZURUM	TRABZON	RİZE	ERZİNCAN	AĞRI	VAN	HAKKARİ	Y.OVA	GİRESUN	ARTVİN	KARS
HAKKARİ	Merkez	336,43	882,6	817,2	785,5	420,9	191,8	0	71,1	1013,2	719,5	565,7
	Çukurca	356,14	891,6	625,6	843,3	478,7	244,5	63,8	127,6	720,8	759,1	597,2
	Şemdinli	409,9	925,6	857,6	828,5	463,9	234,8	120,1	49	1056,2	762,5	582,4
	Yüksekova ..	367,57	876,6	811,2	779,5	414,9	185,8	69,8	0	1007,2	695,3	533,4
ORDU	Merkez.........	459,8	177,4	250,9	413,4	639,1	868,2	1060	1054	46,8	390,8	577,2
	Akkuş...........	908,5	300,1	373,6	295	658,5	887,6	1079,4	1073,4	166,4	513,5	680,6
	Aybastı.........	435,5	268,9	342,4	253,8	618,4	852,7	1053,2	1033,33	120,1	482,3	646
	Çamaş.........	504	219,4	292,9	385,8	683,2	906,9	1105,3	1096,7	88,8	432,8	613,3
	Çatalpınar....	513,2	229,6	303,1	384,4	691,3	920,4	1222,6	1106,2	99	443	624,7
	Çaybaşı........	523,1	279,2	352,7	427	694,2	924,8	1116,6	1110,6	135,2	492,6	679
	Fatsa...........	496,9	213,6	290,5	372,1	675,3	904,4	115,3	1102,1	83	427	613,4
	Gölköy.........	417	226,7	300,2	232,5	597,1	836,3	1018	1012	94,6	438,6	619,9
	Gülyalı.........	546,9	162,1	235,6	422,8	623,8	852,9	1044,7	1038,7	31,5	375,5	561,9
	Gürgentepe..	498,7	217,8	289,8	406,7	673,3	908,5	1101,8	1088,2	85,7	436,4	611,7
	İkizce...........	557,5	274,7	347,7	337,5	735,9	931,2	1123,4	1117	130,7	491,2	674,5
	Kabadüz.......	480,8	191,6	265,1	438,5	653,3	882,4	1074,2	1068,2	61	405	585,5
	Kabataş.......	445,2	258,6	332,1	261,8	629,5	854,4	1956,6	1042,7	108,3	472	655,4
	Korgan.........	527,2	245,2	322,1	373,9	706,9	934,8	1126,6	1120,6	113,4	457,4	649,8
	Kumru..........	530,6	246,3	318,6	357,6	705,9	935,9	1126,8	1121,7	113,6	470,4	638,1
	Mesudiye.....	379,7	428	501,5	194,7	558,2	790,5	989,5	973,1	120,1	563,7	580,3
	Perşembe....	476,9	109,5	264	409,5	652,2	881,3	1073,1	1067,1	59,9	403,9	590,3
	Ulubey.........	485,4	197,5	272,5	407,8	660,7	889,8	1081,6	1047,1	68,4	410,9	592,9
	Ünye............	521,6	237,1	311,8	495,7	698,8	927,9	1130,1	1113,7	106,5	451,7	640,4

Appendix 4: **Turkey Earthquake Map and Active Faults**



Appendix 5: **Earthquake Scenario for Fault 1**



Appendix 6: Illustration of an Earthquake Scenario

DEPREM SENARYOLARI										
Fayın Geçtiği İl	Hakkari, Van, Şırnak									
Fay hattı no	1									
Fay uzunluğu	262 km									
Senaryo no	I	M	R	Etkilediği İller	Etkilediği İlçeler	Etkileme Derecesi	İlçe Nufüsu (kişi)	Etkilenen Nufüs (kişi)	TOPLAM (Kümülatif)	Toplam
1	10	7,5	4,59	Hakkari	Merkez(Hakkari)	6%	94158	5650		
				Van	Şemdinli	20%	56928	11386		
					Yüksekova	11%	125165	13769		
					Başkale	6%	55540	3333		
					Çatak	6%	25259	1516		
					Gürpınar	8%	33222	2658	38312	
1	9	7,5	10,28	Hakkari	Merkez(Hakkari)	10%	94158	9416		
				Van	Şemdinli	70%	56928	39850		
					Yüksekova	35%	125165	43808		
					Başkale	9%	55540	4999		
					Çatak	10%	25259	2526		
					Gürpınar	15%	33222	4984	105583	67271
1	8	7,5	23	Hakkari	Merkez(Hakkari)	60%	94158	56495		
				Van	Şemdinli	90%	56928	51236		
					Yüksekova	75%	125165	93874		
					Başkale	35%	55540	19439		
					Çatak	40%	25259	10104		
					Gürpınar	35%	33222	11628		
					Çukurca	35%	5203	1822	244598	139015

INTEGRATING GREEN MANAGEMENT CONCEPTS INTO A GREEN SUPPLY CHAIN MANAGEMENT: THE CASE OF THE BODY SHOP INTERNATIONAL

Aslı Süder[1] and Güneş Küçükyazıcı[2]

Abstract — *Today, changes in the state of the environment, which lead to subsequent public pressure and environmental legislation, have necessitated a fundamental shift in business practices. It is now imperative to analyze the entire life-cycle effects of all products and processes. Therefore, the traditional structure of the supply chain must be extended to include mechanisms for product recovery, which is known as "Green Supply Chain". This will enable organizations to become and remain competitive while achieving sustainable processes. This paper is gives information about supply chains, green supply chains, and green logistics. In order to show the application of these concepts in business life, a case study in cosmetics industry was examined which The Body Shop International applied. It is well-known worldwide brand, which applies green logistics practices.*

Keywords — *Green Logistics, Green Management, Green Supply Chain, The Body Shop International*

INTRODUCTION

Today, in response to the changing and stringent environmental regulations, and also in response to the changes in environmental management philosophy, there has been a corresponding need to develop operational guidelines and standards to assist organizations in moving towards ecologically sustainable business practices. Some companies have started focusing on a variety of environmental activities. These include developing environmentally conscious products, reducing the environmental impact of the products and promoting product recycling. These companies have been formulating environmental targets. Green Management is a set of new mid-term targets that will serve as a yardstick for the environmental activities of these companies. As indicated by Lee and Ball (2003), in the field of business and environment literature, green management refers to the management of corporate interaction with, and impact upon, the environment. It emerged in 1990s and became popular slogan internationally in 2000s. The concept, defined as the process by which companies manage environmental or green issues and develop environmental management strategies, becomes strategically dominant issue for large companies, especially multinational enterprises operating their business globally [1]. The key question for executives at corporations regarding corporate greening or green management is "how to integrate environmental decision making into business with profitable results." [7].

It is now aimed to give some important and continuously developing concepts of today's business life. The most general concept is supply chain, which is the series of activities and organizations that materials – both tangible and intangible – move through on their journeys from initial suppliers to final consumers [13], or in other words, it is the flow and transformation of goods from the raw materials stage (extraction), through to the end user, as well as the associated information flows [6]. Supply Chain Management (SCM) is a recent development in management theory and was introduced as a result of increased competition on international markets [16]. Handfield and Nichols (1999) stated that SCM is the integration of activities through improved supply chain relationships, to achieve a sustainable competitive advantage.

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The other important concept is logistics that is the function responsible for keeping materials at the right place in the right amount, at the right time. The supply chain can include procurement, manufacture, and distribution and waste disposal, together with associated transport, storage and information technology. Logistics is the time related positioning of resources or the strategic management of the total supply chain [13].

The supply chain is a very complex concept and this complexity necessitates new application methods in business life. These new methods must be compatible with environment, which creates the concept of ‘green supply chains’. Green supply chains aim to balance the supply chain performance with environmental issues. Logistics is management of all the activities required to move products through the supply chain. The logistic activities consist of freight transport, storage, inventory management, materials handling and all the related information processing. The main objective of logistics is to co-ordinate these activities in a way that meets customer requirements at minimum cost. In the past this cost has been defined in purely monetary terms. As concern for the environment rises, companies must take more account of the external costs of logistics associated mainly with climate change, air pollution, noise, vibration and accidents [19]. Waters (2007) emphasized logistics management is essentially an integrative process that seeks to optimize the flows of materials and supplies through the organization and its operations to the customer. It is essentially a planning process and an information-based activity. Requirements from the marketplace are translated into production requirements and then into materials requirements through this planning process.

Recently, concept of reverse logistics became popular in business life. Sbihi and Eglese (2010) stated that reverse logistics is a process which encompasses the logistics activities all the way from used products no longer required by the user to products again usable in a market. Dowlatshahi (2000) explains reverse logistics as ‘a process in which a manufacturer systematically accepts previously shipped products or parts from the point for consumption for possible recycling, manufacturing or disposal’. It is the process of planning, implementing and controlling backward flows of raw materials, in process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal.

Green logistics is a form of logistics that is aimed to be environmentally and socially friendly in addition to being economically functional. Green logistics activities include measuring the environmental impact of distribution strategies, while reducing the energy usage in logistics activities, reducing waste and managing its treatment. Traditional logistics models for production and distribution have concentrated on minimizing costs subject to operational constraints. But consideration of the wider objectives and issues leads to new methods of working and new models, some of which pose interesting new applications, such as green logistics [10]. In reverse logistics, there should be some flow of products or goods back from the consumer to an earlier stage of the supply chain. The reduction of waste that this implies certainly means that reverse logistics should be included within green logistics. There will be other models of logistics activities involving only forward flows of goods that could not be described as reverse logistics, but if they include environmental considerations, will also be included within green logistics [10].

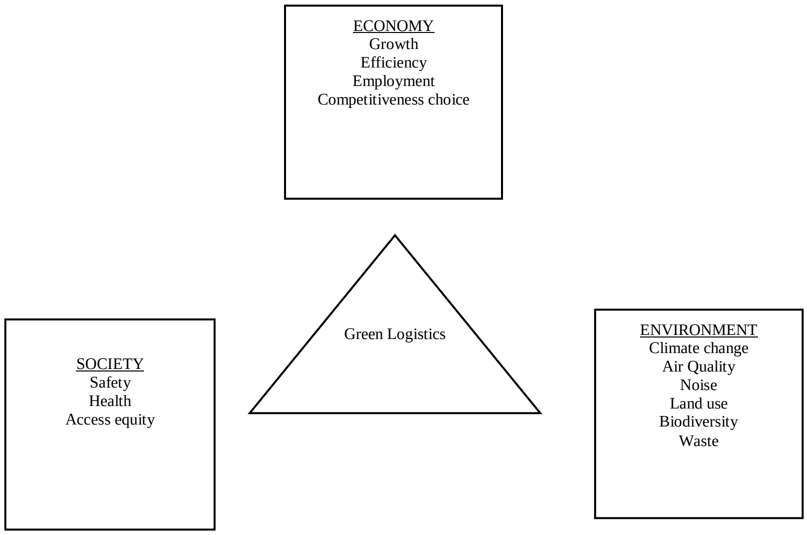

FIGURE. 1

Relationship of Green Logistics with Economy, Society, and Environment [19]

As it is shown in Figure 1; economic growth, industrialization and new technology result in increased waste, dumping and poor disposal. These effect the environment which is damaged by air pollution, deforestation, reduced air quality, land degradation, bio diversity, waste, etc. These damages effect the society which results in poor health, agricultural production, climate change, etc. [17].

There has been increasing public attention placed on the overall condition of the natural environment. The most commonly perceived enemy to environmental protection is manufacturing and production operations [11]. The aim of this paper was to describe the current state of the natural environment of cosmetics industry. In order to achieve this aim, a general procedure was developed within this research to achieve and to maintain the green supply chain for cosmetics industry with the case of The Body Shop. A case study was conducted about The Body Shop International, which is the famous cosmetic manufacturer and retailer who runs a new mission form green product line to green supply chain, to explain the importance of green supply chain and the strategies to achieve it. After summarizing experiences of the application of The Body Shop, the paper analyses the challenges in the cosmetics industry, and then introduces possible solutions. In the end, conclusions are developed on the basis of these analyses.

GREEN SUPPLY CHAINS AND GREEN LOGISTICS

Currently, as emphasized by Zhu and Cote (2004), green supply chains aim to balance marketing performance with environmental issues. In today's world, to meet with challenges such as energy conservation and pollution abatement, enterprises have tried to green their supply chains, that is, to create networks of suppliers to purchase environmentally superior products or to build common approaches to waste reduction and operational efficiencies. One of the key aspects of green supply chains is to improve both economic and environmental performances simultaneously throughout the chains by establishing long-term buyer–supplier relationships. Enterprises have developed a diverse set of initiatives for green SCM, including screening suppliers for environmental performance, providing training to build supplier environmental management capacity, and developing reverse logistics systems to recover products and packaging for re-use and remanufacture [12]. Zhu and Cote (2004), indicated green supply chains are designed to improve economic and environmental performance by promoting expanded buyer-supplier relationships. To summarize, it can be said that green supply chains enable organizations to:

- Specialize and concentrate manufacturing efforts in a way that manages environmental risks and costs of compliance with existing or new regulations.
- Improve product, process, and supply quality and productivity.
- Make innovative decisions that respond to “green economy” requirements.
- Gain access to key markets through certifications.
- Improve or create brand differentiation and customer loyalty by offering unique capabilities to address environmental related requirements and expectations.
- Reduce customer pressure and even gain preferred status [18].

Green logistics is a form of logistics which is believed to be environmentally and often socially friendly in addition to economically functional. As early as the 1980s, several companies were concerned with developing green logistics, and interest in the concept soared with increased consumer concerns about how products were manufactured and delivered in the early 21st century. Many modern companies pride themselves on their environmentally friendly policies and practices, and companies which are interested in adopting green logistics can utilize the services of logistics consultants who specialize in helping companies convert, reform, and streamline their existing logistics systems [23]. Green logistics is concerned with producing and distributing goods in a sustainable way, taking account of environmental and social factors. Thus the objectives are not only concerned with the economic impact of logistics policies on the organization carrying them out, but also with the wider effects on society, such as the effects of pollution on the environment. In recent years there has been increasing concern about the environmental effects on the planet of human activity and current logistic practices may not be sustainable in the long term. Many organizations and businesses are starting to measure their carbon footprints so that the environmental impact of their activities can be monitored. Governments are considering targets for reduced emissions and other environmental measures. There is therefore increasing interest in Green Logistics from companies and governments [10].

Consequently, while green logistics is the attempt to measure and minimize the ecological impact of logistics activities, reverse logistics is moving goods from point of use to point of origin for disposal or to recapture value. Green logistics encompasses any logistical activity that minimizes environmental impacts. Although green logistics is distinct from the reverse logistics trend, the two categories do overlap. Both green and reverse logistics can be key solutions for the shrinking availability and rising cost of landfills [9].

APPLICATION: THE CASE OF BODY SHOP INTERNATIONAL

The Body Shop International was generally seen as a company with a clear and consistent commitment to the environmental cause and good relationships with its suppliers, both of which are critical facilitators of the process of green supply chains [14]. The Body Shop is a world-wide well-known British brand, is a strong supporter of environment and human rights. In recent years, it has accelerated its global presence by its beauty and cosmetics products which are naturally inspired, and ethically produced.

The Body Shop International plc is now a wholly owned subsidiary of L’Oreal S. A. The very first Body Shop store was opened in 1976, in England. In 1985, in its first year as a public company, The Body Shop sponsored posters for Greenpeace. A year later, it created an Environmental Projects Department of its own. In 1990 The Body Shop Foundation was established, which was a charity which funds human rights and environmental protection groups. During 2002, The Body Shop ran global campaign with Greenpeace International on promoting renewable energy, which culminated in the presentation of over six million customer signatures at the World Summit for Sustainable Development in Johannesburg. They furthered their commitment to environmental sustainability through investment in renewable energy, funding of energy efficiency projects in the developing world, and incorporating post-consumer recycling into their packaging. In 2005 The Body Shop joined the Campaign for ‘Safe Cosmetics’ and was commended by Greenpeace and the Breast Cancer Fund for their responsible chemicals policy [21].

As implied by Ting, et al. (2010), it is basically a cosmetic chain retailer.The Body Shop International operates in 63 countries with about 2,550 stores [20]. It is headquartered in Littlehampton, UK and employs about 5900 people. They position themselves to be "massive" sell relative lower cost than competitors while maintain the prestige of brand. The company has a strong product development program which enables it to maintain a healthy pipeline of products. The Body Shop is committed to environmental protection and respect for human rights and developing trading relationships with communities in need.

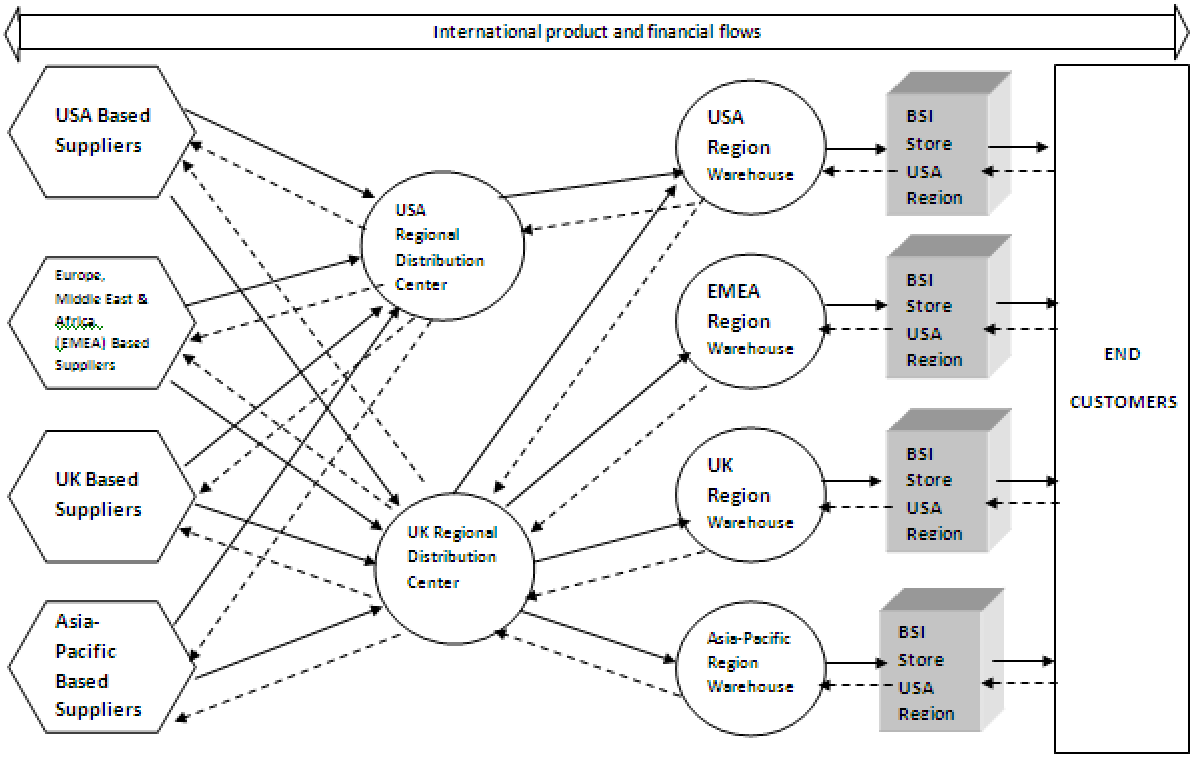

FIGURE. 2

Traditional Global Body Shop Supply Chain [11]

The traditional supply chain of the Body Shop was so much detailed and complicated. This caused complexities and delays in logistics activities. By using improved supply chain starting with the use of green logistics, these delays were eliminated and the whole process was simplified and developed.

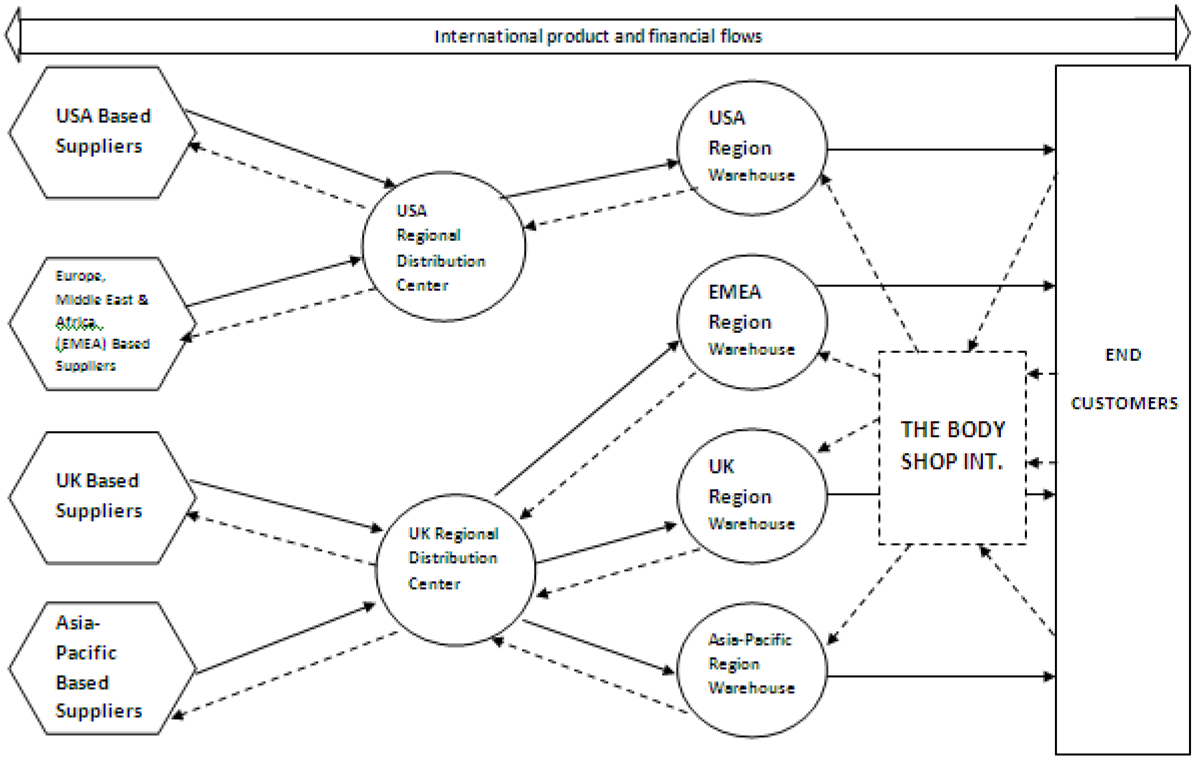

FIGURE. 3

Imptoved Body Shop Supply Chain [11]

From the beginning, the company focused on being socially responsible. The company's mission statement describes their mission as "to dedicate our business to the pursuit of social and environmental change". Bryan Weaver, stated that, a spokesman from the company's US home office, "Early on in forming it, Mrs. Anita Roddick wanted to establish a business that was socially responsible. The cornerstone of the company is that she was able to have a business with ethics". She has successfully established herself and her company as leaders in the arena of social responsibility. Anita herself has been referred to as "The Mother Theresa of capitalism". Mrs. Roddick once said, "I'd rather promote human rights, environmental concerns, indigenous rights, than promote a bubble bath". The Body Shop International's philosophy of social responsibility has begun to receive increasing attention, and this attention has been mostly of a positive nature. In short, it has been suggested that the Body Shop International has been held up as a model of social responsibility and ethics in business [3].

The Body Shop takes a strong position on activism, ethical business, human rights and environmentalism in a global perspective. The Body Shop's values, culture and marketing approaches coincide with the same values as the current policies of advocating Scientific Development Concept to build a harmonious society [15]. Emphasized by Grundey and Zaharia (2008), it pursues environmental and social change improvements and encourages its consumers to do so as well. It co promotes one or more social/eco campaigns each year with in-shop and promotional materials.

As it is indicated in Yuping and Jinger's research (2007), The Body Shop sees cause-related marketing as an opportunity to enhance their corporate reputation, raise brand awareness, increase customer loyalty, build sales, and increase press coverage. Its corporate values are composed of five core values. The first one is to Oppose Animal Testing. The opposing animal testing for both cosmetic products and ingredients began in 1976. In the 1980s and 1990s, they successfully campaigned with animal protection groups to change the UK and European laws to support the development of alternative testing methods. At the very beginning, the products were tried on human volunteers. Along with the development of technology, tube testing has played a leading role to protect the rights of both human and animals. The second one is to Support Community Trade. The Community Trade Program initiates the “Trade Not Aid” objective of creating trade to help people in the Third World utilizing their resources to meet their own needs. This reflects its avowed practice of trading with communities in need and giving them a fair price for natural ingredients or handcrafts they purchase from these often marginalized countries. They have found many trade partners in over 24 different countries that are often overlooked by the local as well as the global society. The third one is to Activate Self Esteem. Generally women are the main customers and employees in The Body Shop. They have never neglected protecting women’s rights. The first campaign against domestic violence took place in the mid-1980s in Canada. Now, the campaign has been spread to 27 countries in the world. The fourth one is to Defend Human Rights. The Body Shop has long campaigned on human rights, highlighting abuses and increasing the global awareness of issues by making full use of the geographic advantages of their shops and supporting other human rights organizations. The last and the most important one is Protect Our Planet. In 2001 a huge campaign against global warming was hosted by the Body Shop and Greenpeace. They advocated the use of recyclable source and materials. Significant progress was made at the World Summit on sustainable development hosted at South Africa. They successfully persuaded the leaders to promise the Green Effect. It is also renowned for its forest protection. The Body Shop is a large consumer of plants and forests, but at the same time, it is a protector. It cooperated with the Forest Stewardship Council to maintain the balance in forests. In late 1990s, a series of environmental protection activities were held by the Body Shop [22].

Famous for creating a niche market sector for naturally inspired skin and hair care products, The Body Shop introduced a generation of consumers to the benefits of a wide range of best sellers. All the products of The Body Shop are made from exotic natural ingredients, the company purchases such ingredients as blue corn from the Pueblo Indians in New Mexico and Brazil nut oil from the Kayapo Indians of the Amazon River Basin, and thus prove to be environmental beneficial. The Body Shop always tries to make its products 100 percent natural and environmental. It intends to create a marketing edge by using greening as a unique selling point with environmentally conscious customers; hence, it starts to courageously ensure that their business is ecologically sustainable: meeting the needs of the present without compromising the future [11].

There are 13 Body Shop stores in Turkey in 4 different cities: Istanbul, Ankara, Izmir, and Bursa. The headquarters are in Istanbul, Maslak. The main warehouse is located in Ikitelli. The products come directly from UK to the main warehouse, and then they are transferred to all stores in Turkey.

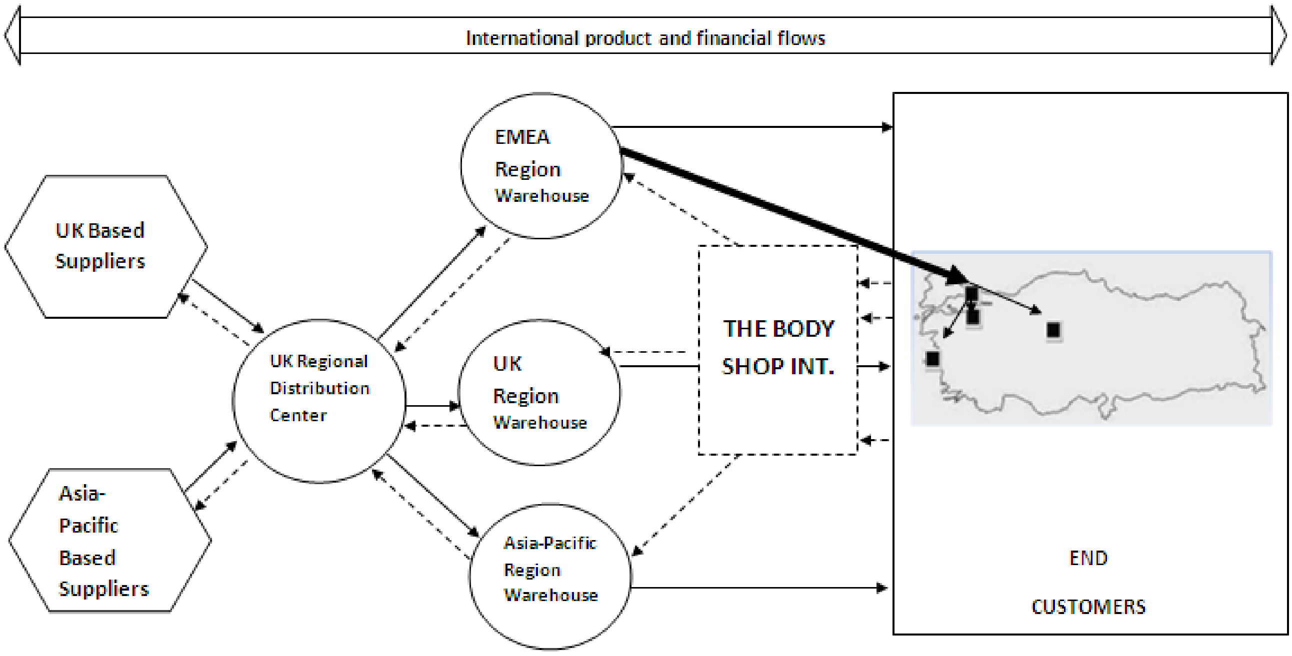

FIGURE. 4

It is clear that business organizations must be profitable to survive although the Body Shop promotes its core values concerning the environment and human rights. The Body Shop is a brand with more global vision. The Body Shop's direct competition is not from the world brands like Dior, Shiseido, Channel, Olay or Pond's, but rather the less well-known brands in the market. The world brands represent status and wealth, while the Body Shop stands for the protection of the environment and animals [15].

CONCLUSION

This paper has described some concepts such as supply chain management, logistics, reverse logistics, green logistics, green management and green supply chain management. There are so many real life applications about green supply chain management. In this paper, the case of Body Shop International is given as an example. It is chosen because of its worldwide effective strategies. It is well-known to be environmentally conscious and socially responsible in order to create a green world. As Beamon (1999) indicates, no longer it is acceptable or cost effective to consider only the local and immediate effects of products and processes; it is now imperative to analyze the entire life-cycle effects of all products and processes. Therefore, the traditional structure of the supply chain must be extended to include mechanisms for product recovery. Supply chain design and analysis need to have an additional level of complexity in order to meet this extension. This additional level consists of product recovery mechanism which gives rise to numerous issues affecting strategic and operational supply chain decisions. As a result, establishment and implementation of new performance measurement systems are required for the extension of the traditional supply chain. New measurement systems will serve as the milestone of environmentally conscious improvement. This milestone will enable organizations to become and remain competitive while achieving sustainable processes.

Consequently, organizations will create ecological efficiency that will reduce environmental risks and their negative impacts by adding green logistics strategies to their management processes. This will increase their profits and market share in the long run. Win-win strategies will be developed. Costs will be reduced; product qualities and efficiency will be improved. Social relationships will be strengthened. In order to achieve these better conditions, organizations should take their actions with environmental sensitivity and social responsibility. The Body International is a great success story for the application of green logistics strategies. There should be follower organizations to create a greener world. Recently, consumers prefer green products and services and they might also adjust their preferences towards environmentally friendly business practices. For business worldwide, green supply chain and green logistics have become a competitive prerogative business performance. Ultimately, being environmentally correct in business will provide competitive advantages to the firms and this will help them to survive and remain advantageous in the market.

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A FUZZY QFD APPROACH TO ANALYZE SUSTAINABLE SUPPLY CHAIN

Gülçin Büyüközkan[1], Gizem Çifçi[2]

Abstract — *Sustainability has emerged as a growing topic, receiving increasing interest in the supply chain (SC) area. It can be seen as a framework for companies and their management to transform their responsibility for environmental, economical and social behavior into business practices within the legitimacy of our society. Linked to this, and in response to increasing demands from various stakeholder groups, companies start to look at their SC to enhance their overall sustainability profile. This paper presents an approach to integrate sustainability standards into supply management. In particular by using the quality function deployment (QFD) as a product/system development tool, a sustainable SC structure can be reached. For this reason, a fuzzy logic based group decision making (GDM) approach in QFD is proposed in this study to devise the SC improvement strategy for companies. Finally, a case study from Turkey is given to demonstrate the potential of the proposed approach.*

Keywords — *Fuzzy group decision making, multiple preference formats, quality function deployment, sustainable supply chain.*

INTRODUCTION

In the current business environment, global competition is an unpreventable fact and customer demands are diversified [1]. Organizations worldwide are continuously trying to develop new and innovative ways to gain and maintain ***competitive*** advantage in the global market. Integration of sustainability into SC is also seen as a potential source of competitive differentiation. As industrial production can have a great impact and damage on the sustainability of the natural environment and human life (such as the impacts include depletive resource use, global and local environmental impacts, health impacts, and safety risks); recent years have seen a growth in academic and industrial research related to the environmental and social concerns associated with supply chains (SCs). The integration of sustainability concerns within supply chain management (SCM) has itself evolved into a separate and growing field.

To obtain more sustainable solutions, organization properties must meet sustainable SC and customer requirements. Especially, quality function deployment (QFD) is one of the techniques for designing needs of customer and turning them into practical measures. This approach enables the firms to become proactive to quality problems rather than taking a reactive position by acting on customer complaints. The approach bases on total quality management, which offers a vast technique to ensure the improvement of quality and productivity. QFD is comprised of major group decision making (GDM) processes. In practice, determining the weights of customer requirements (CRs) is a GDM process. This mainly because of the 'danger' of relying on a single decision maker (DM) with his/her limitations of experiences, preferences or biases about the issues involved, and the fact that individuals are often unable to clearly identify their own states. Multiple DMs, thus GDM, are often preferred rather than a single DM to avoid the bias and minimize the partiality in the decision process [2], [3].

Generally, different and/or even subjective opinions are quite often in a GDM process due to the limitations of experience and impreciseness. Obviously, the importance of each CR in QFD is

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determined by a group of people with ambiguity. In addition, people tend to give information about their individual judgments in multiple formats such as numerically or linguistically depending on their different knowledge, experience, culture and circumstance. Under such circumstances, fuzzy set theory [4] and multiple preference formats [2], [3], [5], [6] can be applied to deal with group decisions when the information is imprecise and diverse. This paper applies an extended QFD methodology by introducing a GDM approach that takes multiple preference formats into account, and fuses different expressions into one uniform group decision by means of fuzzy set theory. Moreover, a specific supply chain example is provided to show the proposed GDM approach can be effectively used in QFD. There exists limited QFD studies in literature that takes multiple preference formats into account, and neither is applied in sustainable SCM field.

The paper is organized as follows. In section 2, sustainable SCM concept and model description are given. Section 3 describes the proposed approach and computational procedure step by step. After the application of the model in Section 4, Section 5 contains some concluding remarks.

SUSTAINABLE SCM

Integration of sustainable development in the business is potentially a source of competitive differentiation. Discussions of sustainability are driven by the basic notion that a SC's performance should be measured not just by profits, but also by the impact of the chain on ecological and social systems [7], [8]. Different authors and researchers have defined sustainable SCM from similar and different perspectives, driving forces and purposes. However, all sustainable SCM structures have commonly three main pillars, namely *economy*, *environment*, and *society*.

Interest in green and now sustainable supply chains has been growing for over a decade and the topic is becoming mainstream [8], [9]. Seuring and Müller [10] define SSC as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements". Many companies have discovered that there are economic advantages to changing designs towards being more sustainable, whether because they are easier to market or cheaper to produce. The most applicable benefits are better organization and documentation of their environmental activities, increased legal certainty, improved image, greater employee motivation, reductions in resource use, enhanced plant safety, and optimization of process flows [11], [12].

Requirements for a Sustainable SC

In order to develop a rational framework from many different types of sustainability criteria, relevant studies in the sustainable SC literature are examined. The basic requirements are structured on the three main pillars of sustainability.

Economical requirements (CR_1): There is no doubt that cost reduction (CR_{11})and continuing financial benefit are fundamental goals of a supply chain. A number of studies have found that an increased emphasis on sustainability in the supply chain is related to lower costs and a neutral or positive effect on value [13–15]. Asset utilization (CR_{12}), efficient use of assets is needed for efficiency of the supply chain [16–19]. Quality (CR_{13}) is a widely accepted performance indicator for SSCs and it represents a common driving force for sustainable supply activities [13], [20], [21]. Finally, to enhance customer service (CR_{14}) is one the main focuses of SSCs. Several studies identified a trend that organizations are integrating environmental processes to their supply chains to reduce operating costs and improve their customer service [13–15].

Environmental Requirements (CR_2): The three major economical requirements dimensions are waste and emission reduction (CR_{21}), energy efficiency (CR_{22}), and natural resource usage minimization (CR_{23}). The environmental based expectations of companies from a SSC are reduction of waste produced, material substitution through environmental sourcing of raw materials, waste minimization of hazardous materials, and efficient use of energy [17], [19], [21]. The environmental practices are dependent on wider aspects to be integrated in order to achieve firm's goal of waste elimination and lower environmental impact. Hence, firms must integrate environmental aspects to ensure corporate survival and toward sustainable development.

Social Requirements (CR_3): Social requirements comprise five main dimensions such as reduced impact on community (CR_{31}), health and safety (CR_{32}), strengthened relationships (CR_{33}), contribution to community (CR_{34}), and laws and regulations (CR_{35}). The aims to comply with legal requirements and to create a systematic management system have been reported as important driving forces for companies to implement sustainable/environmental activities [15], [21], [34]. Commitment to health and safety which meets minimum legal requirements is also needed as a social responsibility. Finally, strengthened business partner relationships are important. By this means, firms can gain competitive advantage and improve performance.

Design Requirements for a Sustainable SC Structure

As a result of the literature survey [7–22], design requirements (DRs) for a sustainable SCM are determined as price strategy (DR_1), SC optimization (DR_2), inventory management (DR_3), forecast accuracy (DR_4), Lifecycle management (DR_5), supplier management (DR_6), flexible and cleaner technology (DR_7), Delivery performance (DR_8), use of effective systems and tools (DR_9), environmental management system (ISO quality standards) (DR_{10}), green innovation (DR_{11}), environmental product design (DR_{12}), environmental activity capability (reduce, reuse, recover, ...) (DR_{13}), eco-friendly transportation (DR_{14}), efficient handling and storage (DR_{15}), reverse logistics (DR_{16}), green and back packaging (DR_{17}), collaboration with partners (DR_{18}), human resource management (DR_{19}), outsourcing (DR_{20}), stakeholders' rights (suppliers, customers, property, etc.) (DR_{21}), monitoring and maintenance (DR_{22}).

TECHNIQUE OF THE PROPOSED EVALUATION MODEL

The question of applying how to infuse sustainability criteria into product/system design and how to compare sustainable requirements with traditional design requirements is gaining vital importance and it can effectively be solved by QFD approach [23]. In particular by using the QFD multi-criteria matrices, an 'environmental compromise' can be reached [24]. QFD is an interdisciplinary team process that aids in planning for new or improved designs and processes such that focus is on customer requirements; competitive environment and market/customers are factored into all decisions; the inter-functional teamwork is strengthened; customer requirements are translated into measurable goals for each department; and the involvement of all employees is garnered towards "listening to the voice of customer" [25].

One of the products and also heart of QFD is a "house of quality" (HOQ). The HOQ matrix contains information about what to do (e.g., what customers want), how to do it (e.g., how technically customer requirements can be achieved), and the relationships between each of these aspects; prioritization of CRs and technical/design requirements (DR); and what are the company's target levels. Quality functions are deployed by carrying "how to do" into the successive HOQ as "what to do" [26]. Figure 1 depicts the proposed integrated approach. Detailed description of the HOQ steps applied in this study is given in next section.

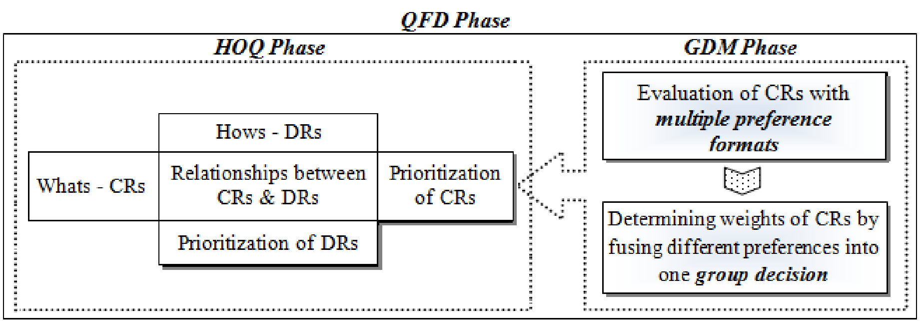

FIGURE. 1
Integrated Evaluation Approach.

As a typical GDM process, DMs always give preference information on decision matrices to construct the HoQ. Since the DMs may have diverse cultural and educational background and value systems, their preference would be expressed in many different ways. However, determining consensus group decisions is not an easy task under such complex circumstances. Thus, authors proposed studies in which the DMs are asked to express their preferences on a variety of criteria using different preference formats.

Zhang, Chena and Chong [27] proposed "Decision consolidation: criteria weight determination using multiple preference formats" and studied a uniformity method and an aggregating method to provide both convenience and accuracy in generating the final outcome and higher DM satisfaction. Similarly Xu [28] presented a procedure for GDM based on multiple types of preference relations in their study named "Group decision making based on multiple types of linguistic preference relations".

Multiple preference formats also used in QFD applications. Büyüközkan and Feyzioglu [3] extended the QFD methodology by introducing a GDM approach that takes into account multiple preference formats and fusing different expressions such as preference orderings, utility analysis, optimal subset method, linguistic preference relations and fuzzy pairwise comparisons. Then Büyüközkan, Feyzioğlu and Ruan [29] again proposed a fuzzy GDM approach to fuse multiple preference styles to respond CRs in QFD.

Recently Büyüközkan and Feyzioglu [30] proposed an integrated GDM approach for new product development based on multiple preference formats and Choquet integral. Distinctly from authors'other studies, additionally they proposed a benchmarking procedure based on the Choquet integral is proposed to rate competing systems and find which dimensions need improvement. Zhang and Chu [31] focused on fuzzy GDM for multi-format and multi-granularity linguistic judgments in QFD. In their study, the DMs can give their judgments according to two formats: fuzzy pairwise comparisons and linguistic preference relations.

COMPUTATIONAL PROCEDURE OF THE PROPOSED APPROACH

Step 1 - "Whats - Identifying the CRs": "Whats" can also be called as *the voice of customers*. In this step CRs must be identified and placed on the left side of the house. These requirements can be identified with the aid of questionnaires to customers, literature surveys, or expert views.

Step 2 - "Prioritizing CRs": In this step, a comparison of the subjected CRs is used to determine their relative importance degrees. These importance degrees of CRs will aid in the design analysis step. However, the information gained from DMs may not be adequate to accurately assign the importance degrees. We will overcome this obstacle through fuzzy GDM.

Step 2.1 - "Harmonizing Dissimilar Individual Assessments": The DMs are assumed to give their importance value according to the following formats:

1. They can give an ordered vector ($o(1), \ldots, o(N)$) where $o(i)$ is the importance ranking (the more important is 1 whereas the least important is N) of CR i. This importance ordering can be transformed into a relative importance relation such that

$$x_{ij} = 9^{u_i - u_j} \text{ for all } 1 \le i \ne j \le N \qquad (1)$$

where $u_i = (N - o(i))/(N - 1)$.

2. They can give an importance degree vector ($u_1, \ldots, u_N$) where $u_i \in [0,1]$ $i = 1, \ldots, N$. The importance degree u_i will be more significant if it is close to 1. This vector can be transformed into relative importance relation such that

$$x_{ij} = u_i/u_j \text{ for all } 1 \le i \ne j \le N. \qquad (2)$$

3. They can give a linguistic importance vector ($s_1, \ldots, s_N$) where s_i $i = 1, \ldots, N$ can be one of "Not Important (NI), Some Important (SI), Moderately Important (MI), Important (I) and Very Important (VI)." Given that a fuzzy triangular number can be noted as (a_i,b_i,c_i) where b_i is the most

encountered value, one possible set of membership functions for these linguistic terms can be NI = (0.00, 0.00, 0.25), SI = (0.00, 0.25, 0.50), MI = (0.25, 0.50, 0.75), I = (0.50, 0.75, 1.00) and VI = (0.75, 1.00, 1.00). Then, the linguistic term vector can be transformed into a relative importance relation such that

$$x_{ij} = 9^{b_i - b_j} \text{ for all } 1 \le i \ne j \le N. \qquad (3)$$

4. They can express that some CRs are more important than others without identifying the degree explicitly. In this case,

$x_{ij} = 9$ and $x_{ji} = 1/9$ if i is more important than j (4)

and $x_{ij} = 1$ if nothing mentioned.

5. They can prefer to select only a subset of CRs (R') and argue that they are important for them. For this case, the CRs in the set R' are equivalent to each other and dominate those in R/R'. The CRs in R/R' are also equivalent to each other. The preference relation can be defined as

$$x_{ij} = \begin{cases} 9 & , i \in R', j \in R/R' \\ 1/9 & , i \in R/R', j \in R' \\ 1 & , \quad otherwise \end{cases} \qquad \text{for all } 1 \le i \ne j \le N. \qquad (5)$$

6. They can prefer to select only a subset of CRs ($\overline{R}$) and give the importance of those requirements linguistically. Using the same notation given in (3), the relative importance relation can be defined as

$$x_{ij} = \begin{cases} 9^{b_i - b_j} & , \quad i, j \in R \\ 9^{b_i - 0.5} & , i \in \overline{R}, j \in R/\overline{R} \\ 1 & , \quad i, j \in R/\overline{R} \end{cases} \qquad \text{for all } 1 \le i \ne j \le N. \qquad (6)$$

7. They can give a pair wise comparison matrix where each element represents the relative importance of one CR compared to another. This can be achieved by using the ratio scale originally proposed by Saaty [32]: $p_{ij} = 1$ if CR i and j are equally important, while $x_{ij} = 9$ if CR i is absolutely much more important than j. Intermediate importance values range from 2 to 8. The matrix is multiplicatively reciprocal, in other words $x_{ij} = a$ and $x_{ji} = 1/a$ for all $a \in \{1, \ldots, 9\}$.

Step 2.2 - "Aggregation of the evaluations": This process will reflect the opinions of the majority of the DMs. Let $\{p_{ij}^1, \ldots, p_{ij}^K\}$ be the set of values to be aggregated for any $i, j \in R$ and K DMs. Then, the ordered weighted geometric (OWG) operator is defined as:

$$\Phi^G\{(p_{ij}^1, p_{ij}^2, \ldots, p_{ij}^K)\} = \prod_{k=1}^{K} \left(\overline{p}_{ij}^k\right)^{w_k} \qquad (7)$$

where, $W = (w_1, \ldots, w_K)$ is an exponential weighting vector, such that $w_k \in [0,1]$ and $\sum w_k = 1$, and each $\overline{p}_{ij}^k$ is the kth largest valued element in the set $\{p_{ij}^1, \ldots, p_{ij}^K\}$ [2], [27], [33]. The OWG operator reflects the fuzzy majority if we calculate its weighting vector W by means of a fuzzy linguistic quantifier [34],[35]. Traditionally, the majority is defined as a threshold number of the individuals. In this study, we make use of the fuzzy majority which is a soft majority concept expressed by a fuzzy linguistic quantifier. Proportional quantifiers, such as *most*, *at least half*, may be represented by fuzzy subsets of the unit interval, [0,1]. Then, for any $r \in [0,1]$, $Q(r)$ indicates the degree to which the proportion r is compatible with the meaning of the quantifier it represents. For a non-decreasing relative quantifier, Q, the weights are obtained as $w_k = Q(k/K) - Q((k-1)/K)$, $k = 1, \ldots, K$ where $Q(y)$ is defined as [36]: 0, if $y < a$; $(y - a)/(b - a)$, if $a \le y \le b$; and 1, if $y \ge b$. Note that $a, b, y \in [0,1]$ and $Q(y)$ indicates the degree to which the proportion y is compatible with the meaning of the quantifier it represents. Some examples for the relative quantifiers are "most" (0.3,0.8), "at least half" (0,0.5) and "as many as possible" (0.5,1). When the fuzzy quantifier Q is used for calculating the weights of the OWG operator Φ_W^G, it is represented by Φ_Q^G. Therefore, the collective multiplicative relative importance relation is obtained as follows;

$$p_{ij} = \Phi_Q^G\left(p_{ij}^1, p_{ij}^2, ..., p_{ij}^K\right), 1 \leq i \neq j \leq n. \qquad (10)$$

Step 2.3 - "Obtaining priorities from the judgment matrix": After the group opinion is collected in the matrix *P*, it must be exploited to determine the importance weights of the criteria. Note that in *P*, the element *ij* reflects the relative importance of criterion *i* compared to criterion *j*. Next, calculate the quantifier guided importance degree (QGID) of each criterion, which quantifies the importance of one criterion compared to others in a fuzzy majority sense. By using the OWG operator again, we have

$$QGID_i = \frac{1}{2}\left(1 + \log_9 \Phi_Q^G\left(p_{ij} : j = 1, ..., n\right)\right) \qquad (11)$$

for all $i = 1, ..., n.$ Finally, the obtained $QGID_i$ values should be normalized, i.e.,

$$QGID_i = QGID_i \, / \sum_i QGID_i \qquad (12)$$

to have the importance degrees in percentage for the group. These steps need to be pursued in all nodes of the evaluation model. The importance degree of each hierarchy leaf node requirement is calculated by multiplying its importance value with the importance values of its up level requirements. Finally, we calculate the weighted sum of CR's group importance values given group importance weights to obtain the aggregate CR importance.

Step 3 - "Hows - Developing/defining the DRs": The first step of the DR part is transforming CRs to technical attributes. DRs are specified on the basis of the company's operational or managerial resource allocation plans in order to satisfy the customers. In defining the DRs, the most important point is finding direct solutions to defined CRs.

Step 4 - "Relation Matrix": Here, a relationship matrix is constructed between CRs and DRs. Each of the DRs is correlated individually to each of the CRs by considering to what extent a requirement contributes to meeting customer needs for the attribute. Depending upon the impact of the DRs in meeting CRs for the attribute, values "Empty=no relationship", "1=possible relationship", "3=moderate relationship", and "9=strong relationship" is assigned.

Step 5 - "Prioritizing DRs": The importance of each technical/design requirement is computed using the relationship matrix and the relative importance of each CR. This computation process intertwines CRs with DRs. That is, the resulting value determines the relative weight of each DRs as compared to CRs. The importance of each DR is calculated as the sum of each CR importance value multiplied by the quantified relationship between the same CR and the current DR.

CASE STUDY

The selected company for application is ABC Turkey (The company's name is not given due to privacy). The reason why this company is chosen for application is that the company considers sustainability as the basis for their future business success and as a key pillar of their corporate culture. They produce sustainable solutions for problems in industry, energy, environment and healthcare matters. To illustrate the proposed approach, a meeting is arranged with ABC Turkey project team (DM group) especially formed for this application includes two engineers and quality management systems manager of ABC Turkey.

Step 1 - Identifying CRs: Here in this study, CRs can also be considered as company requirements. Either customers/stakeholders or companies have common requirements from a sustainable SC. The requirements constructed based on literature survey in Section 2, is discussed with respect to company targets. Project team considered the proposed structure adequate. No revisions are done for CRs.

Step 2 - Priority analysis:

Step 2.1 - Harmonizing Dissimilar Individual Assessments: For an illustrative purpose, evaluations of the group for the purpose of measuring the importance degrees among first level CRs are given:

- DM1 provides an ordered importance vector {1, 2, 2}.
- DM2 gives an importance degree vector {0.3, 0.3, 0.3}.

- DM3 provides a linguistic importance vector {VI, MI, MI}.

By using formats 1, 2 and 8, the preference relation matrices are computed and shown in Table 1.

TABLE 1
Preference relation matrix of dms

	DM1			DM2			DM3		
	Eco	Env	Soc	Eco	Env	Soc	Eco	Env	Soc
Economical (Eco)	-	3.00	3.00	-	1.00	1.00	-	1.00	1.00
Environmental (Env)	0.33	-	1.00	1.00	-	1.00	1.00	-	1.00
Social (Soc)	0.33	1.00	-	1.00	1.00	-	1.00	1.00	-

Step 2.2 - "Aggregation of the evaluations": After first two multiplicative preference matrices are transformed into fuzzy preference matrices, evaluations can be aggregated. Taking into account all matrices obtained from project group, the OWG operator with fuzzy linguistic quantifier 'at least half – (0,0.5)' is obtained with weighting vector (0.667,0.333,0.000). Then, these weighting vectors are used to compute the following group importance relation matrix.

1.00	3.00	3.00
0.69	1.00	1.00
0.69	1.00	1.00

Step 2.3 - "Obtaining priorities from the judgment matrix": Eq. (11) is used to compute group aggregated importance values with weighting vector (0.000,0.333,0.667) corresponding to the fuzzy linguistic quantifier 'as many as possible – (0.5,1)'. Then, these obtained importance values are normalized using Eq. (12), and the collaborative importance values are calculated as (0.40,0.30,0.30). Using the same reasoning, second level factors are evaluated and priorities are determined. Multiplying first level values with each of the secondary importance values produces the global importance vectors. Global priorities of CRs can be seen in Table 3.

Step 3 - "Defining DRs": DRs are listed based on literature survey in Section 2. No revisions are done.

Step 4 - "Relation Matrix": Here, project team constructed a matrix and assigned relationships between CRs and DRs. The accuracy of the results relies heavily on the quality of the relationship matrix. Thereby, project team discussed the relations in depth and reached a consensus decision. Relation matrix can be seen from the final HOQ matrix in Figure 2.

Step 5 - "Prioritizing DRs": The importance of each DRs is computed with respect to the relationship matrix and the relative importance of each CR. As an instance for this computation process, importance weight of "inventory management - DR_3" is calculated as (9*0.12)+(9*0.08)+(3*0.08)+(9*0.12)+(1*0.09)= 3.21 which corresponds to 0.043 percentile. Step 5 can be seen again from the final HOQ matrix in Figure 2.

Drivers (CRs) \ Key Practices (DRs)		DR1	DR2	DR3	DR4	DR5	DR6	DR7	DR8	DR9	DR10	DR11	DR12	DR13	DR14	DR15	DR16	DR17	DR18	DR19	DR20	DR21	DR22	Group Opinion
CR_1	CR_{11}	S	S	S	M	S	M	S	M	S	P	M	M	M	M	M	P	P	M	M	S	M	P	0.120
	CR_{12}	M	M	S	S	S	S	M	S	S	M	M	M	S	P	S	M	M	M	M	S	P	S	0.080
	CR_{13}	M	M	M		S	S	M	S	S	M	M	M	M	P	M		M	S	S			S	0.080
	CR_{14}	S	S	S	S	S	M	S	S	S	M	S	S	M	M	M	M	S	M	S		S	S	0.120
CR_2	CR_{21}	M	P	P		S	P	S		S	S	S	S	S	M	P	S	S	M	S		S	M	0.090
	CR_{22}	S	P		P	S		S		S	S	S	S	S	M	M	M	S	P	S		M	M	0.120
	CR_{23}	M	P			S		S		S	S	S	S	S	M	M	S	S	M	S		M	M	0.090
CR_3	CR_{31}	P	P			S	M	S		S	S	S	S	S	S	M	S	S	S	S		M	M	0.042
	CR_{32}	P	P			S	M	S		S	S	M	M	M	M	M	M	M	M	S		M	M	0.078
	CR_{33}	P	M			M	P	S		S	S	S	S	S	S	P	M	M	P	S	M	M	M	0.060
	CR_{34}	P	P			M	M	S		S	S	S	S	S	S	M	S	S	M	S	M	M	M	0.060
	CR_{35}		P			P	M	S		S	S	S	S	S	S	P	S	S	S	S	M	S	M	0.060
Importance of DRs		4.500	3.360	3.210	2.280	7.800	3.030	8.040	2.880	9.000	6.360	6.852	6.852	6.612	4.012	3.060	4.572	6.252	3.732	7.800	2.340	4.220	4.440	
Importance %		0.060	0.045	0.043	0.030	0.104	0.040	0.107	0.038	0.120	0.085	0.092	0.092	0.088	0.054	0.041	0.061	0.083	0.050	0.104	0.031	0.056	0.059	
Ranking		11	16	17	22	3	19	2	20	1	8	5	5	7	14	18	10	9	15	3	21	13	12	

FIGURE. 2
Final HOQ matrix

According to the results, top 5 practices for the company to design a sustainable SC structure are/ should be using effective systems and tools with 12%, flexible and cleaner technology with 10.7%, HR management and lifecycle management with 10.4%, green innovation and environmental product design with 9.2%.

CONCLUSION

Obviously there are considerable activity and continuing development in the field of sustainability, that it is worthwhile for researchers to consider the implications and impacts of sustainability. For this reason, this paper aimed to propose a QFD model to determine the key practices for obtaining a sustainable SC structure. As QFD is a team process, it requires people to give their preferences. However it is difficult for a DM to provide his/her preferences in a specific format for all pairs of factors. They tend to give information in many different ways depending on their background. Therefore, another aim was to show the use of different preference formats in GDM applications. To extend the proposed method, future work can involve the use of different aggregation operators [34], [37].

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CROSS-NATIONAL COMPARISON OF THE ASSOCIATIONS BETWEEN POSTPONEMENT STRATEGIES AND MANUFACTURING PERFORMANCE IN SUPPLY CHAINS

Artur Swierczek [1]

Abstract — *Postponement is one of the most popular strategic concepts widely applied in supply chains operating in different countries worldwide. Although different approaches are employed while studying a postponement concept, there is a general consensus that it denotes delaying manufacturing and logistics activities until customer's order has been received.*

Many years of research and practice in the field did not eliminate several conceptual and practical gaps in the postponement concept. The paper investigates the relationships between different postponement strategies and manufacturing performance in supply chains from the perspective of cross-national context. In order to achieve the aim of the paper a necessary methodology and statistical analyses have been employed. The research has been carried out in manufacturing companies operating in European, Asian, African and American supply chains. The conclusions obtained from the completed empirical study were based on the comparative analysis of selected manufacturing performance indices identified for different postponement strategies in supply chains.

Keywords — *manufacturing, postponement, supply chains*

INTRODUCTION

One of the most important links of supply chains are manufacturers who developed many supply chain strategies to address the problems of product proliferation and meeting exact customers' needs. Among many other strategies aiming at perfect customer service and balanced asset utilization, postponement has been identified as important characteristics of modern and competitive supply chains. Implementation of postponement may require quite significant reconfiguration of the supply chain and all companies being its links have to participate in that effort [34].

Although the concept of postponement has recently been a subject of intense studies, it still faces many challenges and requires further empirical validation. One of the areas which determines the progress in a research is the assessment of postponement as a valuable tool enhancing the performance of supply chain. In the opinion of van Hoek many newer variations of postponement need further development and explanation prior to being validated in terms of performance issues [35]. It may be concluded, there is a dearth of research concerning an impact of postponement strategies on supply chain performance.

The aim of the study is to investigate the relationships between postponement strategies and manufacturing performance of supply chains operating in different countries. In order to accomplish the goal, a paper was structured into several sections.

Following the issues concerning the application of postponement strategies in supply chains, the theoretical foundation of measuring of manufacturing performance has been discussed. Then, a methodological framework has been developed. Next, the empirical findings obtained from the statistical analyses have been presented and discussed in a relation to the research questions. Finally, the conclusions from the results of research have been drawn and the implications for the further empirical studies are indicated.

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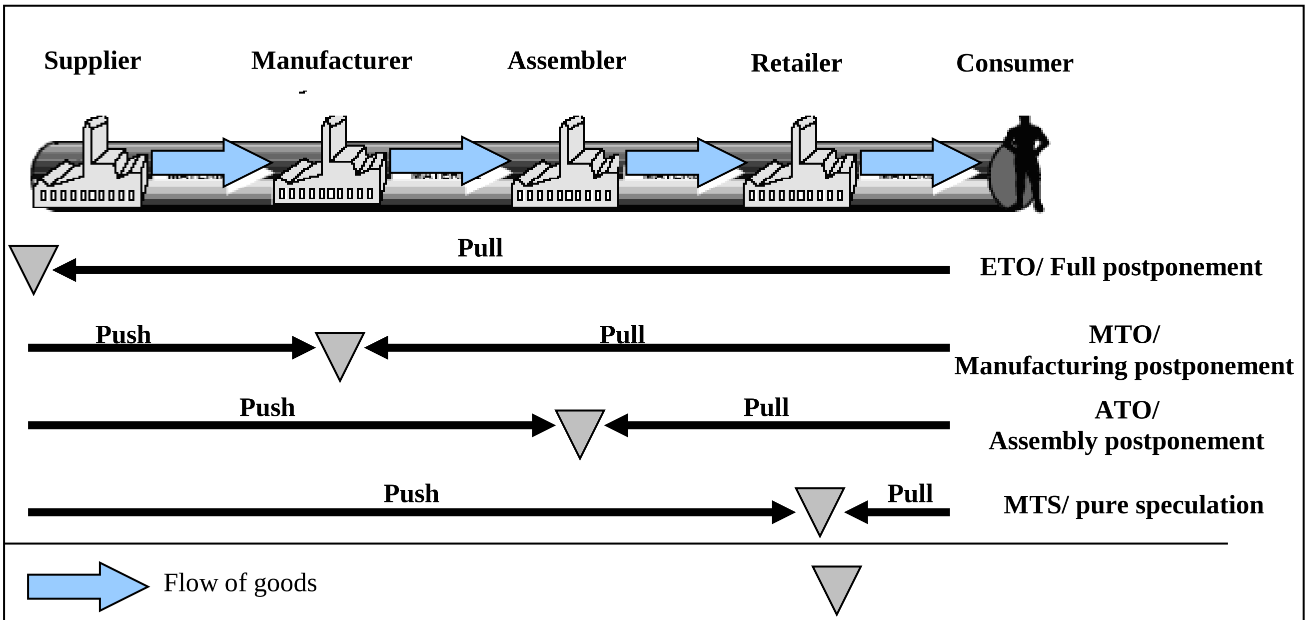
THE POSTPONEMENT STRATEGY IN A SUPPLY CHAIN

The concept of postponement has a long history not only in academic literature [2], [10] but also in practical application e.g. [8], [12]. Over the years researchers changed their views concerning postponement understood once mainly as a strategy that changes the differentiation of goods according to their form, identity and inventory location to as late as possible. Nowadays postponement is considered as an organizational concept whereby some of the activities in the supply chain are not performed until customer orders are received [35]. During that evolution of the concept authors were proposing different types of postponement relating it to the degree of delay when the final product reaches its shape, form or place [41]. One can easily notice the overwhelming diversity of postponement practices and underlying complexity of the issues connected to it, both on a company and supply chain level.

The extent of application of the postponement strategy may decrease or increase gradually in the supply chains being determined by an appropriate location of material decoupling point. In the opinion of Hoekstra and Romme "the decoupling point is the point that indicates how deeply the customer order penetrates into the goods flow"[18]. The material decoupling point is a buffer between upstream and downstream partners in the supply chain. This enables them to be protected from fluctuating consumer buying behavior and therefore establishing smoother upstream dynamics, while downstream consumer demand is still met via a product pull from the buffer stock[25]. On the left side of material decoupling point the activities are forecast driven, initiated by a push strategy, according to plans and forecasts. On the right side of material decoupling point the activities are order-driven which means they are originated by a pull strategy, according to customers' market demand.

The extent of postponement in a supply chain can be indicated by the location of material decoupling points which are reflected in the most popular classification of manufacturing types, namely: make-to-stock (MTS), assembly-to-order (ATO), make-to-order (MTO) and engineer-to-order (ETO).

In make-to-stock manufacturing products are standardized but not necessarily allocated to specific locations; the demand is anticipated to be stable or readily forecasted at an aggregate level. In assemble-to-order system products can be customized within a range of possibilities, usually based upon a standard platform. Make-to-order is characterized by raw materials and components which are common but can be configured into a wide variety of products. In the last manufacturing system engineer-to-order products are specially designed from engineering specifications. While the products might use some standard components, at least some of the components or arrangements of components have been specifically designed by the customer or the customer working with the producer [7], [15], [27].



Decoupling points

FIGURE. 1
Potential locations of material decoupling points in a supply chain.
Adapted from: [18].

Adapting a view of Yang and Burns [42] those four stages can determine the extent of application of postponement strategies in a supply chain: make-to-stock MTS is typical for pure speculation strategy, assembly-to-order ATO refers to assembly postponement, make-to-order MTO is linked to manufacturing postponement and engineer-to-order ETO corresponds to full postponement. Those points develop a continuum indicating different extent of application of the postponement strategies in supply chains – Fig.1. Therefore, the location of material decupling point is often perceived as a primary tool to indicate an extent of the application of postponement strategies in the supply chains.

PERFORMANCE MEASURES OF MANUFACTURING PROCESS

A large number of different types of performance measures have been used to characterize systems, particularly production, distribution, and inventory systems. Such a large number of available performance measures makes their selection difficult. Generally, performance measurement research focuses on analyzing performance measurement systems that are already in use, categorizing performance measures and then studying the measures within a category [6]. The measurement is recognized to be a vital issue for identifying the problems, improving and increasing productivity. To achieve this, it is necessary to establish appropriate metrics for measurement purposes.

One of the most important measures is manufacturing performance. Hayes and Wheelwright [17] claim that manufacturing is considered to be an important element of firm's endeavor to improve company performance. Measuring manufacturing practices has been based on the assumption that given performance level is a result of certain management processes and it is an outgoing point for further analysis of competitive factors contributing or limiting constant improvements in that field. Defining proper measures is a key step in the whole process, especially because these measures may vary depending on the conditions and circumstances in a particular country or even industry sector.

Very often the measurement of the manufacturing process may be more accurate by measuring the result of the activity, i.e. business performance. There are several different opinions on what exact aspects of purchasing performance should and could be measured [21].

Many researches have studied and identified variation in manufacturing processes that reduce product quality and increase the overall costs of operation. Subsequently, several indices were presented to assess the efficiency of manufacturing process. Maull [26] argues that the value of the products/items affects the volume by value of the items being phased-out, and, thus, the potential scrap costs. The average scrap rate in phase-in/out is a very good measure of manufacturing process efficiency. The scrap rates belong to a group of indices which assesses the internal failure costs of manufacturing. It reflects the failures in achieving the specified quality [5]. General manufacturing scrap embraces the following manufacturing process characteristics: materials supply scrap level, manufacturing scrap level and final product scrap level. They are used to assess the performance manufacturing efficiency. Materials supply scrap level describes the percentage of a materials supply batch that is scrapped, manufacturing scrap level concerns the percentage of a manufacturing batch that is scrapped [39] and final product scrap level indicates the percentage of a final distribution product that is scrapped.

The other performance dimension often linked to the manufacturing efficiency is productivity [11] which is seen as one of the most vital factors affecting a manufacturing company's competitiveness [31]. Productivity is the ratio of actual output to input over a period of time. Inputs might include transforming and transformed resources, such as staff and equipment. Outputs are goods and services [29], [32].

In its simplest form, labor productivity could be defined as the hours of work divided by the units of work accomplished [33]. Another productivity dimension which have been studied for several decades is the productivity of manufacturing facilities. It is a metric used for measuring and analyzing the productivity of individual production equipment in a factory. Equipment productivity metric assess an internal efficiency and it is a measure of the value added in a manufacturing process by an equipment [20].

Beamon [6] enumerates different measures, namely: flexibility, resource and output. Flexibility is a firm's ability to respond changes in products, delivery times, volume and mix. Therefore, it may include new product flexibility, delivery flexibility, volume flexibility. Resource measures are concerned with the efficiency in using the resources in manufacturing process. It includes costs of using several resources, inventory levels in a supply chain, and return on investments. Output measures include customer satisfaction in terms of on-time deliveries, order fill rate, response time, sales quantities, and profit [16].

Another important group includes time-based performance measures. Generally they reflect the companies' ability to reduce lead times relative to manufacturing a product [19].

Many empirical analyses have been conducted on manufacturing practices in specific industries and countries worldwide. Several studies was conducted on differences between manufacturing planning and control characterizing practices within various industries including machinery sector and textile industry. This stream of studies contains the analysis of the companies within specific countries, often comparing practices between industries or between firms of different sizes. For example Sohal and Samson analyzed the manufacturing practices in Australia [30], Rho and Whybark conducted analysis on manufacturing practices in Korean companies [28], Kovacevic, Lopez and Whybark examined manufacturing in Chilean companies from textile industry and machine tool sector [23], eventually, Flores, Burgos, Macias compared manufacturing practices in Mexican textile and machine tool industry [14].

Other studies focused on differences in manufacturing practices between countries. For example Wacker compared a productivity in industrial machine sector for Japan and US [37]. In his subsequent paper, Wacker conducted analysis on the factors affecting manufacturing profitability in North America and Russia [38]. Joint cross-industrial and cross-national perspectives have been documented by Whybark and Boone who studied a relationship between productivity and manufacturing practices in various industries and different regions [40]. In other studies Zhong and Hong focused on changes in manufacturing practices in Chinese machine tools industry [44].

The enumerated papers report there are manufacturing practice differences between the industries and even greater ones between countries. Therefore, it seems to be interesting to compare different types of postponement strategies and their significant associations with the groups of manufacturing performance measures in supply chains operating in the examined countries.

METHODOLOGY

Sample characteristics and data collection

The sample was compiled from surveys of manufacturing firms and consisted originally of 861 manufacturers. As a result of initial data analysis, screening and elimination of observations with missing values 305 companies remained as a subject of further analysis. The respondents were mainly small and medium-sized companies. Those groups embraced mainly manufacturers from USA (28 %), Fiji (19%), China and Shanghai (19%), Poland (12%), Hungary (11%) and others.

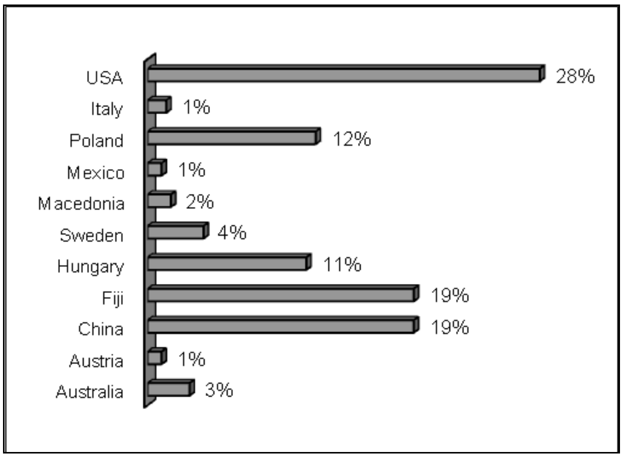


FIGURE. 2

Sample breakdown by country of origin

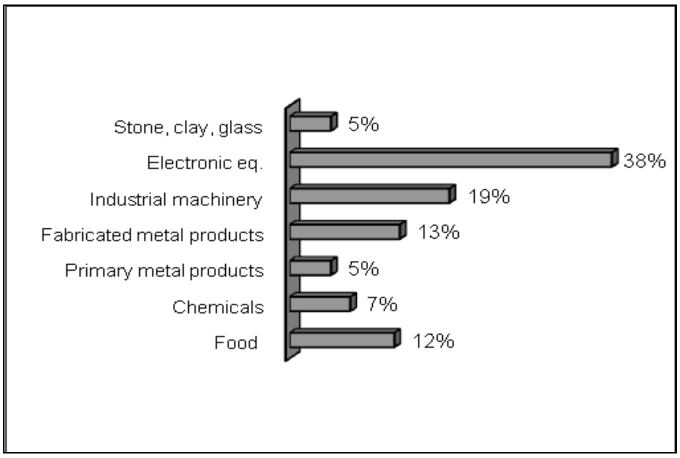


FIGURE. 3

Sample breakdown by industry type

The majority of the surveyed companies operate in electronic and other electrical equipment industry (38%), followed by industrial and commercial machinery equipment (19%), fabricated metal products (13%), food industry (12%), chemicals (7%), primary metal products and stone, clay, glass, concrete products – each industry constitutes 5% of the sample. The sample breakdowns were graphically illustrated in Figures 2 and 3.

The main research instrument used for this study was a questionnaire developed by the Global Manufacturing Research Group consisting of several sections examining manufacturing practices. There is no single meta-theory for guiding a development of GMRG survey. Instead, many aspects of general manufacturing practices were a subject of investigation. Data collected within a fourth release of a survey has been gathered between 2006 and 2008 by researchers from several countries in Europe, North America, Asia, and Africa. The survey was a random sample of firms in a given geographical area [36]. For the purpose of the research presented in this paper only a portion of selected variables has been used. Originally 31 (27 independent and 4 dependent) variables were a subject of initial analysis.

Research questions and methods

The aim of the study is to explore the relationships between postponement strategies and manufacturing performance of supply chains in different industries. In order to realize an empirical aim of the study, two research questions were raised, namely:

RQ1: what are the significant indices of manufacturing performance in investigated supply chains?

RQ2: which aspects of manufacturing performance should be considered while implementing the postponement strategies in supply chains operating in different countries worldwide?

In order to answer the research questions a two-step statistical analysis was employed. The first step was the reduction of the 27 independent variables through Exploratory Factor Analysis EFA. Those variables reflected multidimensional indices of manufacturing performance. In order to perform the factor analysis a Principal Component Analysis (PCA) with Varimax Rotation were employed. The analysis was conducted on standardized variables.

TABLE. 1

Structure of Indices Obtained through the Factor Analysis

Variables	*Groups of performance indices*				
	Cost & flexibility	*Product's characteristics*	*Manufacturing productivity*	*Failures of mfg process*	*Manufacturing time performance*
Direct manufacturing costs	0,835				
Total product costs	0,836				
Flexibility to change output volume	0,582				
Flexibility to change product mix	0,681				
Product features		0,866			
Product performance		0,890			
Perceived overall product quality		0,796			
Index of manufacturing cost			0,578		
Index of labor productivity			0,871		
Index of equipment productivity			0,868		
Share of rejects of incoming material				0,569	
Share of rejects during processing (scrap rate)				0,850	
Share of rejects at final inspection				0,824	
Index of mfg throughput time					0,599
Share of the set-up time in the production elapsed time					-0,513
Share of the processing time in the production elapsed time					0,773

In the result of EFA an anti-image correlation matrix has been obtained. Its inspection has led to the elimination of 4 variables whose a measure of individual sampling adequacy is below a nominal cut off point of 0.5. Additionaly, in the result of factor analysis 7 variables were excluded as they indicated factor loadings below a nominal cut-off point of 0.65. Finally, the factor analysis which was carried out on 15 items, revealed the following structure of five constructs explaining 63.7 percent of the total variance (Table 1):

Factor 1: Cost and flexibility (direct manufacturing costs, total product costs, flexibility to change output volume, flexibility to change product mix),

Factor 2: Product’s characteristics (product features, product performance, perceived overall product quality),

Factor 3: Manufacturing productivity (labor productivity, equipment productivity),

Factor 4: Internal failures of manufacturing process (rejects of incoming material, rejects during processing - scrap rate, rejects at final inspection), Factor 5: Manufacturing time performance (manufacturing throughput time, set-up time in the production elapsed time, processing time in the production elapsed time).

The number of 5 factors was determined according to the analysis of the percentage of variance explained and the Kaiser criterion [1]. KMO coefficient score indicating a suitability of the sample for factor analysis in a space of 15 variables is 0.715 which in the opinion of Kaiser, is a middling result [9], but suficient for larger samples, such as 305 companies. Bartlett's test of sphericity demonstrated sufficiently high value for the extracted factors at p <= 0.000 (Approx. chi-square 1638.9, df = 120). This result proves that the difference between correlation matrix of the components and identity matrix is significant.

In the second stage of the analysis multiple regression analysis was developed. It enabled to make inter-national comparisons of the contribution to variance. Four items were selected as dependent variables based on their relevance as indicators of the extent of postponement in a supply chain. They defined a percent of manufacturing orders falling into four categories: engineer-to-order (full postponement), make-to-order (manufacturing postponement), assembly-to-order (assembly postponement) and make-to-stock (full speculation).

Multiple regression models were developed for each of the five factors with the four dependent variables. The primary reason for using multiple regression was to generate values of *adjusted* R^2 (with the values above .05) for comparison of the strength of relationship and the strength of contribution of variance. Adjusted R^2 is particularly useful in comparing across regression equations involving different sample sizes. Only variables with observed p-values of less than 0.05 were kept in developed models.

Although, initially eleven countries were a subject of the analysis, six of them represented very low share of the sample (under 10 percent). Therefore they were excluded from the further analysis. The companies from Fiji indicated no significant associations among postponement strategies and manufacturing performance factors. Therefore, finally only four out of eleven represented countries were employed for the further analysis.

RESULTS OF THE ANALYSIS

Table 2 contains the results of the regression analysis for five groups of manufacturing performance indices with the four dependent variables. The inspection of the table allows to notice significant relationships between the dependent variables reflecting the types of postponement strategies and the independent groups of indices.

There are a number of significant associations between postponement strategies and different manufacturing performance measures. It is worth noting that each postponement strategy for all considered countries indicate only one significant relationship with a specific group of manufacturing performance indices. This may suggest that the application of postponement strategies raises the level of performance mainly in one selected group of manufacturing indices.

TABLE. 2

Comparison of regression models for postponement strategies in considered countries

Type of postponement strategy	Country	Efficiency of performance	Std. Coef.	p-value*	R-square**
Full postponement	China & Shanghai	Mfg productivity	-.250	.050	.047
	USA	Mfg time performance	-.250	.002	.050
	Poland	Failures of mfg process	.287	.030	.110
	Hungary	Cost & flexibility	.240	.049	.040
Manufacturing postponement	Poland	Product's characteristics	.293	.027	.080
Full speculation	Hungary	Cost & flexibility	.426	.001	.182

* *p-value < .05*
** *R sq. significant at .05*

The largest number of significant associations may be found between a full postponement strategy and different performance indices.

The first relation concerns the companies from USA and includes the association between a full postponement strategy and manufacturing time performance. This may prove that in the United States a full postponement strategy has to deal with the compression of logistics time flow of products from its project through distribution. This may also suggest that the American consumers want to purchase fully customized products but, at the same time, they also do not like an idea to wait too long for individualized products offered by supply chains. This is consistent with the research conducted by Yang et al. [43] who claim that typically the implementation of postponement might lead to increasing cycle time. In order to reach a consistency between full postponement and time compression some companies decide to apply just-in-time or quick response strategies and use tools enabling to reduce lead time [4], [35].

Next significant associations may be found in companies from China/Shanghai, Poland and Hungary. The Chinese and Shanghai firms report a significant negative association between a full postponement and manufacturing productivity. The obtained results suggest that a greater extent of postponement strategy may lead to a decrease of overall productivity. Although, the customers have to spend more money for an individualized offering, still it seems not to compensate the companies for the investments necessary for manufacturing and delivering customized products (e.g. a long return on investments, necessity to employ additional product managers, subcontractors, service providers etc.). One of the main reason explaining a decline of manufacturing productivity when applying a pure postponement in Chinese and Shanghai firms, is still a high level of expenditures, large capital engaged, and sometimes the overinvestment of many companies from that region.

The other manufacturing performance measure indicating the failures in achieving an internal efficiency are scrap rates. The results suggest that a full postponement is significantly associated with an internal failure of manufacturing process in companies from Poland.

The results suggest that this factor plays specifically important role for a larger extent of application of postponement. The observed tendencies may indicate that the internal failures in manufacturing are particularly important when the activities are customized and initiated by a real customer demand. In a full postponement strategy the whole flow of products is pull-driven from the supplies of raw materials, through processing and distribution of final products. This may partially explain the importance of failures of manufacturing process in a full postponement strategy as each supply of raw material, processing and sale of product is based on real market data and has to be checked thoroughly at all stages of the product flow. The smaller extent of application of postponement strategy may not have a significant impact on failures of manufacturing process as the products are produced and delivered on mass scale and it may be assumed that the potential irregularities of that performance factor are rather common and do not cause overwhelming disruptions in operations.

Eventually, a full postponement strategy is related with cost and flexibility dimensions in Hungary. The obtained results seem to be rather logical as the greater extent of postponement triggers the higher level of costs and raises flexibility. It should be noted that the flexibility of changing output volume and product mix contribute to the higher level of product's customization. The observations made by Ahlstrom and Westbrook [3] suggest that the negatives associatied with product customization have most to do with increased cost. One reason why this occurs may be that the production system incurs a premium cost for the increased flexibility because the manufacturing has not evolved into a full customization, but continues also to produce batches of standard products. This also confirms the previus research showing that in many regions postponement is considered to be a supply chain strategy for mass customization [13], [22], [24].

An interesting result may be observed in Hungarian companies which, similarly to a full postponement, also indicate a significant positive association between a full speculation strategy and cost/flexibility. Such an identical result obtained from the analysis seems to be rather logical as the cost and flexibility construct is not very homogenous both in terms of its nature as well as strength and intensity of influence. The results suggest that the lower extent of postponement strategy leads to a decrease in cost and flexibility in the same group of Hungarian companies. The study indicates that when applying a postponement strategy, cost and flexibility measure is particularly important and should be thoroughly consided by the firms operating in Hungary.

The obtained results show a significant positive association between a manufacturing postponement strategy and another performance measure - product's characteristics. The quality attributes of products seem to be particularly important in Polish companies. It may suggest that particularly in that group of companies manufacturing postponement affects the product's characteristics as the manufacturing technology determines the quality of products. The manufacturing performance in terms of qualitative characteristics of products is depended on the technology of manufacturing process. Presumably that is the major reason why manufacturing postponement has relationships with the product's characteristics.

It should be noted that an assembly postponement strategy indicated no significant associations with any manufacturing performance measures in the examined countries. The other postponement strategies showed significant relationships but their number is still limited to only selected indices. One of the reason may be a diverse level of economic development among examined countries. The most obvious differences may be observed considering the associations between a full postponement strategy and manufacturing performance measures.

Those relationships can be subdivided into two groups, namely the associations between full postponement strategy and external manufacturing performance measures, and the links between a full postponement and internal measures. The external manufacturing indices are more market oriented and refer to the customers' preferences while the internal measures are more focused on situation in a company and search for an excellence of operations performed inside a company. The first group concerns American companies, which report an association between a full postponement strategy and manufacturing time performance. This performance measure is significant as the companies from US operate in economic environment being on a high stage of development. It partially may explain the importance of that group of indices for a full postponement strategy. On the other hand, the firms from China/Shanghai, Hungary and Poland report significant associations between a pure postponement strategy and manufacturing indices concerning the efficiency of operations performed inside the companies. The importance of that groups of indices probably stems from the lower level of development of that countries, less mature market economy and a greater necessity of companies to calculate the internal efficiency of performed operations. The other important issue is also a dominant position of companies in a sample representing electronic and other electrical equipment industry. This may disturb objectivity of the final results obtained from the analysis.

The purpose of the paper was to investigate relationships between postponement strategies and manufacturing performance in supply chains operating in several countries worldwide.

Answering the research question no. 1 (What are the significant indices of manufacturing performance in investigated supply chains?) the study indicated five groups of idicators measuring diffirent dimensions of manufacturing performance in supply chains. The measures concern basic dimensions of manufacturing practices in investigated supply chains, namely cost, flexibility, product's characteristics, manufacturing productivity, internal failures of manufacturing process, manufacturing time performance.

Answering the research question no. 2 (Which aspects of manufacturing performance should be considered while implementing the postponement strategies in supply chains operating in different countries worldwide?) the study shows that there are several significant associations between different types of postponement strategies and manufacturing performance measures in supply chains operating in several countries worlwide. Thus, the study confirmed the observed associations are country specific. The supply chains in the examined countries (China & Shanghai, USA, Poland, Hungary) report different relationships between postponement strategies and manufacturing performance. It is definitely conditioned upon a number of factors connected to the technological issues, complexity of manufacturing process, types of products and general conditions of their storage, transport and packing, consumer demand, adopted organization od supply chain etc. As the results indicated, differences may be noticed among countries representing a diverse level of economic development and environmental conditions of operating for manufacturing companies in supply chains.

It may be concluded that in the result of conducted analysis no surprises were uncovered. However, kowledge of the few significant associations between postponement strategies and manufacturing performance measures might be of importance to some companies operating in a specific region and challenged by the application of specific type of postponement strategy in near future.

The general comparison of countries in terms of the relationships between postponement and manufacturing performance in supply chains shows that the examined types of postponement strategies indicate the associations with the measures of manufacturing performance to a different extent. The study revelas that there are different levels of application of postponement strategies in supply chains operating in examined countries (some strategy may even not exist). On the other hand, some types of postponement are not linked with manufacturing performance which may suggest they do not contribute to an overall effciency of supply chains.

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SUPPLIER SELECTION USING FUZZY ANALYTIC HIERARCHY PROCESS: HOSPITAL INFORMATION SYSTEMS APPLICATION

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Abstract — *Hospitals, as highly information intensive organizations, spend considerable amounts on information systems technologies and integration. The specifications and the quality of the information system affect the administrative success of the hospital, the quality of healthcare information processing, and eventually the quality of the healthcare given. Hence, supplier selection for Hospital Information Systems (HIS) is of great importance for the hospital and the overall healthcare system. Regarding the particular situation of HIS, Fuzzy Analytic Hierarchy Process (AHP) is a widely used method for supplier selection. This study is intended to make an application on HIS supplier selection using fuzzy AHP.*

Keywords — *Hospital information system, supplier selection, fuzzy, AHP.*

INTRODUCTION

In today's competitive business environment, strategic decisions such as supplier selection affect the success of the company as a whole. Supplier selection is a multiple criteria decision-making problem in which the objectives are not equally important [1]. Therefore, choosing the right suppliers involves much more than scanning a series of price list, and choices will depend on a wide range of factors which involve both quantitative and qualitative [2].

Hospital information systems were first developed in the 1960s. They have been an essential part in hospital information management and administration since then. By nature, HIS are highly complex systems consisting of various administrative and medical subsystems. This makes it harder to design and integrate a fully operational HIS for vendors, and even harder for the hospitals to choose the 'best' HIS. Costs are high, and so are the expectations of users - but often disappointment is predictable [3].

In this study, determining the best supplier among the available hospital information system suppliers is chosen as research object. The criteria and supplier selections are made using Fuzzy AHP. The study is based on Reference [4] in which the nine supplier selection criteria were chosen based upon discussion with practitioners, the authors' own experiences and review of the literature.

The rest of the paper is organized as follows. Section 2 describes the criteria used for supplier evaluation and the method. The implementation of *fuzzy AHP* for HIS supplier selection is explained in Section 3. Concluding remarks are given in the last section.

SUPPLIER EVALUATION CRITERION AND THE METHOD

With the review of the literature, one can clearly see that there are hundreds of criteria used for supplier evaluation and selection [2][5][6][7][8]. As stated previously, this study utilizes Ref.[4] for the determination of the criteria. The nine criteria which are categorized in three main criteria sets are presented in Table 1 [4].

Designing the study and the questionnaire; the above mentioned criteria were used in the following meanings:

'Product/service attributes' criterion set includes variables that reflect the potential of a product or service to contribute to the improved performance of the buying organization and to facilitate day-to-day operations [4]. 'Flexibility' indicates production flexibility and responsiveness to customers. 'Ease of use' means that, software must be easy to use for the staff. 'Integration with existing applications'

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shows the compatibility of the software with the hospital's software/system whereas 'Integration with existing database management system' means compatibility with the prevalent database management system. 'Efficiency' is the operability of the software/system within a reasonable range of resource commitment [4]. 'Ease of installation' means the quick installation of the software/system without any troubles.

'Vendor attributes' criterion set measures the decision maker's perception of the vendor and vendor characteristics as opposed to the specific product or service [4]. 'Vendor support' and 'Vendor viability/reliability' show that a trustworthy and credible vendor of choice will 'be there' in need.

'Economic attributes' consist of price attributes. 'Cost' means the total cost of ownership, looking beyond the price of a purchase to include other purchase related costs (such as product cost, quality cost, service cost, etc.) [8].

TABLE 1
Criteria Sets

Supplier Selection Criteria	Abbreviation
1. Product / service attributes	(P/SA)
Flexibility	(FLEX)
Ease of use	(EOU)
Integration with existing applications	(IWEA)
Integration with existing database management system	(IWEDMS)
Efficiency	(EFF)
Ease of installation	(EOI)
2. Vendor attributes	(VA)
Vendor support	(VS)
Vendor viability/reliability	(VV/R)
3. Economic attributes	(EA)
Cost	(COST)

FUZZY AHP METHODOLOGY

To deal with vagueness of human thought, Zadeh [9] first introduced the fuzzy set theory, which was oriented to the rationality of uncertainty due to imprecision or vagueness. A major contribution of fuzzy set theory is its capability of representing vague data. The theory also allows mathematical operators and programming to apply to the fuzzy domain. A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function, which assigns to each object a grade of membership ranging between zero and one. A tilde "~" will be placed above a symbol if the symbol represents a fuzzy set.

Therefore, $\tilde{p}, \tilde{r}, \tilde{n}$ are all fuzzy sets. The membership functions for these fuzzy sets will be denoted by $\mu(x|\tilde{p})$ and $\mu(x|\tilde{n})$ respectively. A triangular fuzzy number (TFN), $\tilde{M}$, is shown in Fig. 1. A TFN is denoted simply as $(\frac{m_1}{m_2}, \frac{m_2}{m_3})$ or (m_1, m_2, m_3). The parameters m_1, m_2 and m_3 respectively denote the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event [10].

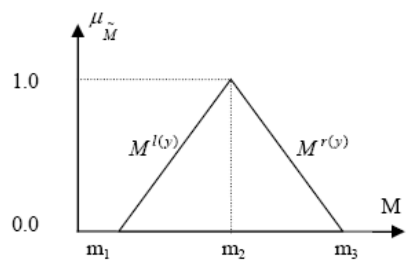

FIGURE 1
A triangular fuzzy number

The analytic hierarchy process (AHP) is one of the extensively used multi-criteria decision-making methods. One of the main advantages of this method is the relative ease with which it handles multiple criteria. In addition to this, AHP is easier to understand and it can effectively handle both qualitative and quantitative data. The use of AHP does not involve cumbersome mathematics. AHP involves the principles of decomposition, pair-wise comparisons, and priority vector generation and synthesis. Though the purpose of AHP is to capture the expert's knowledge, the conventional AHP still cannot reflect the human thinking style. Therefore, fuzzy AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems. In the fuzzy-AHP procedure, the pair-wise comparisons in the judgment matrix are fuzzy numbers that are modified by the designer's emphasis [10].

In the following, first the outlines of the extent analysis method on fuzzy AHP are given and then the method is applied to website evaluation problem. Let

$$x = \{x_1, x_2, \ldots, x_n\} \tag{1}$$

be an object set, and

$$U = \{u_1, u_2, \ldots, u_n\} \tag{2}$$

be a goal set.

According to the method of Chang's extent analysis [11,12], each object is taken and extent analysis for each goal is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M^1_{g_i}, M^2_{g_i}, \ldots, M^m_{g_i} \quad i = 1,2,\ldots,n \tag{3}$$

where all the $M^j_{g_i}$ (j 1,2,...,m) are triangular fuzzy numbers. The value of fuzzy synthetic extent with respect to i*th* object is defined as:

$$S_i = \sum_{j=1}^{m} M^j_{g_i} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{g_i} \right]^{-1} \tag{4}$$

The degree of possibility of $M_1 \geq M_2$ is defined as:

$$V(M_1 \geq M_2) = \underset{x \geq y}{SUP} \left[\min(\mu M_1(x), \mu M_2(y))\right] \tag{5}$$

When a pair (x,y) exists such that $x \geq y$ and $\mu M_1(x) = \mu M_2(y)$, then we have $V(M_1 \geq M_2)=1$. Since M_1 and M_2 are convex fuzzy numbers we have that:

$$V(M_1 \geq M_2) = 1 \text{ if } m_1 \geq m_2 \tag{6}$$

$$V(M_1 \geq M_2) = hgt(M_1 \cap M_2) = \mu M_1(d) \tag{7}$$

where d is the ordinate of the highest intersection point D between μM_1 and μM_2 . When $M_1 = (l_1,m_1,u_1)$ and $M_2 = (l_2,m_2,u_2)$, the ordinate of D is given by equation (8):

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \frac{l_1 - u_1}{(m_2 - u_2) - (m_1 - u_1)} \tag{8}$$

To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i (i= 1,2,...,k) can be defined by:

$$V(M \geq M_1, M_2, \ldots, M_k) = V(M \geq M_1) \text{ and } V(M \geq M_2) \text{ and} \ldots \text{and } V(M \geq M_k) = \min V(M \geq M_i),\ i=1,2,\ldots,k \tag{9}$$

Assume that:

$$d'(A_i) = \min V(S_i \geq S_k) \tag{10}$$

For k =1,2,...,n; $k \neq i$. Then the weight vector is given by:

$$W' = (d'(A_1), d'(A_2),,\ldots, d'(A_n))^T \tag{11}$$

where A_i (i=1,2,...,n) are n elements. Via normalization, the normalized weight vectors are:

$$W = (d(A_1), d(A_2),,\ldots, d(A_n))^T \tag{12}$$

where W is a non-fuzzy number.

APPLICATION ON HIS SUPPLIER SELECTION

In this study, three HIS suppliers as alternatives were designated and evaluated:

- Alternative A,
- Alternative B,
- Alternative C.

Three experts were asked to evaluate the alternatives using the linguistic terms shown in Table 2.

TABLE 2
Linguistic Term and Fuzzy Number

Linguistic term	Very Good (VG)	Good (G)	Moderately Fair (MF)	Fair (F)	Equal (E)
Fuzzy number	(7/2,4,9/2)	(5/2,3,7/2)	(3/2,2,5/2)	(2/3,1,3/2)	(1,1,1)

TABLE 3. Evaluation of Main Criteria Sets

	P/SA	VA	EA
P/SA	E	G	MF
VA		E	G
EA			E

TABLE 4. Evaluation of Product/Service Attributes

	FLEX	EOU	IWEA	IWEDMS	EFF	EOI
FLEX	E	MF	E	E		
EOU		E				
IWEA		MF	E	E		
IWEDMS		MF		E		
EFF	G	MF	G	G	E	MF
EOI	MF	MF	MF	MF		E

TABLE 5. Evaluation of Vendor Attributes

	VS	VV/R
VS	E	
VV/R	F	E

Main criteria sets were evaluated by experts as shown in Table 3. As the result of calculations according to Table 3, main criteria weights were designated as (0.66879; 0.29777; 0.03344).

Product / Service Attributes sub-criteria evaluations are presented in Table 4. As the result of calculations according to Table 4, sub-criteria weights were designated as (0.11264; 0.09251; 0.11053; 0.11053; 0.38927; 0.18452).

Vendor Attributes sub-criteria evaluations are presented in Table 5. As the result of calculations according to Table 5, sub-criteria weights were designated as (0.5; 0.5).

Economic Attributes has only one sub-criterion which is cost, so the weight of cost is designated as

(1).TABLE 6
Summary of Main Criteria Set and Sub-criteria Weights

Criteria Set 1	Weight	Criteria Set 2	Weight	Criteria Set 3	Weight
Product / Service Attributes	0.668788957	Vendor Attributes	0.297771595	Economic Attributes	0.033439448
Flexibility	0.1126362	Vendor Support	0.5	Cost	1
Ease of use	0.09250688	Vendor viability / reliability	0.5		
Integ. with ex. app.	0.11053412				
Integ. with ex. DMS	0.11053412				
Efficiency	0.38927319				
Ease of installation	0.18451549				

Evaluations of Alternatives by the experts according to sub-criteria are presented in Tables 7 to 15.

TABLE 7. Evaluation of Alternatives according to Flexibility sub-criteria.

	A	B	C
A	E		MF
B	G	E	VG
C			E

TABLE 8. Evaluation of Alternatives according to Ease of Use sub-criteria.

	A	B	C
A	E		F
B	MF	E	G
C			E

TABLE 9. Evaluation of Alternatives according to Integration with Existing Applications sub-criteria.

	A	B	C
A	E	MF	E
B		E	
C		MF	E

TABLE 10. Evaluation of Alternatives according to Integration with Existing Database Management Systems sub-criteria.

	A	B	C
A	E	MF	E
B		E	
C		MF	E

TABLE 11. Evaluation of Alternatives according to Efficiency sub-criteria.

	A	B	C
A	E		MF
B	G	E	VG
C			E

TABLE 12. Evaluation of Alternatives according to Ease of Installation sub-criteria.

	A	B	C
A	E	E	
B		E	
C	MF	G	E

TABLE 13. Evaluation of Alternatives according to Vendor Support sub-criteria.

	A	B	C
A	E		MF
B	MF	E	VG
C			E

TABLE 14. Evaluation of Alternatives according to Vendor Viability/Reliability sub-criteria.

	A	B	C
A	E		F
B	F	E	VG
C			E

TABLE 15. Evaluation of Alternatives according to Cost sub-criteria.

	A	B	C
A	E	F	
B		E	
C	VG	VG	E

Comparison of alternatives according to Flexibility sub-criteria is presented in Table 7. As the result of calculations in accordance with Table 7, weights of alternatives are designated as (0; 1; 0). Comparison of alternatives according to Ease of Use sub-criteria is presented in Table 8. As the result of calculations in accordance with Table 8, weights of alternatives are designated as (0; 1; 0). Comparison of alternatives according to Integration with Existing Applications sub-criteria is presented in Table 9. As the result of calculations in accordance with Table 9, weights of alternatives are designated as (0.5; 0; 0.5). Comparison of alternatives according to Integration with Existing Database Management Systems sub-criteria is presented in Table 10. As the result of calculations in accordance with Table 10, weights of alternatives are designated as (0.5; 0; 0.5). Comparison of alternatives according to Efficiency sub-criteria is presented in Table 11. As the result of calculations in accordance with Table 11, weights of alternatives are designated as (0; 1; 0). Comparison of alternatives according to Ease of Installation sub-criteria is presented in Table 12. As the result of calculations in accordance with Table 12, weights of alternatives are designated as (0; 0; 1). Comparison of alternatives according to Vendor Support sub-criteria is presented in Table 13. As the result of calculations in accordance with Table 13, weights of alternatives are designated as (0; 1; 0). Comparison of alternatives according to Vendor Viability/Reliability sub-criteria is presented in Table 14. As the result of calculations in accordance with Table 14, weights of alternatives are designated as (0.13883; 0.86117; 0). Comparison of alternatives according to Cost sub-criteria is presented in Table 15. As the result of calculations in accordance with Table 15, weights of alternatives are designated as (0; 0; 1).

Overall comparisons of the alternatives, in accordance with the calculated weights are shown in Table 16. The ranking of Alternatives is calculated as Alternative B, Alternative C and Alternative A.

TABLE 16
Calculated Weights of Alternatives

	Weight	**Alternative A**	**Alternative B**	**Alternative C**
FLEX	0.075329845	0	0.075329845	0
EOU	0.06186758	0	0.06186758	0
IWEA	0.073924	0.036962	0	0.036962
IWEDMS	0.073924	0.036962	0	0.036962
EFF	0.260341609	0	0.260341609	0
EOI	0.123401923	0	0	0.123401923
VS	0.148885798	0	0.148885798	0
VV/R	0.148885798	0.020669653	0.128216145	0
COST	0.033439448	0	0	0.033439448
TOTAL	**1**	**0.094593653**	**0.674640976**	**0.230765371**

CONCLUSIONS

As a result of rapid improvements in computer and software technology, information systems (IS) become an essential part of our daily life. Hospitals, as many other enterprises, use IS and for managerial and healthcare purposes. For both purposes, selection of the best HIS is a critical decision for the hospital administration. A scientific approach - for sure - will help this decision more accurate, rather than deciding on a price list or asking colleagues which one to use. In this study, three main criteria sets and nine sub-criteria are used for a fuzzy AHP application on HIS. Among the criteria, Efficiency, Vendor Support, Vendor Viability / Reliability and Ease of Installation were found to be relatively important. Alternative B, getting the highest grade has proven to be the 'best choice' among others in this application. Further study can be done in this area using more and different criteria; and other linear weighting or mathematical programming models.

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ANALYSIS FOR APPLICABILITY OF SUPPLIER SELECTION TECHNIQUES IN HOTEL BUSINESS, ACCORDING TO OPERATION OF SUPPLY CHAIN MANAGEMENT

Cevdet AVCIKURT [1], *Ahmet KÖROĞLU* [2], *Murat DOĞDUBAY* [3] , *Mehmet SARIOĞLAN* [4]

Abstract — *In order to be able to fulfill the service in hotel managements, approximately 3000 different products are used, which means about 3000 different suppliers as well. Therefore, selection techniques for different suppliers shall be able to be used in hotel managements during the supplying process of different products. In this study, theoretical feasibility of techniques (Modelling of Supplier Selection Problem Decision Tree as the Expert System, Process of Analytical Hierarchy in Selection of Suppliers, Process of Fuzzy Analytical Hierarchy in Selection of Suppliers, Model of Supplier Selection According to Different Product Groups, Selection of Suppliers with Fuzzy Axiomatic Design, Selection of Suppliers with Data Envelopment Method) which are able to be used in supplier selection under supply chain management in hotels are reviewed. At the end of the theoretical review, it has been concluded that the mentioned techniques for selection of suppliers could be applied, but might be relative according to the establishment and product. Moreover, despite the disadvantage that application of a single supplier selection technique in hotel managements may lead to an ignore of different criterias in supplier selection, it's been determined that the whole feasibility of above mentioned techniques for supplier selection might increase the effectiveness in selection of right supplier for hotel managements in selection of suppliers.*

Keywords — Selection of Suppliers in Hotel Managements, Techniques for Supplier Selection.

INTRODUCTION

Today's contemporary enterprises should consider a lot of elements and manage them successfully in order to be successful and continue their activities (Fink and others, 2010; 103). Among such elements, the first one is the interdependence of companies increasing day by day. Particularly, in order today's complicated products (tourism, car, electronic devices etc.) to be able to be produced, hundreds of raw materials and semi-finished goods have to be procured, transform into product by getting processed and then reached to hundreds of different markets (Zouaghi and others, 2010; 214) . Since such activities are able to be implemented by a single enterprise, interdependence between suppliers, production companies, distrubutors and final sellers are increasing. A hitch within one of such companies shall be experienced in different levels for all other enterprises. Therefore, the enterprices have become dependant to each other The only possible way to effectively manage this dependancy is with supply chain management (Özceylan and Çoşkun, 2008; 77-78).

Selection of supplier has become one of the most important issues in literature for the companies in frame of suuply chain management (Monczka and others, 2009; 41). One of the most prominent decisions to be made by enterprices is the selection of suppliers. The process of supplier selection, which is a multiple criteria decision that includes quantitative and qualitative criterias, has the characteristics to be a critical decision process who has a greater prominence today (Sarjami and Caccetta, 2010; 124). Particularly in the recent times, due to rapid developments in technology and

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growing competititon environment depending upon globalization, it has become indispensible for the enterprises that their suppliers' performances should be successful as well as theirs, for them to be able to make fast replies to their customers' demands. Thus, it's only possible for the enterprises to produce low cost and quality products by selecting the right supplier (Ferreira and Andre, 2010; 227).

Selection of the right supplier provides suitable cost for product purchasing and development of competitive advantage is positively affected as well. The activity of supplier selection is a concrete factor which almost provides analytical approach to all the problems of enterprises and prevent them to occur most times (Chan, 2003; 3549). It becomes obvious that the supplier selection includes a complicated process since non-concrete criterias are used as well as the concrete ones for supplier selection in order to be made effectively (Ghodsypour and O'Brien, 2001; 19).

SUPPLY CHAIN MANAGEMENT AND SELECTION OF SUPPLIERS IN HOTEL MANAGEMENTS

Supply chain management is available in enterprises which produce services as well as the ones which produce goods. The important point here is that the complexity of supply chain differs from sector to sector (Karasu, 2006; 11). Thus in enterprises which offer accomodation services, supply chain management has become more prominent since the raw materials to be used for production are not be able to be stored for a long time and thus purchasing is made regularly (Kothari and others, 2005; 369).

The strategy of supply chain management differs from the strategies at company levels, because since the strategies at company levels require the coordination of inner processes, supply chain management requires the coordination between the member companies of supply chain for all processes. Therefore, achieving the purposes for supply chain management starategy depends on the coordination among the companies (production development, income increasing, reduction of working capital and fixed capital amounts, reduction of operating costs, increasing of market share, customer satisfaction etc.) and commitment to be fulfilled (Ünüvar, 2009; 567).

The supplier of selection process has a great prominence for hotel managements producing complex products as well as for the other enterprises at least. Supplier of selection affects the superiority of hotel managements, their costs, customer satisfaction; and since the products generated in hotel managements directly affect the consumers' everyday life; it plays an important role in sustainability of life functions. In this frame, supplier selection in hotel managements is a more complicated and delicate issue than in the other enterprises (Sarıoğlan and Avcıkurt, 2010; 349).

The most conveniant supplier in terms of hotel managements is the supplier who provides the highest functionality in terms of management's customer and the most compatible one. The returned products to the most compatible supplier is within normal limits. This condition of supplier shows that the power balance is on the purchaser's side or there is mutual solidarity available. In terms of hotel managements, the worst supplier is the one who can not provide the desierd functionality and the required compatibility. The retuned products are above normal limits. This condition of supplier shows that the power balance is on the suplier's side. Adequate but non-compatible supplier may provide the functionality that the management needs, but is not satisfactory in comapatibility (İlhan, 2009; 60).

Since hotel managements are enterprises offering complex products, due to approximately 3000 items being used in service production, they are more important than the other sectors. Being able to produce quality products among that much product range is only possible by selecting effective suppliers. The starategies to be able to be used in selection of suppliers under supply chain management in food-beverage companies have strengths and weaknesses when compared to each other. Increasing such strenghs and minimazing weak points may differ depending upon the consistency of the enterprice's supplier selection policy (Sarıoğlan and others, 2010; 104). And in this study, the techniques (Modelling of Decision Tree as the Expert System in Supplier Selection, Process of Analytical Hierarchy in Selection of Suppliers, Process of Fuzzy Analytical Hierarchy in Selection of Suppliers, Model of Supplier Selection According to Different Product Groups, Selection of Suppliers with Blurry Axiomatic Design, Selection of Suppliers with Data Envelopment Method) which are able to be used in supplier selection under supply chain management in hotels have been reviewed.

Techniques for Selection of Suppliers to be used at Hotel Managements

Selection of the right supplier is an important decision problem since the suppliers, which are one of the most important elements of the supply chain, have to be in a quality that is suitable for the strategy of the enterprise and shall take the enterprise to its targets. If a supplier can be a part of a well-managed and well-designed supply chain, the competitiveness of the whole supply chain may increase (Özel and Özyörük, 2007; 415). Since hotel managements are the managements that offer complex products, approximately 3000 items of products are used in service production. Being able to produce quality products among that much product range is only possible by selecting effective suppliers. The starategies to be able to be used in selection of suppliers under supply chain management in hotel managements have strengths and weaknesses when compared to each other (Sarıoğlan and Avcıkurt; 2010). Increasing such strenghs and minimazing weak points may differ depending upon the consistency of the enterprice's supplier selection policy (Boer and Wegen, 2003). And in this study, the techniques (Modelling of Decision Tree as the Expert System in Supplier Selection, Process of Analytical Hierarchy in Selection of Suppliers, Process of Fuzzy Analytical Hierarchy in Selection of Suppliers, Model of Supplier Selection According to Different Product Groups, Selection of Suppliers with Blurry Axiomatic Design, Selection of Suppliers with Data Envelopment Method) which are able to be used in supplier selection under supply chain management in hotels have been reviewed.

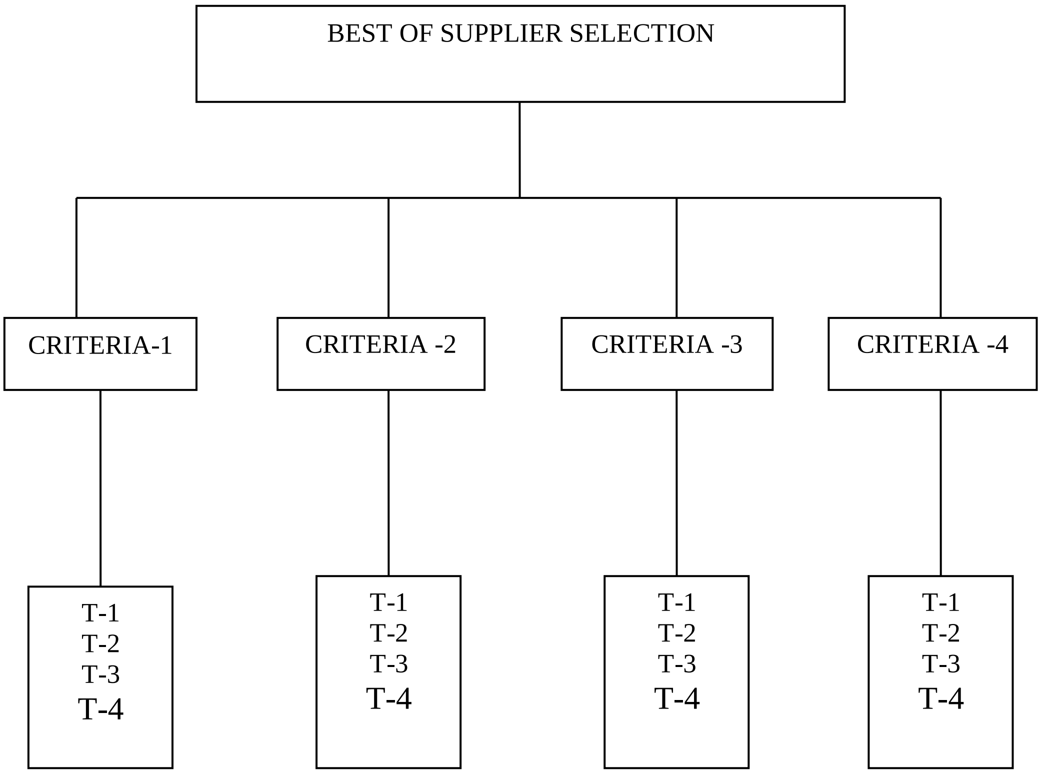
Modelling of the Decision Tree as System in Supplier Selection of Hotel Managements

This modelling used in supplier selection is a technique in which computer aided decision making and expert systems as an extension of it have been informed and which depends on a model developing regarding decision of a supplier selection under supply chain that is a field of production and management as an example of modelling expert systems by using decision tree. Decision theory has been focused on being able to be designed as an expert system in a way to support the experts of supply management by reviewing the problem structure of supplier selection in expert system design and supply chain management, and discussing such approaches together. The discussed approach is a candidate for information both being defined completely and qualitative by using decision trees and reached to more exact solutions that a supplier relations' expert can fulfill (Öz and Baykoç, 2004; 275). In the light of such data, in hotel managements, it is considered to be effective in solving a problem such as supplier selection which entails to express acertain decision flow as successive and interactive processes and finally demands to explain the reason of the decision taken (Öz and Baykoç, 2004; 285).

Analytical Hierarchy Process in Supplier Selection of Hotel Managements

Analytical Hierarchy Method, which is commonly used in supplier selection, is one of the methods that provides to make selection between alternatives in multi criteria decision processes. The aim of this method that was developed by Saaty in 1971 is to reach optimum solution by arranging the problem in a hierarchical structure made up of purpose, criteria, sub-criteria and alternatives. According to Saaty, "Analytical Hierarchy Method is a measurement theory related to deriving of dominant priorities from paired comparison of homogeneous elements according to a common criteria or characteristic" (Lui and Hai 2005; 310). Analytical hierarchy method has the power of presenting a complex, multi-crtiteria and multi-person problem in a hierarchical structure and analyzing those by reviewing every level separetely and then combining them (Huang and Keskar, 2007 ;512).

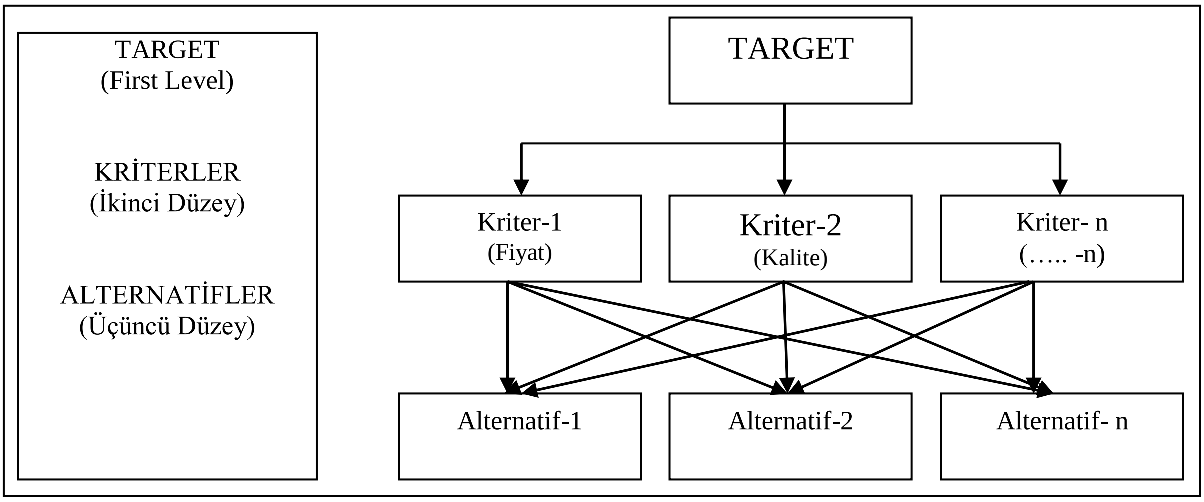
Figure-1: Decision Hierarchy for Selection of Supplier



Source: Haq and Kannan, 2006; 829

Analyical hierarchy method is an important supplier selection technique for providing the testing of evaluation consistency in consequence of using both objective and subjective evaluation criteria, particularly in making very important decisions such as giving priority among the alternatives which are required to be evaluated according to multi-criteria (Eraslan and Algün, 2005; 98). Analytical hierarchy method is a decision making method that is used in solution of complex problems which include more than one criteria. Analytical hierarchy method enables decision makers for modelling of complex problems in an hierarchical structure that shows the relation between the problem's main target, criteria (criteria/ attributes/objectives), sub-criteria and alternatives. The most important characteristic of analytical hierarchy method is that decision maker is able to include both his objective and subjective ideas to the decision process. In other words, analytical hierarchy method is a method in which information, experience, thoughts and visions of individuals are combined logically (Kuruüzüm and Atsan, 2001; 84).

Figure-2: Analytical Hierarchy Process Hierarchy Model



Source: Ramanathan, 2006; 1292.

The feasibility of analytical hierarchy process for supplier selection in hotel managements may differ depending on the product quality. But since there are complex products are available in hotel managements and approximately 3000 items of products are required, the feasibility of analytical hierarchy process may be limited.

Fuzzy Analytical Hierarchy Process for Supplier Selection in Hotel Managements

The Fuzzy Analytical Hierarchy Process technique can be considered as an advanced technique that is developed from Analytical Hierarchy Process which is a well-known analytical instrumentused in modelling of unconfigured problems in various fields such as social, economic and administrative sciences (Akman and Alkan, 2009; 32). Fuzzy logic is a method which aims to bring the human-spesific characteristic of elastic decision making to the machines. Because in the real life, solutions are evaluated as partly right, or right or wrong to a certain probability. Fuzzy logic, as the name says, is to provide the feasibility of rules of logic elastically or fuzzily. It softenes the true or false, yes or no, or sudden transitions such as 1 and 0 in classical logic (Erümit, 2007; 8). In multi-criteria decision making problems, despite the consistency of Analytical Hierarchy Process in considering both numerical and qualitative criteria, it adds the judgements, fuzziness and iuncertainity and indefinite judgements of the decision maker in traditional Analytical Hierarchy Process methods. Although the aim of Analytical Hierarchy Process is to reveal the knowledge of experts, traditional Analytical Hierarchy Process methods still can not reflect human mentality. In Analytical Hierarchy Process, since the base of priorities are the perceptional judgements of the decision maker (and this is particularly right for conditions which have no physical appearance and are intangible), fuzzy AHP are producing more successful results (Zhu and others, 1999; 450).

Fuzzy Analytical Hierarchy Process is an effective and active problem solving method. Fuzzy Analytical Hierarchy Process cuts the problem into pieces and solves in an hierarchical structure. Decision problem may include social, economic, technical and political factors (Özdağoğlu, 2008; 68). Because Blurry logic principles come into front by its superiority in explaination of the uncertainity capacity. The theory isalso eligible for the feasibility of mathematical operations and programming in fuzzy area (Sofyalıoğlu, 2009; 8). In classical set, in case the elements included in a set belong to such set, their membership degree is assumed as equal to 1, and if they do not belong, as equal to 0. However, a fuzzy set is defined with a function that has a membership degree each of whose elements differ between 0 and 1. Such membership degrees present continuity for a fuzzy set. Presentation of a fuzzy set is explained by crossing out the symbol (Günden and Miran, 2008; 197).

It is assumed that in supplier selection for hotel managements, the acceptability rate of fuzzy analytical hierarchy process is high since its field of application does not avoid the uncertanities, in spite of that, its efficiency of feasibility may be low since its parametric variables can not be estimated exactly. But since the effecting of hotel managements from external environmental conditions is high, its level of feasibility is high as well.

Supplier Selection With Fuzzy Axiomatic Design in Hotel Managements

Axiomatic Design is a design method which was developed to make the design field scientific for products, systems and processes. It defines the design with the interaction of the questions “what do we want to perform” and “how do we perform”. It is to create a scientific basis for designs and develop the design activities by supporting the designer with processes and instruments of rational thought. The most important concept in design with axioms is the existence of the axioms. The second one is to create product designs and provide a proportional basis to select the best among the esatblished solution alternatives (Özel and Özyörük, 2007; 416-417). Such axioms are as follows (Suh, 1998; 205-207):

• Axiom-1 (Axiom of Independency): It can be expressed as to provide the sustanability of independency of the functional needs. In an acceptable design, a design parameter (DP) can be arranged in order to provide the related functional requirement without affecting the other functional requirements (*FI*).

• Axiom-2 (Axiom of Information): It can be defined as to minimize the content of information. The best design to provide the Axiom of Independency of alternative designs is assumed to have a minimum information content.

Axiom of Independency defends that the independency of functional needs (*Fİ*) which can be defined as the minimum number of independent functional needs that characterises design purposes should be protected continiously. When two or more functional need is available, design solution must provide each functional need without affecting the other functional need. And this means the selection of a design parameter set which provides functional needs and is able to protect their independencies. Axiom of Information defends that the best design is the one which has the minimum information content among the designs providing axiom of Independency. Because the information content is defined with terms of probability and at the same time, the most likely design to take place according to the second axiom is the best design (Suh, 1998 – Özel and Özyörük, 2007; 417 – Özel, 2007). With the fuzzy axiomatic design, supplier selection in hotel managements shall able to be applied in consequence of big revisions. Thus the feasibility of fuzzy axiomatic design for supplier selection in hotel managements shall be able to be possible with management policy to be determined as focused to right supplier selection.

Supplier Selection With Data Enveloping Method (DEA) in Hotel Managements

Data Enveloping Method (DEA), which is a parametric method (Kaynar and others, 2005; 38), is a mathematical programming technique that calculates the relative activity of decision units under multi-criteria (Ramanathan, 2006; 1290). Data Enveloping Method was first presented in 1978 by Charnes, Cooper and Rhodes as a mathematical programming method which includes multi inputs and multi outputs, and evaluates the relative activities of decision making units (KVB). Each unit that is evaluated for its capability to convert inputs to outs in order to be used for applications in various fields are called Decision Making Units (KVB) (Adler and others, 2002; 250). When considering the whole activity analyse, there appears a lot of factors affecting relaibility of the values found for decision units which are evaluated as non-active. The reasons for being non-active includes non-inclusion of some input and output factors to the model, evaluation of nonhomogeneous decision units together, availability of factors which the admnistrator can not control and non expression of those in mathematical model as necessary (Kaynar and others, 2005; 38-39).

DEA (Data Envelopment Analysis) is a linear programming based technique which aims to measure the relative performance of decision units and used in conditions where inputs and outputs measured with different scales or which have different scale units force to compare (Kazançoğlu, 2008; 128). Alternatives are evaluated out of benefit (output) and cost (input) criteria. An activity or efficiency of an alternative (a supplier) is determined by ratio of weighted output total (return of the supplier) to weighted input total (the cost resulting with supplier's selection). Data enveloping method enables the enterprises to classify suppliers as efficient and non-efficient by finding the optimum weights for each supplier (Boer and others, 2001; 80).

In VZA activity evaluation, which is an activity/performance evaluation method, the formula for ratio of weighted output total to weighted input total is as follows (Karakoç Deveci, 2003; 2):

$$J \text{ (unit activity)} = \frac{\text{Weighted Output Total}}{\text{Weighted Input Total}} = \frac{u1Y1j + u2Y2j + \ldots\ldots + usYsj}{v1X1j + v2X2j + \ldots\ldots + vmXmj}$$

us : s. weight of output　　　　vm : m. weight of input

ysj : Amount of s output of unit j.　　　　xmj : Amount of m input of unit j.

It is deemed as important particularly in supplier selection in which multiple factors should be considered (Sezen, 2004). This characteristic of data enveloping system is to provide validity in hotel managements. Thus it is an important supplier selection technique that should not be avoided in supplier selection for hotel managements where general, economic, social, cultural and cyclical conditions change. In today's globalising world in which rapid changes take place, supplier selection for hotel managements shall be able to have a quite broad application field by data enveloping technique in providing competitive advantage and producing quality products.

CONCLUSION

Although the concept of supply chain method is a new concept for hotel managements, it’s been determined that it’s definitely a prominent management model. And it’s been determined that the most crucial point in feasibility of supplier selection in hotel managements is the supplier selection. And the right supplier selection increases the efficiency of supply chain management. In this study, it has been concluded that in order to implement service production with quality, low cost and competitive in hotel managements, it's necessary to supply chain management effectively, and efficiency for supply chain management can be made possible by selection of right supplier.

The efficiency for supply chain management is that different techniques are able to be applied for selection of the right supplier. Such techniques may differ according to establishment purposes of hotel managements, their management policies, capital structures and management structures. Each supplier selection techniques being able to be implemented in hotel managaments have superior and weak sides to each other. In this frame, it’s been concluded that in supplier selection techniques for hotel managements, it’s required to apply a mixed supplier selection starategy by focusing on the advantages of all techniques (Modelling of the Decision Tree as System in Supplier Selection of Hotel Management, Analytical Hierarchy Process in Supplier Selection, Fuzzy Analytical Hierarchy Process in Supplier Selection, Supplier Selection With Fuzzy Axiomatical Design Supplier Selection With Data Enveloping Method) instead of applying just one technique.

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SUPPLY CHAIN PARTNERS AND CONFIGURATION SELECTION: AN INTUITIONISTIC FUZZY CHOUQUET INTEGRAL OPERATOR BASED APPROACH

Jalal Ashayeri[1], Gülfem Tuzkaya[2], Umut R. Tuzkaya[3]

Abstract — *The concept of a supply chain exists for over twenty years but partners and configuration selection process still is rather unstructured. In order to increase value in any supply chain, a more comprehensive and integrative approach is required to select the right partners and with the right configuration along the chain. Under economic growth wrong decisions does not jeopardize profitability dramatically. However, recent economy downtrends, has made the choice of suitable partners in the supply chain a key strategic concern. The nature of these decisions usually is complex and unstructured. This paper aims to present an intuitionistic fuzzy Chouquet integral operator based approach to partners and configuration selection. In order to bring structure in the evaluation process, the supply chain operations reference (SCOR) model developed by Supply Research Council is employed. The paper discusses the development of the value chain concept from partners selection perspective, outlines general similarities and differences of the value chain and the SCOR, and uses a simple V-form supply chain example to establish the proposed approach. Finally, results of the application are discussed.*

Keywords — *Partner selection; supply chain configuration; Chouquet integral; Intuitionistic fuzzy values.*

INTRODUCTION

The supply chain (SC) concepts were developed in early 1990s as globalization of industry expanded due to outsourcing and offshoring. The core ideas are optimization and coordination of activities across a large number of independent profit centered entities through sharing information.

Earlier to introduction of SC concepts, the “Value Chain” concept was developed and popularized in 1985 by Michael Porter, in “Competitive Advantage,” [1]. However, the value chain concept was then rather limited and bounded within a firm; it suggested that the combination of nine generic value added activities when working together would provide value to customers. Porter linked up the value chains between firms to form what then he called as “Value System”. However, today with greater outsourcing and collaboration “the proper choice of linkages” between multiple firms’ value creating processes is more commonly known as “value chain”. As this name implies, the focus in value chains is not only on the benefits that accrue to ultimate customers, but also is on the interdependent processes that generate value, and on the resulting demand generates the funds flows. Effective value chains generate profits. The values here are not subjective as opposed to value to customers. These are measureable and quantifiable even when it addresses a qualitative issue. There are three forms of value that occur within a value chain, Technical (Resource Value); Organizational (Business Context); and Personnel (Knowledge Content), (adapted from [2], [3]).

Technical value is intrinsic to the resource being provided and occurs in virtually all exchanges; for example the technology adapted for assembly process and product manufacturing in car assembler affects partner selection and that in return influence the quality of product. Organizational value is built upon the context of the exchange, and may derive from a range of factors such as reliability, availability, responsiveness, environmental standards, etc. Brand image may also build organizational value, as well as company reputation. Personnel value and benefits are derived from the individual and collective knowledge and experiences within an entity and is used in the relationships involved in the

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exchange of resources. All these values accrue to the entities involved in a supply chain exchange, and within the entity as well.

Given the above discussion, it can be concluded that the design of an effective chain is a strategic decision and involves careful selection of partners and simultaneously evaluation of the resulting supply chain configuration in order to form an effective supply chain network. Therefore, before any network design optimization one needs to quickly select and evaluate alternative sets of potential partners and feasible network configurations.

The selection process however is a difficult task for many chains, especially many partners are involved. An example is chains like electronics, car manufacturer, where thousands of items are gradually put together and assembled to make the end products. These chains are characterized by high complexity and strong interrelations between sourcing, production, distribution, and information processes. Therefore, it is important to have a decision support tool in order to structure, model, and support analyzing alternative decisions. Even though the design of such supply chains have been studied extensively, most of the existing network design modeling approaches do not address and overlook how the different alternative sets are generated and evaluated. Hence, existing traditional modeling approaches have particular limitations with regard to interrelations between selection of feasible sets of alternatives and the optimization of the network. The multitude of interacting elements requires a modeling approach which allows analyzing all these different elements in single but interrelated views and thereby also at higher level of abstraction.

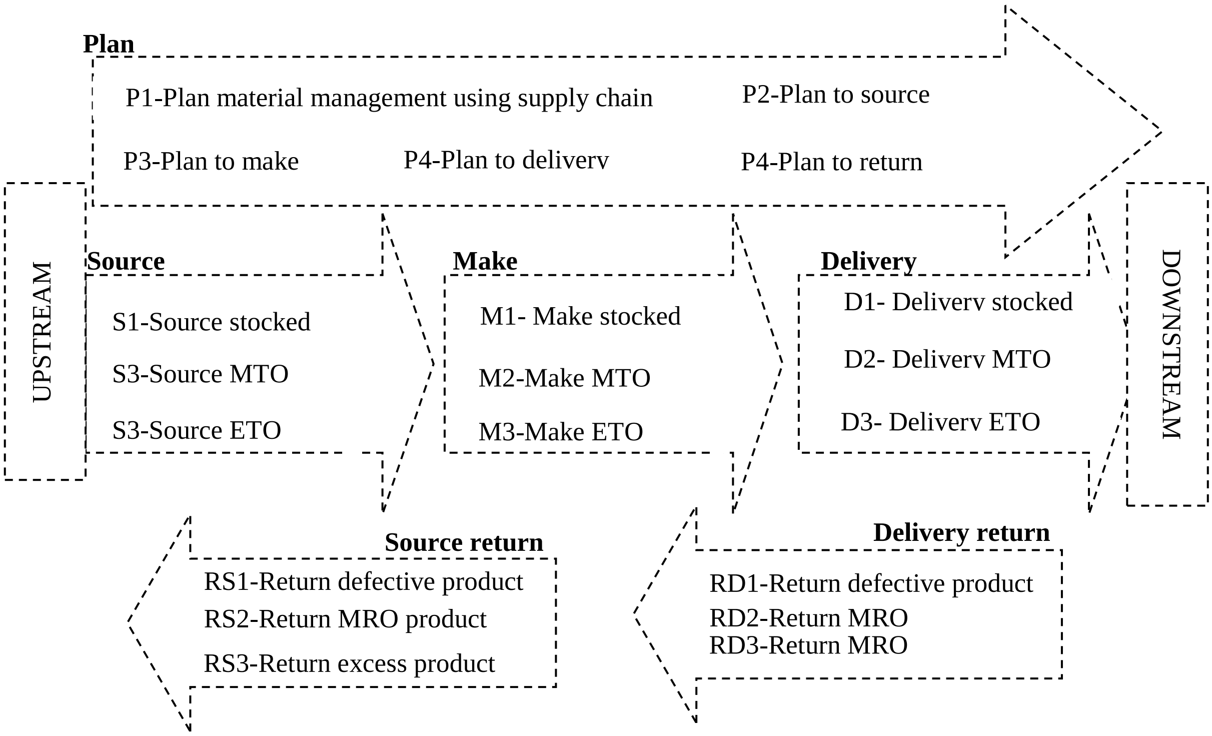
This paper aims to present an intuitionistic fuzzy Chouquet integral operator based approach to select the right partners and corresponding supply chain configuration. We believe this decision processing is absolutely a necessity before a full scale network optimization. In order to bring structure in the evaluation process, we employ the supply chain operations reference (SCOR) model developed by Supply Research Council. In second section we discuss the general similarities and differences of the value chain and the SCOR. Then in third section we present a methodology based on intuitionistic fuzzy Chouquet integral operator. In fourth a simple V-form supply chain example is used to establish the proposed approach. Finally, in fifth section, conclusion remarks are given.

SIMILARITIES AND DIFFERENCES BETWEEN VALUE CHAIN & SCOR MODEL

The basic motivation and the significance of building generic supply chain models have been to provide a language for communicating among supply-chain partners. Such a modeling approach was adopted by Supply-Chain Council -up and the model is known as the SCOR model (Supply Chain Operations Reference Model, see Figure 1)). The model is a way to see or map supply-chains, rather than an optimization tool [4].

Before making the comparison, here we will present briefly only the general processes: Plan(P)this activity covers processes to balance resource capacities with demand requirements and the communication of plans across the supply chain. Source (S) – this activity covers the identification and selection of suppliers, measurement of supplier performance as well as scheduling of their deliveries, receiving of products and processes to authorize payments. Make (M) – in the scope of make are processes that transform material, intermediates and products into their next stage, meeting planned and current demand. Deliver (D) – this activity covers processes like order reception, reservation of inventories, generating quotations, consolidation of orders, load building and generation of shipping documents and invoicing. Return (R) – this activity represents all return processes for returning defective or excess supply chain products, or return for recycling and disposal. For the sake of simplicity, in our example given later we do not include the "Return" activities.

These definitions constitute the first level of SCOR. SCOR defines five levels. The second level drills down each block by its characteristic. For example a level 2 process element S1 (Source 1) represents a Source stocked product. Thus it is a source process with the level 2 variant or the make to stock strategy. At this level three process-elements for each block are indicated in the Figure 1. Each process element has a set of inputs and outputs. SCOR presents the best practices at both level 2 and level 3. SCOR defines its scope only until level 3 processes. For implementation the model has to be taken further down into lower level of detail. The level 4 represents the tasks associated with a process element. The next level, level 5, includes all measures per activity. This level of detail is necessary for implementation purposes (see SCOR 8.0).



MTO: Make to order
ETO: Engineer to Order
MRO: Maintenance, Repair and Overhaul

FIGURE 1.
Supply Chain Operations Reference (SCOR) Model

TABLE 1.
Comparison of Value Chain with SCOR.

Normative Category	Normative Category
Procurement	Source – Plan
Human Resources	Plan*
Transportation	Deliver
Manufacturing	Make
Marketing & Sales	Plan *
Customer Service	None
Financing	None
Administration	None
None	Return

* Could be included in "Plan"

By describing supply chains using these five process building blocks, the SCOR model can describe a very simple or very complex supply chain. As a result, different entities can be linked to illustrate the depth and breadth of virtually any supply chain. The model provides a basis for supply chain improvement. To this end the Value Chain concepts meet most of the objectives of SCOR level 1 and level 2 – the idea of identifying the right partners with the right capabilities and competences to match the objective of the whole supply chain (right configuration) is basically similar to those of Value Chain. However, SCOR can be also used as a management mapping tool, while Value Chain is a concept and remains as such. SCOR model falls under the classification of normative models, where it provides standard definitions of measures and procedure. Despite this fact SCOR does not provide a computational tool in order to select and evaluate the right partners or evaluate the supply chain configuration. When comparing both conceptually we see certain elements missing under each item but similarities at the first two levels are high (see Table 1).

Our objective here is to go a step further and develop a complimentary concept and a tool that allows management to carry out an extensive aggregated analysis and decide the right potential combination of partners (entities) and define proper supply chain configuration (networks) for advanced optimization.

METHODOLOGY

In this study, a methodology based on intuituinistic fuzzy Chouquet integral operator is utilized. The methodology framework is presented in Figure 2. Detailed information on the generic steps of intuituinistic fuzzy Chouquet integral operator can be found in Tan and Chen [5].

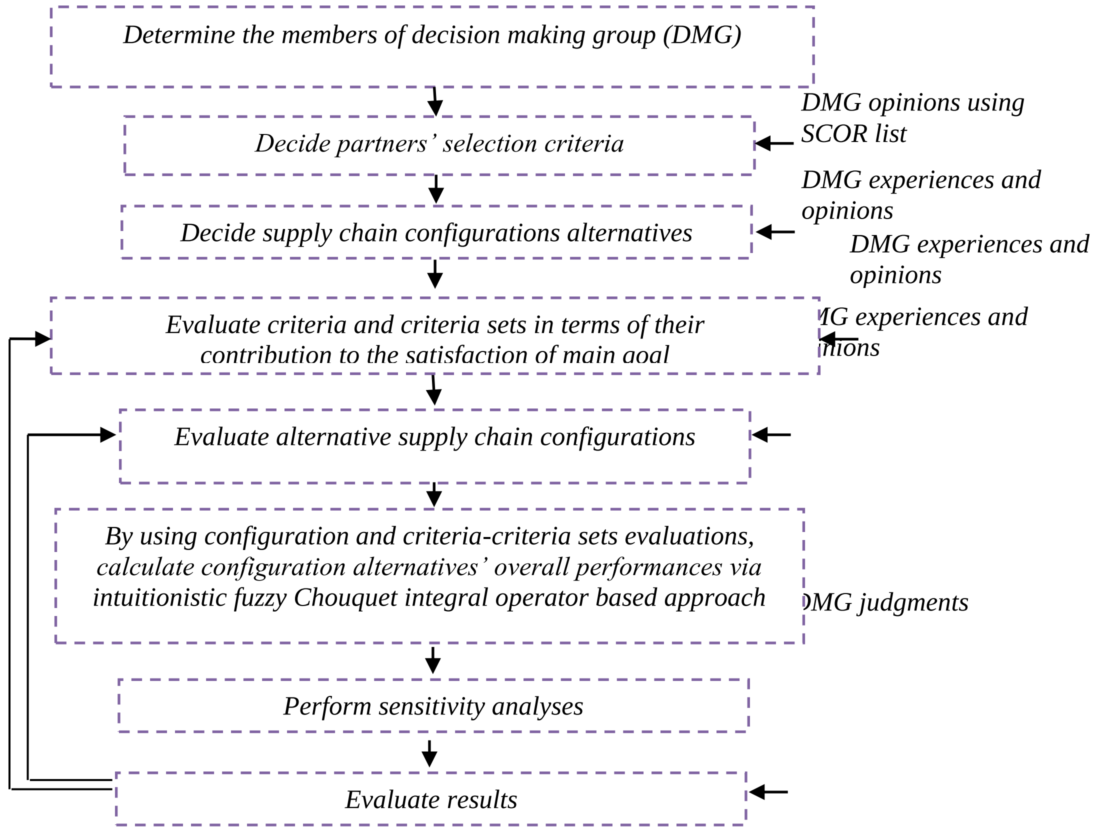


FIGURE 2.
The Methodology Framework.

THE MODELING PROCESS AND THE APPLICATION

To the best of our knowledge, there is no literature about combined use of SCOR modeling and the selection of partners in order to configure supply chain network. Considering the use of SCOR model, there is plenty of literature available [6]. Concerning the use of meta techniques like fuzzy sets, AHP, etc., we can refer to many studies but all are meant simply to rank choice of supplier and some of them are summarized as follows.

Xiao et al. [7] defined the concept of cycle quality chain management on improved SCOR model and they built up a model which realizes the cycle operation by an added quality process of reverse manufacturing. All the quality processes are connected by acceptable probability so the optimized objective function is described as a fuzzy multi-objective function in the study. Wang et al. [8] adopted supply chain operations reference (SCOR) model using level 1 performance metrics as their decision criteria. The authors employed an integrated AHP methodology and preemptive goal programming based multi-criteria decision making methodology. Ozgen et al. [9] proposed a two phase possibilistic linear programming methodology for multi-objective supplier evaluation and order allocation problem. In that study, they integrated sustainability point of view to SCOR level 1 performance metrics and proposed integration of AHP and multi-objective possibilistic linear programming technique. In another study, Rabelo et.al. [10] integrated the AHP, system dynamics, and discrete-event simulation to model the service and manufacturing activities of the supply chain of a corporation. They used SCOR model as a guide to develop discrete-event simulation model. In that study, managers evaluate the competing decision alternatives based on the obtained simulation results of the hybrid models and other qualitative factors using group AHP analysis. Tuzkaya et.al. [11] employed a multi-objective decision making methodology namely, Linear Physical Programming, for the selection of most suitable supplier(s) depending on their suitability rankings. They used the main criteria of SCOR model by embedding the sustainability criterion to the model for calculating the overall supply chain effectiveness but not the main feature for configuring the chain. Considering the related literature, contribution of our study is configuring the supply chain while selecting the partners by using SCOR as structuring reference model. Additional contribution is the computational framework proposed for evaluating of the alternative supply chain configurations using an intuitionistic fuzzy Chouquet integral operator based method.

Our modeling process consists of assemblage of independent firms that come together to meet the needs of specific customers or fast-changing market opportunities. The formation can last for a limited period or long-term. This type of supply chains usually contain many players (partners) and strive towards bringing a product to ultimate customers and work together through virtual setting, a virtual supply chain (V-SC) forming. The reasons for considering V-SC can be listed as; accelerating pace of business, short product life cycles, quick response to market opportunities, low cost of market entry, increasing mass customization demands and the pressure for globalization to remain competitive. In V-SC, there are fewer levels of bureaucracy and a modularized structure. All the partner companies are specialized in their core competencies and have improved the efficiency and effectiveness, reaching standards of their respective industry. Therefore, the partner companies can form more easily an effective chain; meeting adaptability, flexibility, agility, and speed requirements. Lifecycle of a V-SC is consists of four phases: identification, formation, operation and termination. Identification phase includes discovering the strong opportunities in the market, evaluating them and selecting the right one. Transforming this opportunity to reality strongly depends on the success of formation of the virtual supply chain. Determining the possible partners, evaluating these alternatives and choosing the suitable ones to form the supply chain are the stages of formation phase. In the operation phase, designing, marketing, financial management, manufacturing and distribution activities are realized. And this structure may be abandoned with the end of market opportunity. Operations are terminated and asset dispersions are started considering the accounting and legal issues. The phases of the organization-SC's life cycle can be seen in Figure 3.

Partners selection is placed in the formation phase of the life cycle of V-SC. Because of the advantages like using standard process, well-defined key performance indicators, and easy understanding, SCOR model approach is used to structure the selection of right partners in the chain. Each basic supply chain is a chain of source, make and deliver execution elements as explained in Section 2. Considering these core management processes, SCOR model entirely contains 19 process elements (Figure 1).

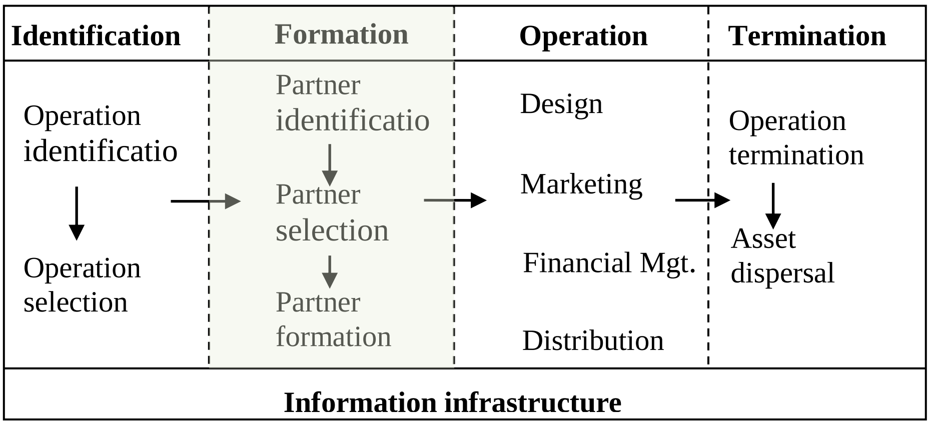


FIGURE 3.
Life cycle of a V organization

Considering the abovementioned explanations and the methodology (Figure 2), our application starts with constructing the DMG. In this study, a DMG constituted from decision makers (DMs) who are supply chain experts, like supply chain department managers and when necessary academic specialist in the field. After constructing the DMG, decision making criteria are established by conducting interviews with DMG and utilizing the concepts of second level of the SCOR model. In our case example, the authors and two company supply chain managers made the following choices as the main criteria:

- *Capacity (c1):*
  The maximum amount of the fulfilled demands of customers. This criterion depends on the weakest part of the supply chain. Production, warehousing and delivering capacities should be taken into account for this criterion.
- *Capability (c2):*
  The ability of the supply chain to perform planning, production, procurement, forecasting and customer management actions collectively.
- *Reliability (c3):*
  The accomplishing ability of fulfilling all requirements and demands of the customers in a stabilized and continuous way.
- *Flexibility (c4):*
  The ability of the supply chain on adapting the change in volume or type of customer demands. Also, dealing with the changes in seasonal or economical factors can be taken into account for this criterion.
- *Information infrastructure (c5):*
  The ability of the integration of processes through the supply chain to share valuable information.
- *Global marketing (c6):*
  The ability of the supply chain for entering to the global market for marketing on a worldwide scale.

Following the criteria determination phase, alternative configurations are determined with the help of DMG. The best V-SC design is configured with the different partners among the alternatives considering the SCOR model's process elements (Figure 1) using the methodology discussed earlier. In the case study, the constraints on inclusion of firms to form a new V-SC are such that four mutually exclusive alternative designs are feasible:

- Configuration 1 (a1): S11-M12-D12-M22-C
- Configuration 2 (a2): S11-M12-D13-M21-C
- Configuration 3 (a3): S11&S12-M11-M21-C
- Configuration 4 (a4): S12&S13-M11-D12-C

These alternatives consists of three Sources Elements (supplier firms) (S11, S12,S13), four Make Elements (two make to stock manufacturing firms,M11, M12), (two assembly to order firms, M21, M22), and three Deliver Elements (distribution firms, D11, D12, D13), have been identified for possible inclusion in alternative supply chain designs to meet the market demands of customers, C. For example in configuration 1, S11 stands for source stock process (S1) and partner 1 as alternative to source from, M12 stands make stocked (M1) process and potential partner manufacturer 2. The remaining reads in the same way. Finally C indicates the ultimate customer.

In the next stage of the application, DMG evaluates the criteria and criteria sets correlations, considering their contribution to the main goal. According to the DMG judgments fuzzy measures of each criterion and criteria sets as are determined.

After the criteria and criteria sets fuzzy measures' determination phase, DMG is asked for the evaluation of configuration alternatives for selected criteria (Table 3). In this evaluation, DMG evaluates the alternatives linguistically for the criteria with the "strong for criteria", "weak for criteria" and "no judgment for the criteria" options. For example, if a3's evaluations for c5 is considered and seven DMs think, it is strong for this criteria, two DMs think, it is weak for this criteria and one of the

DMs does not have a judgment, the IFV for this evaluation can be obtained as (0.7, 0.2), (Step 2 for the intuitionistic fuzzy Chouquet integral operator based methodology-[5]):

TABLE 3.
Intuitionistic fuzzy decision matrix for partners' alternatives

	a1	a2	a3	a4
c1	(0.5,0.2)	(0.5,0.2)	(0.5,0.4)	(0.9,0.1)
c2	(0.5,0.3)	(0.5,0.1)	(0.6,0.2)	(0.5,0.2)
c3	(0.9,0.1)	(0.8,0.2)	(0.7,0.1)	(0.5,0.4)
c4	(0.6,0.3)	(0.6,0.1)	(0.8,0.2)	(0.5,0.1)
c5	(0.5,0.1)	(0.7,0.1)	(0.7,0.2)	(0.7,0.3)
c6	(0.8,0.1)	(0.7,0.3)	(0.5,0.3)	(0.6,0.4)

Utilizing the methodology of Tan and Chen [5], for ordering the supplier evaluations score and accuracy values of supplier evaluations are calculated and configuration evaluations in ascending order are obtained as in Table 4.

TABLE 4.
Configuration evaluations in ascending order

	a_1		a_2		a_3		a_4
$\alpha_{a1}(x_{\sigma(1)})$	(0.5,0.3)	$\alpha_{a2}(x_{\sigma(1)})$	(0.5,0.2)	$\alpha_{a3}(x_{\sigma(1)})$	(0.5,0.4)	$\alpha_{a4}(x_{\sigma(1)})$	(0.5,0.4)
$\alpha_{a1}(x_{\sigma(2)})$	(0.5,0.2)	$\alpha_{a2}(x_{\sigma(2)})$	(0.5,0.1)	$\alpha_{a3}(x_{\sigma(2)})$	(0.5,0.3)	$\alpha_{a4}(x_{\sigma(2)})$	(0.6,0.4)
$\alpha_{a1}(x_{\sigma(3)})$	(0.6,0.3)	$\alpha_{a2}(x_{\sigma(3)})$	(0.7,0.3)	$\alpha_{a3}(x_{\sigma(3)})$	(0.6,0.2)	$\alpha_{a4}(x_{\sigma(3)})$	(0.5,0.2)
$\alpha_{a1}(x_{\sigma(4)})$	(0.5,0.1)	$\alpha_{a2}(x_{\sigma(4)})$	(0.6,0.1)	$\alpha_{a3}(x_{\sigma(4)})$	(0.7,0.2)	$\alpha_{a4}(x_{\sigma(4)})$	(0.5,0.1)
$\alpha_{a1}(x_{\sigma(5)})$	(0.8,0.1)	$\alpha_{a2}(x_{\sigma(5)})$	(0.7,0.1)	$\alpha_{a3}(x_{\sigma(5)})$	(0.7,0.1)	$\alpha_{a4}(x_{\sigma(5)})$	(0.7,0.3)
$\alpha_{a1}(x_{\sigma(6)})$	(0.9,0.1)	$\alpha_{a2}(x_{\sigma(6)})$	(0.8,0.2)	$\alpha_{a3}(x_{\sigma(6)})$	(0.8,0.2)	$\alpha_{a4}(x_{\sigma(6)})$	(0.9,0.1)

Criteria weights, configuration alternatives' evaluations, and ordered configuration evaluations are used and integrated configuration evaluations are obtained via intuitionistic fuzzy Chouquet integral operator given in Step 4 of the intuitionistic fuzzy Chouquet integral operator based methodology (Tan and Chen, 2010). Results are obtained as (0.71, 0.17), (0.75, 0.09) (0.70, 0.18), (0.74, 0.16), for a1, a2, a3, and a4 respectively. Obtained integrated evaluations are ordered using the rule in Step 3 and the final order from best to the worst configuration alternative is as follows: a2, a4, a1, and a3 (Step 5 for the intuitionistic fuzzy Chouquet integral operator based methodology- Tan and Chen [5]).

The best to the worst configurations are ordered as: a2, a4, a1, and a3. Although, a2 is found as the best configuration alternative, a4 has very close evaluation results with it in terms of membership degrees. However, in non-membership degrees, there is not an ignorable difference. This means that the number of members in DMG who think positive for a2 and a4 are almost equal, however, the negative evaluations for a4 is more than a2. On the other hand, a2 has the best evaluation value for only c5 which has the weight of 0.2. Also, for c1 and c2, a2 configuration's evaluations are about the average considering the other alternatives; and for c3, c4 and c6, its evaluations are above average. It should be also noted that, importance degrees coming from satisfying certain criteria sets together has also affect on the results. For example, satisfying criteria set c3-c4-c5-c6 together has more importance than satisfying criteria set c2-c4-c5-c6 together and a2 has better evaluation results considering the first criteria set. Additionally, some sensitivity analyses are conducted to show the changes in the evaluations with the changes in the criteria weights. Considering the sensitivity analyses results, supplier evaluation orders are sensitive to the change in the criteria weights. After the analyses of the configurations, results are presented to DMG and DMG found the selected configuration is proper to company objectives.

CONCLUSIONS

In this study, partners selection and supply chain configuration problem which is an important issue in supply chain strategic design is investigated. In order to bring structure in the evaluation process, we implement the supply chain operations reference (SCOR) model. The unique feature of our approach is that partners selection for certain supply needs are not evaluated in isolation, but supply chain configuration is also investigated. Considering the difficulties for obtaining criteria evaluations in a numerical way, DMs are asked to evaluate them linguistically. Additionally, vagueness in the evaluation environment is taken into account using fuzzy intuitionistic Chouquet integral operator. By doing so, instead of taking certain evaluation judgments, calculations starts from firstly linguistic judgments and then continue with membership and non-membership degrees of satisfaction. The approach considers different importance levels coming from satisfaction of different criteria sets. As a future research direction, the number of evaluated configurations can be increased with a more comprehensive investigation. Additionally, criteria and criteria sets' importance levels on the achievement of main goal can be calculated with an integrated MCDM technique, like as ANP, AHP, etc. Future research may include financial aspect of supply chain formation, like costs and revenues.

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CITY LOGISTICS VERSUS QUALITY OF LIFE IN THE AREA OF PUBLIC TRANSPORT AFTER AN EXAMPLE OF A MEDIUM SIZED CITY[1]

Maja Kiba-Janiak[2], Katarzyna Cheba[3]

Abstract ***—*** *The objective of this paper is to present mutual dependencies between city logistics and quality of life. On account of the limited paper length, the authors have focused on city public transport. The task assigned to city logistics as regards public transport is to find such solutions which to a considerable extent will improve the comfort and easiness of movement of people across cities. This paper represents results of a research into the impact of selected aspects of city logistics narrowed down to public transport on quality of life of middle sized city dwellers – in this case of Gorzów Wielkopolski, a town in the west of Poland. The article is based on an empirical study. It presents the results of quantitative research based on a questionnaire survey. The authors used the method of deductive reasoning.*

Keywords: city logistics, urban logistic system, collective transport, quality of life

INTRODUCTION

The issue of quality of life has been bothering researchers for years. Quality of life in many criteria is seen as is affected by a number of factors, material and immaterial, such as satisfaction with spiritual and aesthetic needs. A statement might be ventured that quality of life increases along with Maslow's pyramid successive needs satisfied.

Quality of life is affected by many aspects connected with a sense of safety, health care, access to education, culture, social wealth or movement of dwellers of urban agglomerations which are getting more and more congested.

Rapid and efficient transit across a city and adjacent suburban spheres is taking on even more importance for city dwellers – especially for those living in medium and large sized centres [1]. The historical sources reveal that even ancient townsfolk would be affected by traffic jams caused by running chariots, horse pulled rigs or the very pedestrians. The invention of the car and motorways gave a new dimension to the old lived pest. A good deal of tools have been formulated to tackle the issue quantitatively or statistically [2], [3]. Regrettably, even today many a town grapples with too heavy congestion on the road. Looking for solution for issues diagnosed in this way belongs with city logistics, which is playing more and more pivotal role in the way passenger and goods flows are handled across the city.

The present paper shows a certain aspect of city logistics, namely that of collective city transport (a system of means of transport providing services to many people), and its impact on quality of life of inhabitants. Collective transport in many towns does not meet their dwellers' expectations as regards quality of services. Stops are frequently spaced by more than 300 metres, various means of transport (tram and bus) are not connected, while in rush hours passengers have to travel on congested vehicles. All such impediments discourage many city dwellers from using public transport. On the other hand municipal transport companies begin to perceive passengers as their customers who have to be cared of and who exact certain flexibility.

The Gorzów Wielkopolski Municipal Transport Company (MZK) is one of such establishments that since 2003 has regularly been surveying its passengers. The surveys are to evaluate the services

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provided by MZK and make the basis for decisions that will improve the quality of the services provided by the company, and further on improving the quality of life of the inhabitants.

CITY LOGISTICS VERSUS QUALITY OF LIFE

Despite the fact that quality of life excites more interest in various social groups, the terminology used still needs sorting out, which to a large extent hampers index quantification in empirical research. Apart from the term of quality of life, generally other terms are used too: living conditions, standard of living, life style or ways of living [4].

There are many terms defining quality of life and each of them points at factors that a particular researcher sees important. Campbell is of an opinion that quality of life can be described by definite criterion which is uniform for the whole set of criteria, such as family life, occupation, material and occupational status, health, neighbours, friends, children, level of activity, etc. [5].

Flanagan is of a similar opinion, yet he believes that for individuals various spheres of life will have different weights [5]. And thus, for some the priority is their family, while for others the priority is given to safety or occupation.

R. Kolman gives a number of definitions of quality of life:

- ‘degree of satisfaction with man’s spiritual and material needs;
- the degree of satisfaction with needs determining the level of material and spiritual lives of individuals and whole society;
- the degree to which conventionally expected normality is met in activities and everyday situations of individuals and society’[6].

A. Zaliś differentiates between standard of living and quality of living. According to him **standard of living** finds its expression in the quantity of goods, services and aids (such as clothing, food, education, health, sense of safety) that a full and respectful life requires, while **quality of life** is made up from feelings, emotions, in other words in the degree of satisfaction of the standard of living. Quality of life is most often described in terms of quality, while standard of living by means of quantity [7].

Presently one of the most significant factors affecting style of living and ways of living is time. It is a criterion underlying many decisions made by city dwellers – for instance a choice of an adequate means of transport to get to the destination as soon as possible. This issue relates to city logistics [8].

City logistics has been playing a more and more important role in many cities in the world. Recently the number of passenger cars has increased significantly, which in turn made problems with moving people and freight across the city become more pronounced.

According to the Council of Logistics Management ‘city logistics may be defined as a process of planning, performing and checking of flows:

- initiated outside and directed citywise;
- initiated internally and directed outside city;
- passing the city;
- as well as internal flows and accompanying information flows with meeting needs by city agglomerations in view as regards quality of economy, life and development’ [9].

According to Krawczyk ‘city logistics means planning, coordination and controlling of logistic processes over urban areas. The specific quality of city logistics is that the goals set up by players taking part in the processes and the manner in which the process is effected have to account for operating, market, infrastructural and legal requirements and limitations posed by the city environment, inclusive of the city as a collective unit’ [10].

Therefore, in the opinion of the present authors, city logistics focuses first and most of all on planning, coordinating and controlling of processes talking place within the boundary of a given urban area an related to physical movement of goods (raw materials, semi-products, goods and waste, etc.) and people and related information in a manner that will optimise costs, congestion and improving quality of life.

The goal for city logistics will therefore be optimisation of the city’s logistics system, which is composed of the following functional subsystems [11]:

1. transport of both material goods and provision of utilities;
2. transport and storage of municipal waste;
3. collective and individual transport;

4. storage of material goods and industrial and commercial zones and in city's commercial chains;
5. controlling flows of material goods and humans.

Therefore, it can be taken for granted that the city's logistics system is an organised and coordinated flow of material goods, utilities, human resources and related information within a given urban agglomeration in such a manner that will optimise costs and satisfying needs of dwellers as regards quality of life and management of material resources.

A city analysis requires that integration of spatial planning, transport and functional location should be accounted for. These requirements met will allow for an economic development, environmental abilities and coexistence as well as securing social provisions for urban dwellers [12].

Currently, more and more people are migrating from town to the adjacent countryside. Therefore, it is important that the city logistic system be seen with the so called Larger Urban Zones (LUZs) (see Fig. 1).

LUZs in the case of towns with the population between 100 and up to 250 thousand are rural municipalities bordering directly on the city limits. LUZs were defined by the Chief Statistical Office on the basis of NTS 4 (Nomenclature of Territorial Units for Statistics (NUTS) is in force in EU member states where NTS 4 stand for districts or boroughs) [13].

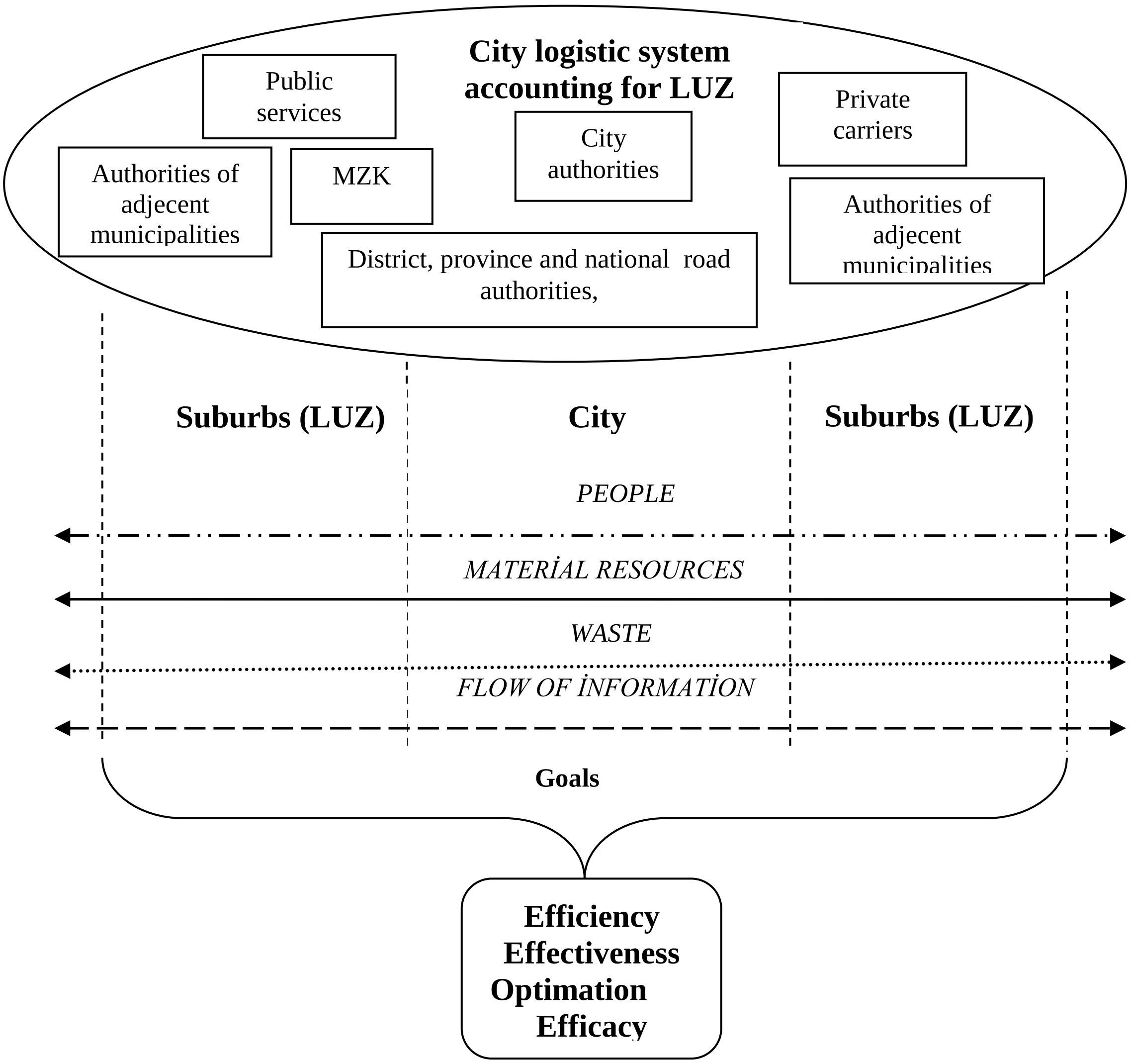

FIGURE. 1
City logistics system accounting for LUZs

The definitions given above make it obvious that one of the principal goals of city logistics is meeting needs of urban dwellers as regards quality of life. On the other hand an increase in quality of life contributes inter alia to a growth in individual means of transport, and this in turn leads to more congested towns for vehicular transport, which again in turn leads to a reduced quality of life.

EVALUATION OF QUALITY OF LIFE OF DWELLERS OF GORZÓW WIELKOPOLSKI IN THE AREA OF PUBLIC TRANSPORT

Gorzów Wielkopolski is a town located in the western part of Poland, in the province of Lubuskie. This makes the location quite attractive on account of the fact that the Polish-German border is very close, and hence the capital of that state Berlin is too. The population of Gorzów Wielkopolski is 125 157 [14].

City transport is managed by bus and tram services in Gorzów Wielkopolski. As the statistical data [15] show since 2005 there has been no increase in the length of bus or tram routes; while over the same period the province of Lubuskie has increased the bus routes by more than 130 km. The total length of the city routes as per 1000 inhabitants is 742 metres while in Poland the average route length is 825 metres.

Passenger transport collectively in Gorzów Wielkopolski shows a sizeable drop in the number of passengers serviced. The number of people using public transport has dropped between 2003 and 2008 by 16.73%. The sharpest drop took place in 2005 when the number of passengers decreased as compared to the previous year by about 8%, in the years to follow the drop stayed at the level of about 3% [16].

The unquestionable impact on the number of passengers in the collective transport has been exerted by the dynamic increase in the number of individually owned passenger cars. Over the 2003-2008 period the index of individual motorisation rose by about 47% at a simultaneous drop in the number of passengers publicly serviced by some 17%. The reciprocal relation between the motorised index and the number of passengers is shown in Figure 2.

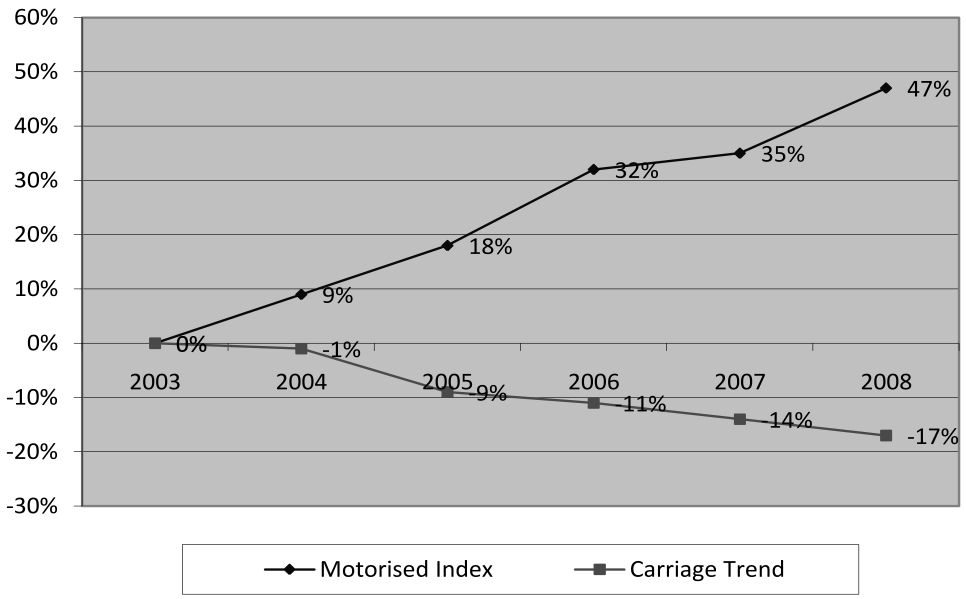

FIGURE. 2
Dynamics of passengers serviced and motorised index between 2003 and 2008 [16]

The causes of the decreased demand for municipal transport services can also be seen in a drop of dweller mobility who now may enjoy a developed commercial infrastructure in the largest town districts; to do shopping they don't have to go far.

Another factor which has an impact on the number of passengers is most likely a drop in birth rate, which in the school year 2008 and 2009 caused an estimated 6.5% drop in the primary and secondary school students [16].

No less significant is migration of Gorzów Wielkopolski dwellers. The balance has been negative for a few years running, and since 2004 has been around -250 persons. To a certain extent this has been the outcome of the fact that quite a few of them have moved to neighbouring rural municipalities (the so called LUUs zones). These people as a rule do not use public transport.

The quality of the services provided by the Gorzów Wielkopolski based MZK company has a marked impact on the number of passengers. One of the methods to measure quality of services is index reliability assessment: dependent and independent of the carrier. In 2008 the bus and tram services showed an increase in the performed reliability indices and in the case of the reliability of passenger tram services it was 99.52% for the independent index, and 99.79% for the dependent one [16].

The fact that so high indices were attained means that for 10,000 planned tram runs caused by the carrier's faults (breakdowns, traffic events) 21 runs were not performed, while the number of failed runs independent of the carrier (blocked trackways, demonstrations, traffic events with no public transport vehicle involved) counted 48.

The consequences of this short come in the performance of full service or an improper quality of services, caused by such factors like punctuality, regularity, rolling stock and stops kept tidy and clean, were reduced subsidies granted by the Town Office.

The Municipal Transport Company, seeing a drop in the number of passengers served as well as the requirements set forth by the Town Office as regards the quality of services, went about marketing surveys to find out opinions their passengers had about the transport services. The pollees has an opportunity to present their expectations and the quality of the services provided by the carrier.

Customer satisfaction surveys have been carried out since the Gorzów Wielkopolski Municipal Transport Company was awarded an ISO 9001:200 Quality Management Certificate, that is since 2003.

In 2008 the sample pool had a character of a selection of quota to stratum in accordance with the following criterion [16]:

- gender (male, female);
- age (up to 18, 18-25, 26-50, 51-60 and 60 plus);
- occupational status (students, employed, unemployed, OAPs);

The sample counted 207 people.

Among the surveyed the most numerous group was represented by the employed (42.88%), then OAPs – 18.88%, students – 14.88%, unemployed 12.32% and primary and secondary school students – 11.04% [3].

While surveyed the respondents were asked to give their preferences and rank to 12 qualities as offered by the municipal transport services, and then to asses them. The respondents gave their expectations from the city transport system and assessed its quality using a simple five point scale (5 – very good, 1 – poor) [10]. The survey results (Table 1) show that in 2008 the passengers showed punctuality as the most required quality (4.59), to be followed by safety (4.50), frequency of runs (4.49) and availability of public transport (4.46). The least preferred qualities were: fare price (3.79), ability to voice their opinions on the transport system (4.12) and conditions in which they lined at stops (4.37).

The highest scores were given to such qualities as: timetables legible and easy to read out (3.80), punctuality of runs (3.73) and information placed on stops, inside and on the outside of vehicles (3.71). The lowest scores were assigned to fare price (3.13), ability to voice their opinions on the transport system (3.23) and journey conditions (3.30). The average assessment of the quality of services equalled 3.50 and was lower than the 2007 surveys (4.08), but is comparable to the average scores of 2003 (3.53), 2004 (3.50), 2005 (3.63) and 2006 (3.52) [16].

TABLE 1
Average preference scores for individual qualities of services provided by the municipal transport system in Gorzów Wielkopolski in 2008 and their ranks [16]

Pos.	Quality	Passenger preferences	Quality rank
1.	Punctuality of runs	4.59	1
2.	Frequency of runs	4.49	3
3.	Ride safety	4.50	2
4.	Conditions inside a vehicle	4.44	6
5.	Waiting conditions at stops	4.37	10
6.	Availability of municipal transport	4.46	4
7.	Fare	3.97	12
8.	Direct connections	4.44	7
9.	Driver manners	4.44	5
10.	Information (stops, inside and on the outside of vehicles)	4.40	9
11.	Legible and easy to remember timetables	4.43	8
12.	Ability to voice opinions on services	4.12	11

In the other part of the questionnaire the respondents assessed the level of quality of the services provided and voiced their satisfaction with services provided by the Gorzów Wielkopolski Municipal Transport Company. The results are shown in Table 2.

TABLE 2
Average assessments for individual qualities of services provided by the municipal transport system in Gorzów Wielkopolski in 2008 [16]

Pos.	Quality	Passenger preferences	Quality rank
1.	Punctuality of runs	3,73	2
2.	Frequency of runs	3,41	8
3.	Ride safety	3,60	5
4.	Conditions inside a vehicle	3,30	10
5.	Waiting conditions at stops	3,37	9
6.	Availability of municipal transport	3,68	4
7.	Fare	3,13	12
8.	Direct connections	3,50	7
9.	Driver manners	3,51	6
10.	Information (stops, inside and on the outside of vehicles)	3,71	3
11.	Legible and easy to remember timetables	3,80	1
12.	Ability to voice opinions on services	3,23	11

The survey MZK carried out to find preferences and customer satisfaction allowed them to assess relative and absolute quality gaps (Table 3). A relative quality gap is calculated as a remainder of real preferences and assessments as given by the respondents, whereas an absolute gap is a remainder of maximal possible and ideal expectations from a given service and real assessments as given by the respondents.

As the Table shows the widest relative gaps showed up in conditions in vehicles, frequency of runs and waiting conditions at stops. Amongst the widest absolute quality gaps were apart from those already indicated fare prices and possibility to voice opinions on public transport [16].

TABLE 3
Average assessments and preferences for individual qualities of services on a 1 to 5 scale [16]

Pos.	Quality	Maximal preferences	Passenger preferences	Passenger assessment	Relative quality gap	Absolute quality gap
1.	Punctuality of runs	5.00	4.59	3.73	0.85	1.27
2.	Frequency of runs	5.00	4.49	3.41	1.08	1.59
3.	Ride safety	5.00	4.50	3.60	0.90	1.40
4.	Conditions inside a vehicle	5.00	4.44	3.30	1.14	1.70
5.	Waiting conditions at stops	5.00	4.37	3.37	1.00	1.63
6.	Availability of municipal transport	5.00	4.46	3.68	0.79	1.32
7.	Fare	5.00	3.97	3.13	0.83	1.87
8.	Direct connections	5.00	4.44	3.50	0.94	1.50
9.	Driver manners	5.00	4.44	3.51	0.93	1.49
10.	Information (stops, inside and on the outside of vehicles)	5.00	4.40	3.71	0.69	1.29
11.	Legible and easy to remember timetables	5.00	4.43	3.80	0.63	1.20
12.	Ability to voice opinions on services	5.00	4.12	3.23	0.89	1.77

Another important aspect covered by the research demanded that the degree of passenger satisfaction with the public transport system in Gorzów Wielkopolski be determined. The result obtained for the sampled pool is an averaged weighted of assessments and batch size (*i.e.* assessment × the number of into the number of subjects surveyed).

On the basis of the obtained results the degree of passenger satisfaction may be assumed to be high as it was at 66.58% in 2008 in Gorzów Wielkopolski. While the largest number of responses, that is 64.96%, was placed within the 60-80% bracket, while the largest percentage of respondents (25.12%) declared their satisfaction at 70% [16].

Another criterion that might have impact on the degree of passenger satisfaction with public transport is the number of claims they lodged and the manner in which the claims were processed. In 2008 71 claims were lodged in Gorzów Wielkopolski, out of which the Transport Company found 29 to be well grounded, while as many as 42 were rejected as unfounded [16].

Of the total of claims 73.35% concerned the relationships between driver and passenger, out of which as few as 38.46% were found well grounded. Passengers complained about conditions in public transport vehicles (15.49%), especially they spoke out strongly against overcrowded vehicles at rush hours [16].

In 2008 public transport passengers lodged 21 complaints, with 14 given appositive response by the company. The largest number of complaints (more than 33.33%) concerned changes in timetables and new services running (28.57%).

As a result of the survey MZK of Gorzów Wielkopolski undertook a series of measures to step up quality of life, embracing inter alia four additional bus runs, and changed three bus routes allowing people to get their workplaces in TPV LCD Monitor Company.

Furthermore, a new night bus service was opened allowing supermarket and commerce centre staff to return home [17].

SUMMARY

City logistics is indispensably connected with quality of life of city dwellers. On the one hand it can be said that an effective organisation of human and freight movement within the city limits has an influence on societal quality of life. On the other hand, however, it might be claimed that it is the quality of dwellers' lives that affects logistics. A rise in general wealth, closely followed up by a rise in individual transport in town causes more and more aggravated problems resulting for instance from congestion. It could be relieved by granting public transport vehicles a status of privileged vehicles, by setting up transmitters on vehicles which would control traffic lights or by providing additional bus lanes.

It is more than half of Gorzów Wielkopolski population that uses individual means of transport, and, as the results of the survey indicate this tendency will be rising in the years to come. Public transport is used mostly by students and OAPs that is people of low income or no income at all. The problems that a majority of passengers will complain about is conditions in which they are made to ride, harsh external conditions while queuing at stops and fare prices.

Among favourable factors that may encourage people to use public transport are: making rides on public transport vehicles attractive, stepping up the competitive edge that public transport may have as compared to individual solutions and reducing fare prices.

An efficient functioning of city logistics requires that not only the establishments serving town transport are involved, but foremost is would be the town authorities – a local government responsible for managing the town; institutions, which are in charge of district, province and national roads, and also establishments located within the town limits and residents themselves.

A referential model of city logistics could provide a solution facilitating an efficient movement of humans and freight across the city. Such a model will account for real flows and control and cooperation. A referential model should visualise organisational and functional relations between the entities in charge of city logistics and traffic participants. The essence of that model will be improving city logistics in Gorzów Wielkopolski so that the quality of life and living standard of Gorzów Wielkopolski dwellers are taken into consideration.

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SOLVING DELIVERY TRAFFIC PROBLEMS IN CITIES THROUGH THE CO-OPERATION OF LOGISTICS SERVICE PROVIDERS. THE CASE OF POZNAŃ, POLAND

Maciej Szymczak[1]

Abstract — *Delivery transport predominates in the entire urban cargo traffic. Cargo traffic in cities poses a number of problems and it is growing fast. In order to provide higher living standards in the city we should decrease cargo flows, and therefore reduce exhaust emissions and noise levels, and increase safety on the roads. This can be achieved by the restriction of the number of cargo trips. Transport companies implement co-operative projects with a view to reducing operation costs and improve their economic standing. This limits congestion in city streets, and also contributes to the reduction of operating costs in those companies, demonstrates the benefits of co-operation and promotes its development. We can observe numerous examples of such co-operation worldwide. In this paper results of two complementary surveys on delivery traffic and co-operation between various logistics service providers in Poznań, Poland are described to find if implementation of the above-mentioned co-operation programmes is really feasible under Polish conditions. Both were initiated and conducted by a team headed by the author.*

Keywords — *city logistics, delivery traffic, road cargo traffic*

INTRODUCTION

Freight transport in the city is connected with the functioning of businesses and institutions located on its premises[2]. The supply for industrial, trade and service providing enterprises generates the largest share of this freight. Additionally there is the supply of institutions and offices with equipment and office supplies and foodstuffs. However, the transportation as a function of distribution, initiated by those entities cannot be ignored. The rest of the freight in the city is not linked to the functioning of organizations located in its territory, because the point of loading and the receiving point are located outside the city. These are transit transportations. The observations confirm that 80% of all supply transport implemented within the city limits constitutes road transport [1]. Cars supplying urban retail outlets, service points and industrial plants account for about 10 – 17% of all traffic in the city [2], and the transport of supplies dominates throughout the freight traffic in the cities. Despite this small-scale freight, the transport in urban areas raises many problems, and additionally this traffic grows the fastest. The problems of urban freight transport in particular concern four issues [3]:

- the difficulties in the supply of goods to their places of destination,
- the impact on the environment,
- safety and traffic flow on roads,
- the impact on the image of the city, life and economic functions.

These problems can be solved in different ways:

- through the reconstruction of transport infrastructure,
- by changing the organization of traffic,
- through the use of ecological vehicles,
- by introducing new forms of freight transport, also based on the present ones, such as cargo tram [4] or capsule pipelines [5],

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[2] I disregard here the freight for the residents of buildings, such as the transport of furniture during removal or delivery for home of the goods purchased a shop.

- administratively by introducing a total ban on traffic, a ban on traffic of vehicles with a given total weight or a given axle load,
- by night deliveries.

The result should be the reduction of freight flows, thereby reducing the exhaust of fumes and the emission of noise, improving road safety and consequently improving the quality of life and the economy in the city. The problem is that the use of any of the methods is either impossible in specific urban conditions, or extremely costly, or real only in the long term, and the problems of freight transport in urban areas are extremely urgent and require immediate action.

THE CO-OPERATION OF THE LOGISTICS SERVICE PROVIDERS

Retail outlets, restaurants, institutions and companies have different transportation needs. Small shops prefer frequent and small deliveries. Large multi-retail outlets and department stores need both large and frequent supplies. These institutions are supplied with a wide range of products, requiring different conditions of carriage, which further increases their need for transportation: food is supplied separately, household chemicals separately, separately clothing, separately electronic home appliances and radio and TV. All retailers are interested in regular deliveries. The same applies to catering companies. Restaurants, bars and cafes must have fresh products, and therefore require frequent, small and very regular supplies. Industrial enterprises receiving large supplies are also interested in having these supplies frequently and regularly. Today, no industrial customer is interested in maintaining a surplus stock, so deliveries are more frequent than before.

The increasing level of integration of modern supply chains and networks served by the dynamic development of exchange information technology lets these structures operate with minimal inventory.

Lean and flexible logistics systems, in which such strategies are implemented as just-in-time, quick response and Efficient Consumer Response (ECR) bring companies considerable benefits in terms of reducing costs and are becoming extremely popular in many sectors of the economy. Unfortunately, these systems require constant restock – a very frequent one and consecutively repeated. This implies a significant increase in the number of the logistic services provided. Taking this into account it should be noted that the current trends in business logistics are not conducive to alleviating urban transport infrastructure in the field of freight.

Transportation is usually not implemented in these entities with their own means as they take advantage of the extensive service offer of logistics service providers and courier, express and parcel service providers (CEP). These service providers serving many customers are able to combine shipments and reduce empty runs as well as a fuller utilization of vehicles, leading to a reduction in freight flows. There are no such possibility, for example, in servicing small cargo carried out on behalf of individual clients in the form of so-called cargo taxi (luggage taxi). As a result of a more attractive offer (also for an individual customer) of the CEP service providers this form of transport is currently in decline. For example, the number of cargo taxis in Poznań fell from 426 cars in 2002 to just 13 in 2005 [6]. Therefore, the managing entities having a dilemma concerning make or buy in the sphere of transport service, determine the size of the urban freight traffic, and the buy decision creates good conditions for its limitation. In this case, it can be shown that the present tendencies of business logistics create possibilities of relieving urban transport infrastructure.

Competing transport companies carry out co-operative projects to reduce operating costs and improve their economic situation (co-opetition). Combining the resources of different carriers results in an even greater degree of use of the stock, reducing empty runs, increasing customer service levels, or even decides about the possibility of servicing some orders. Such supply systems are designed to maximize the use of the stock, and to make the supply process involve less vehicles and less chaotic. This reduces the cargo traffic and its burden to the city, the congestion on city streets is limited, waiting time in front of the ramp in transportation hub and distribution centres is reduced, and this additionally affects the cost reduction of activities in these companies, convinces about the rightness of co-operation and leads to its development. Numerous examples of such co-operation come from Germany [7]. The most spectacular co-operative project of this kind so far is – also German – ISOLDE project implemented in Nuremberg [8]. Its essence is the use of local, inner-city logistics centres in the supply of small traders and service points. Similarly as on a completely different scale large retail chains are serviced. This service model is being strongly promoted in Europe, where the logistics centres become the most important hubs in the logistics systems of individual countries and regions. A lot of the concept of local urban logistics centers (there called Urban Consolidation Centres) has been devoted to the project Best Urban Freight Solutions (BESTUFS) financed by the European Commission and implemented in 2000-2008 [9].

One of the basic requirements of logistics centres today is to create favourable conditions for business co-operation. The concentration of the transport and logistics services and the CEP service providers who settled there serves occasional contacts and exchange of views, allowing to identify similar problems. Thus, after an economic assessment it is easy to start joint action that will bring benefit both for them and for the city. Specifically it is related to the consolidation of deliveries and transit routes leading to the reduction in the number of freight transits. It turns out that even relatively small reductions in this area with a huge number of transits undertaken daily in the metropolitan agglomeration result in a significant reduction of emissions [10]. Such efforts are also undertaken, among others, by Berlin, Copenhagen and Bangkok. In Berlin, on the basis of public-private partnership, the 'Goods Traffic Platform' was organized, under which the principles of reducing the number of deliveries were established, the designation of parking places for unloading, and the rebuilding of some intersections [11]. In the medieval centre of Copenhagen, the program was launched entitled the 'City Goods Ordinance', which aimed to limit the entry of trucks and vans through the better use of cargo space. The access to the historic part of Copenhagen has been restricted – there are certificates issued authorizing the entrance to this part of the city [12]. In the heart of Bangkok a network of public trans-shipment terminals was created and a ban on traffic of large trucks was introduced. This limited the number of destinations for these vehicles, which allowed them to reduce traffic in the city as a result of combining shipments and increased loading capacity utilization, but in turn contributed to the increase of delivery vehicles traffic in the centre [13]. The effects of combining shipments and transit routes using a logistic centre are shown in Figure 1.

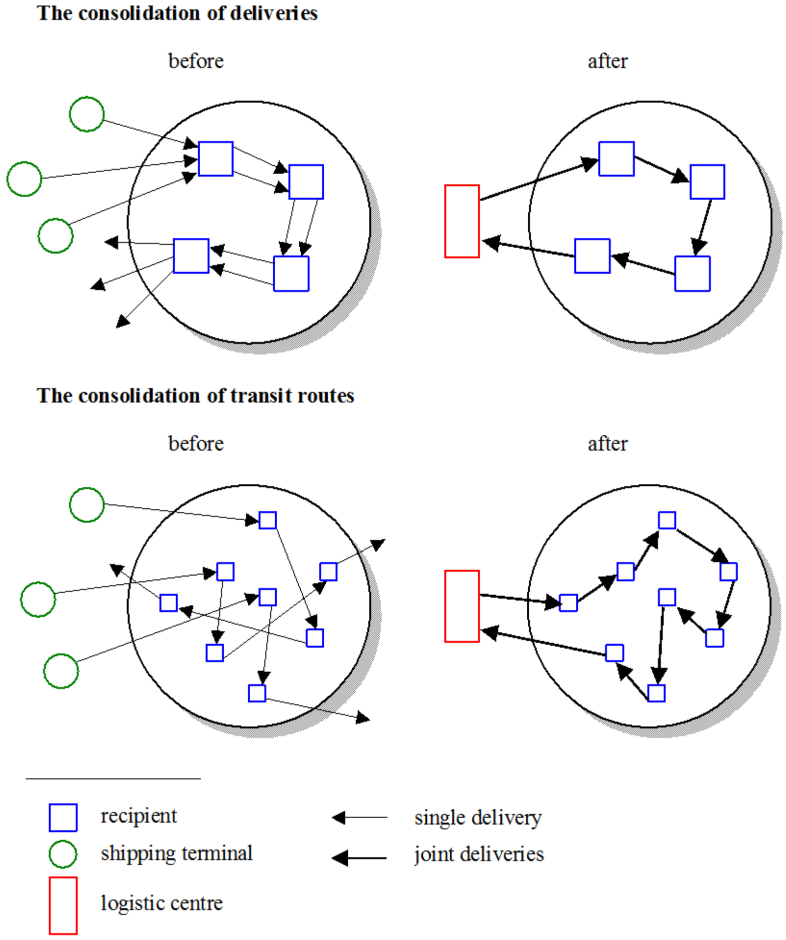

FIGURE 1
The effects of consolidation of deliveries and transit routes [14]

In addition, the co-operation of entities in the logistics centre consists in using common infrastructure of the centre: warehouses, storage yards, docks, computer system, etc. This way the duplication of investment is avoided, investment which is required in the activities of each of the entities. As a result, less surface area (but more efficiently used) within the city limits is designed for those infrastructures. There is no doubt that the co-operation between the CEP and transport, forwarding and logistics enterprises should be encouraged by the city. A promotional campaign has to put the emphasis on improving the economic situation of enterprises, which is an element attracting attention, which in this case goes hand in hand with improving the situation of mobility, relieving the road network and improving the quality of life and economy in the city.

THE CHARACTERISTICS OF THE DELIVERY TRAFFIC IN THE CENTRE OF POZNAŃ

In Poland nowadays there are only programs that reduce and regulate the access of trucks in city centres. They are preceded by an analysis of traffic and are now implemented as a trial. Unfortunately, the involvement of municipal authorities is not seen here. One of the first cities, in which such a program has been implemented is Wrocław, where with the participation of the academic staff of the Technical University of Wrocław a program called DORED was implemented. The aim of the program was to develop a methodology for the organization of van traffic supplying trade outlets in selected areas of the city in terms of minimizing the environmental impact.

A team led by the author, together with students from a scientific circle 'AE Logic' staged a similar study on a similar scale in Poznan in November 2007. The study area was in the centre of the town, near the Old Market Square, surrounded by the streets: Garbary, Wodna, Ślusarska and Szewska, Małe Garbary. The willingness to participate in the survey was reported by 108 entities operating in the area that generate delivery traffic. Basing on the survey results it can be concluded that [15]:

- almost one quarter of the entities (24.1%) take delivery of the goods once a day, less than a third (32.4%) less often, but at least once a week, only 15.7% of entities are supplied more than once a day;
- what may seem strange, most entities located in this area (25.9%) are supplied less than once a week – this is evident from the specificity of this region, in which a considerable number of art galleries, antique shops, law offices and notary offices, consulting companies, branches of banks, exchange offices, pawnshops, etc. are located;
- in half of the entities the schedule of deliveries is used (from which in 25.9% of the entities there occur a derogation most often resulting in an increase in frequency), in the second half the declared supply frequency was not due to the existence of the current schedule, but only meant the average frequency of deliveries;
- in most cases (50.9%), the average size of a one-time delivery does not exceed 20 kg, and in the vast majority (85.5%) it does not exceed 100 kg; receiving supplies weighing over 300 kg was declared by only 5.6% of the entities;
- deliveries are handled by trucks with a maximum authorised total mass of 3.5 tonnes (55.6%), light commercial vans up to 2 tons (34.3%), rather than by trucks with a maximum authorised total mass above 3.5 tons (7.4%);
- goods are delivered primarily in cartons, packages or containers (90.7%), cargo on pallets are regularly supplied to a small number of entities (3.7%);
- deliveries are realized in different ways, but generally during the working hours of the most entities, i.e. from 10:00 am to 6:00 pm (75%); due to the current fee for parking for the vehicles in these times, some entities takes delivery in the morning until 10:00 am (14.8%);
- the majority of the participants of the research (60.2%) indicated problems with stopping the vehicle during unloading: there is no parking space or a specially assigned parking space is occupied by another vehicle; 20.4% of the entities find convenient parking space at the time of delivery, and only 14.8% declared to have a specially dedicated parking space and no problems with its availability.

The results of the research are largely consistent with the results obtained by the DORED program in Wrocław [16]. The analysis of the results of the two studies conducted independently results in same conclusions. In the cities there is a significant problem when the vehicle stops for loading and unloading. Few retail outlets and service points have their own parking place. Deliveries are usually performed during working hours of these entities. The results of both studies confirm that the basis of supply of managing entities located in city centres are small (up to 100 kg) and frequent (daily or almost daily) deliveries by light trucks (with a maximum authorised total mass up to 3.5 t). Therefore, it is easy to complement full truck load shipments. Similar requirements are expected by recipients concerning the delivery date, and the ability to anticipate by many of them future requirements for the supply leads to the development of an established delivery schedule. This significantly facilitates the creation of cargo rounds for a simultaneous service of multiple entities. A very important additional outcome of this research is the observation that a huge impact on the efficiency, frequency and timing of deliveries has the fact of having by the recipients their own designated parking space. To obtain an advantage of its ownership it is extremely important to be able to – if a place is determined – punish and remove unauthorized vehicles parking there. These prerequisites should be a clear signal and an incentive for the service providers to start co-operation activities in the sphere of consolidation of deliveries and routes for the benefit of the entities supplied, service providers, and also for the city and its inhabitants.

THE AREAS OF CO-OPERATION – IN OVERCOMING THE AGGLOMERATION PROBLEMS

Recognizing, from the results of the studies carried out, that in large Polish cities there are favourable conditions for the logistics service providers to co-operate, a team headed by the author conducted another survey in November 2008. This time the survey was addressed to the transport and forwarding companies, logistics and CEP service providers (hereinafter referred to as service providers in general), so those entities which are responsible for the organization and delivery of supplies. The study included 19 service providers who have their branches in the urban area of Poznań. The questions raised in the questionnaire were divided into two groups. Questions in the first group concerned undertaking co-operation with other service providers. They have been formulated in general, without any indication to Poznań. It is clear that the entities under study operate throughout the country, organize and carry out transport operations in international relations. However, since the people providing answers were employees of local branches[1] it can be assumed that the formulated answers accounted for the local perception, the current problems related to the activities of the branch, and the situation as it is in Poznań. However, given the similarity of the results of studies of commercial vehicle traffic in various cities and pointing to the same issues in the urban supply traffic from the perspective of entities generating this traffic, also the results of this part of the study can be considered over-locally. Questions in the second group were specifically related only to the realization of orders within the agglomeration of Poznań.

The results of the survey show that:

- 42.1% of the service providers often co-operate with other service providers in the implementation of supplies in the urban area, 31.6% do so occasionally, 15.8% very rarely, and 10.5% do not undertake it;
- among those who engage in co-operation, this co-operation mostly concerns the use of external services (52.9%) and the use of external resources (23.5%);
- the consolidation of deliveries and consolidation of routes, as the area of co-operation was indicated by 23.5% of the service providers undertaking co-operation, whereas in this group the consolidation of deliveries (75%) strongly dominates the consolidation of routes (25%);
- the service providers take the greatest benefit from the co-operation on the operational costs – it is declared by 41.2% of service providers, in the form of opportunities to operate more orders – 35.3% of the service providers, as well as in the time and timeliness of deliveries – 23.5%;
- the service providers who do not take co-operation with other service providers as the main reason for this situation give the lack of a suitable partner, no motives which led to the co-operation, the lack of

1 Among the respondents there were also employees of the company headquarters. It relates to those (few) companies surveyed, which have their headquarters in the agglomeration of Poznań.

willingness to co-operate on the part of potential partners and – in last place – the fear of co-operation with a competitor.

As far as the problems in the agglomeration of Poznań faced by service providers are concerned, it appears as follows:

- the biggest problem for the service providers is in an urban environment the fact of reaching their destination – all respondents pointed to such problems; the problems in this group are mostly related to the significant prolongation of time for reaching the destination related to traffic congestion (73.7% of service providers), then the inability to reach the destination due to the prohibitory traffic signs (15.8%) and significant prolongation of the road associated with a large number of one-way streets (10.5%);
- second on the list as the biggest inconvenience for the service providers is parking at the loading and unloading – the problems with the stoppage was indicated by 84.2% of respondents, the lack of convenient parking space was reported by 63.2% service providers, while in the vast majority of cases (83.3%) this problem implies a stoppage on the road, which means the obstruction of traffic and the dangers associated with working during the loading and unloading, and in the remaining cases (16.7%) – the need to stop at a considerable distance; too short time allowed for a stoppage is a problem for 21.1% of the service providers;
- at the third place respondents pointed to problems of the storage in the city; they affect 79% of the surveyed service providers; the most burdensome are: the high cost of rent of the storage space (36.8% of the service providers) and the lack of urban logistics centres (31.6%).

CONCLUSION

The results of the studies conducted in Poznań show that although there is good potential for co-operation in the sphere of consolidation of deliveries and routes in the cargo traffic, the co-operation between service providers still focuses on the use of external resources and using the services of external resources. Service providers lend to one another, on a commercial basis, the resources which they at the moment do not use or do not fully use (such as vehicles, storage space). In this context, both parties have obvious benefits improving their financial results: some of them may undertake to perform further orders even though they do not have the necessary free resources of their own, others may increase the use of the resources, which at a given time exceed their current needs. Only every fourth service provider, which at all undertakes any co-operation with others (in relation to all the service providers this proportion is much lower), takes on the task of consolidating deliveries or routes. Within these activities the consolidation of deliveries clearly dominates, what is most likely affected by the complexity of the task. Consolidation of cargo routes requires from co-operators developing new, joint supply systems taking into account all the points of delivery using an optimisation account to minimize costs, which – as it turns out – is now the area of the biggest benefits, the benefits which are certainly the most expected ones. It is a pity that so few service providers still undertake the co-operation which can bring tangible benefits to themselves, to the entities being supplied – to their clients, as well as to the city and its residents. In relation to the city of Poznań, the most burdensome for the service providers is the traffic congestion. The hours of the morning and afternoon communication peak significantly lengthened. Also, during off-peak hours, we observe a significant level of congestion. This makes the time of getting to the place longer and requires the improvement of the operational efficiency of the other elements of the execution process of the task for keeping the declared delivery date (the impact on the level of customer service). Interestingly, the service providers do not raise the problem of straying due to inadequate information of direction and address in the city, which is often indicated by the drivers of private cars. Behind this lies probably the experience that the drivers of service providers acquire while carrying daily supplies in the same area of the city, often visiting the same destinations. Almost all of the service providers confirmed difficulties with a convenient stopping place during loading and unloading, which were signalled by their clients in previous studies. Moreover, it turned out that the problem is not the lack of convenient storage location near Poznań. In the vicinity of Poznań we now have 10 warehouse parks. The supply of modern warehouse space at the end of 2009 in the Poznań region amounted to 860,900 sq m, and a further 30,000 sq m was under construction [17]. Service providers rather see the lack of urban logistics centres like the German hubs which are the basis of urban supply systems there.

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LOGISTICS MANAGEMENT ASPECTS OF THE CITY INFRASTRUCTURE[1]

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Abstract *— Article presents the competence of local government within the scope of infrastructure management in order to ensure local development. For this purpose, authors will present the definitions of infrastructure and its classification, as well as certain ways of using the infrastructural resources to satisfy the needs of its community and improve the living conditions of the population. The infrastructure has a huge impact on local and regional development. Furthermore, it can be stated that local development determines the development of infrastructure. It is the intention of county council to increase economic and social activity of the local community as well as improving their quality of life. There are also presented the areas of logistics management in the city management. This article is a part of research, which is considered to the problem of management (economy) of the infrastructure in city logistics.*

Keywords —Infrastructure, management, city logistics, areas of city logistics.

INTRODUCTION

This article aims to show competence in the field of municipal infrastructure management. Due to the complexity of the issues of infrastructure management, in further considerations we will present only one aspect of the logistics management of city infrastructure.

Managing the economy of the local government requires the ability to influence the processes and phenomena in the interests of residents.

For the purpose of these deliberations, a broad understanding of management has been adopted. Management in this sense is treated as a process of influencing the management subject by the local government bodies and administration in such a way so that its proceedings (behaviour) aimed at reaching the determined goals are for example, consistent with the goals adopted by the management unit. The management object may include such persons, organizations and things that are related to planning and realization of public tasks and which, contrary to organizations, do not have to be subject to the administrator. With reference to that, management forms the behaviour of people and other business entities and management itself belongs to the area of regulating processes. Local government economy management is the ability to affect the course of processes and phenomena in the interest of the local community.

From the point of view of management, local and regional authorities are oriented at the control of development and the functioning of cities, counties and regions. In other words, their proceedings should concern all fields constituting the spatial, social and economic structures. In this sense, the nature of policy conducted by these authorities is expressed in shaping the city, county or region.

The key position in the activity of a local government is occupied by managing public affairs that belong to its basic competence. That covers such issues as: the place, conditions, mechanisms and principles of managing what is of fundamental importance to the interest of community and what fits the technical capabilities of local government bodies.

A municipal community has been generally assigned the rights to manage its affairs independently. The independence means that a local government:

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- has got public tasks assigned by law, the tasks are executed autonomously and according to its own will,
- is a legal entity,
- performs the tasks on its own behalf and on its own responsibility,
- owns allocated public assets,
- possesses its own funds separate from state funds,
- has its own administrative apparatus,
- is entitled to establish laws that are publicly binding within the local government area,
- is subject to judicial protection i.e. it may sue the state bodies in front of an independent court for violating its autonomy.

The autonomy of local authorities is expressed in their right to make decisions on the community matters when acting on behalf of its communities and acting collectively in front of the central government.

INFRASTRUCTURE

From an encyclopaedic and dictionary perspective, infrastructure consists of basic devices and service-providing institutions necessary for the functioning of economy and society [25].

E. Bittnerowa claims that infrastructure facilitates and even conditions the proper functioning of the production processes. Moreover, it limits the possibilities to satisfy the needs of the population [15]. A. Piskozub defines infrastructure as created by man, permanently localized linear and spot objects of public use constituting the foundations of socioeconomic life, due to their function of transferring people and loads (transport), information (communication), electricity (power industry) and water (water management) [12]. The definitions of infrastructure have a similar meaning and are determined as [2]:

- Devices and service-providing insitutions (transport, education, health care), essential for the proper functioning of society and production branches of economy;
- Material and technical equipment of a particular territory with the devices for transport, communication, telecommunication, settlement, educational, energetic, water and health care etc.;
- Basic devices and service-providing institutions necessary for the functioning of economy and society. Alternatively, fixed means and service-providing institutions essential for the functioning of economy. Infrastructure usually includes: roads, railways lines, other communication networks, energy and water supplies and educational facilities. Some definitions include objects connected with health care and entertainment.

Infrastructure may also mean the human capital without which one cannot discuss the development of production activity or improvement of the living conditions of residents in a particular area. It is an area of activity and research in city logistics. These activities aim at providing optimum conditions for the purpose of city functioning with the consideration of costs and efficiency of services realized towards city subjects in consideration of aspects of environmental protection, and the aim is to improve the life quality of a local community [18].

Generally, infrastructure can be divided into two fields, material and non-material. The non-material infrastructure includes such elements as: the society's level of education, its traditions, culture, discipline, thrift, sense of responsibility as well as the legal-organizational conditions of functioning of economic units. The material infrastructure consists of social and technical infrastructure (technical-economic) [11].

The recipients of services of the social infrastructure in a community are the residents, because the community is responsible for rendering public services.

The notion of a city technical infrastructure is often defined as a municipal infrastructure [17]. From a legal perspective, public utilities are specified by the public utilities act [28]. In accordance with this act, public utilities include the execution of the cities' own tasks in order to cover the collective needs of a local community.

The municipal property is the ownership and other property rights that belong to - municipal legal persons. The objects of property are among others elements of technical infrastructure which includes [27, 29]:

- waterworks - a set of technical devices operating together and providing water supplies for consumers,
- sewage system - a complex of sewage devices used to drain sewage;
- power network - a system of wires supplying electricity to consumers by the enterprises conducting activity within electricity transmission and distribution;
- gas network - a system of pipes supplying gas fuels to consumers by the enterprises conducting activity within gas transmission and distribution;
- heating network - a transmission network defined as a system of connected and cooperating fittings aiming at a transmission and distribution of the heating factor to consumers.

The devices of the technical and economic infrastructure cover the demand of the production and non-production sphere, as well as individual and collective needs of the population.

CITY LOGISTICS

Logistics covers the planning, coordination and control both in the aspect of time and space, the course of actual processes in the realization of which organization is a participant, for the purpose of efficient and effective goal achievement by an organization. It particularly concerns spatial and timely arrangement (where?), state (how much and in what configuration?) and flow (where from, where to and by what means of transmission?) of goods constituting the components of these processes, i.e. people, material goods, information and funds [8].

Institute of City Logistics defines the city logistics as a process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy [30].

The subject of research of city logistics is the issues of intentionally organized and integrated flow of materials, people and information in an agglomeration. These problems include among others: the issue of the city communication accessibility, supplying the commercial objects, supply of water and energy, sewage disposal, waste utilization, construction and maintenance of telecommunication networks and environmental protection – ecological aspects.

City logistics is a particular type of logistics service, and is confronted with particular problems, due to the concentration of activities on a limited geographical scale, and the combination with many other activities going on in cities.

City logistics is directed at solving the problems of functioning of highly urbanized areas of microregions. Due to the implementation of its accomplishments, the often non-coordinated system of transport streams conditioned by the historic development of cities is substituted by new streams enclosed by the local logistic system [1].

City logistics is a set of processes of managing the flow of people, loads and information inside the city logistic system according to the city developmental needs and goals, in consideration of natural environment protection and taking into account the fact that a city is a social organization the superior goal of which is to satisfy the needs of its users [16].

The aim of the city logistics is therefore the connection of all business entities acting in a city into a single controllable whole and the management of this network in a manner providing the desired level of life quality and managing the city at a minimum cost level, whilst considering ecological standards [5].

The task of logistics in the above-mentioned areas is to provide the optimum "living" conditions of a city with respect to costs, productivity and services realized in order to satisfy the needs of subjects functioning in this city. The realization of the function of logistics aims at raising the life quality of the agglomeration society and improving the work of business entities with a simultaneous elimination of unnecessary transport, shortening transport times, limiting supplies and lowering the cost of services provided for the city.

AREAS OF CITY LOGISTICS

One of the most important goals is the consolidation of transport streams, connection into a single controllable whole of business entities and institutions which are concerned with movement and act within the city area, as well as the event network management in a way providing a desired level of life quality and the city management at a minimum cost level in consideration of ecological standards [20]. The coordination also includes an appropriate organization of municipal services provided for business entities and the people. Another important goal is the reorganization of in-city relations to achieve a stable balance between space and transport within this space. It may be accomplished by relevant planning, organization and management [23].

The primary objective is to create transport solutions for the benefit of the city environment in terms of road safety, air and noise pollution, accessibility, energy consumption, safety and the visual environment. This applies to transport of goods and services to and from city areas. At the same time, goods transport should ensure a level playing field for the retail trade in the city area and the vast shopping centres outside the centre of city.

The use of the basic principles of city logistics aims at the integration of activities and cooperation between the participants of logistic processes in a city in order to eliminate the bottlenecks that make an efficient functioning of a city centre impossible. The goal is to provide a relevant layout of the determined and regular but so far uncoordinated and scattered transport streams running through the city and its centre, as well as to coordinate the city supplies by meeting the condition of binding them in order to minimize the number of transport operations and to eliminate the commodity transport [23]. The integrational functions of logistics are the source of synergy - integration is recognized as a permanent unattainable goal of logistics [16].

City transport plays a considerable part in the spatial development of a city. Its influence on the city development is connected with access to public transport in its particular areas. The target times are lengthened by distances that are to be covered and which are obviously influenced by the size of the city area. It occurs that the level of the communications development of a city is an obstacle to the proper functioning of an agglomeration.

Important areas of city logistics are the activities of gathering, disposal, storage or distribution of municipal and industrial waste. The processes connected with waste management have become part of the city logistics together with the rising amount of waste, by-products and useless consumer articles after expiry date generated by urban agglomerations [4].

A properly formed set of goals and tasks is necessary for city logistics to solve the emerging problems. The activities should be illustrated by a balanced development strategy of the centre. The basic tasks include the assurance of city areas' development, with a simultaneous satisfaction of the needs of agglomeration: social, economic and environmental, such as the living standard, management and balanced development. Providing the conditions for the city development in all those three dimensions should constitute a long-term goal. Within the scope of complexity of the city logistic system, numerous secondary goals connected with the functioning of particular logistic concepts may be identified.

Nowadays, one can observe the use of telematics in the field of the flow management in cities more often. Telematics - is the use of telecommunications, informatics and information as well as the solutions of automatic control adjusted to the needs of the supported physical systems - resulting from their tasks, infrastructure, organization, maintenance and management - and integrated with these systems. The use of telematic concepts in city areas aims at facilitating the access to shopping or industrial centres within large agglomerations that are burdened by traffic jams. Any novelties introduced to IT solutions must be closely integrated with the binding system of city management, which is restricted to the control and management of traffic in a particular city, but also of logistic centres, the handling of goods from out-of-city traffic to city areas. The telematic technologies support the accumulation, archiving, processing and transmission of data. Their application includes: the use of devices, computer equipment and telecommunications appliances with software. The data for the purpose and on demand of the city logistics is transmitted by the Internet, but not only. Intelligent Transportation Systems are also applied [13].

The creation and adaptation of a relevant infrastructure for transport by means of bicycles in large cities is also an important element.

In order to cover distances in a city on foot in a comfortable way, it is necessary to modernize the city infrastructure, which includes [16]:

- creating consistent systems of pedestrian precincts,

- installing posts that separate pavements from roads and which secure pavements against being blocked by the parking vehicles,
- eliminating the division of space into roads and pavement on local streets,
- broadening pavements,
- improving night lighting of pedestrian precincts,
- creating the guiding lines for the blind or visually impaired,
- installing devices facilitating the movement of the disabled,
- modernizing pedestrian precincts and squares,
- creating places of transition from pedestrian means of covering distances to the mechanized means of transport,
- providing signposts for pedestrians.

CASE STUDIES

The actions of logistics come down to finding a compromise between cost and operations support in the processing of materials, people and information. Christopher M. states that the purpose of logistics is to ensure not only availability in time and space, but also cost-effectiveness of access [3]. Logistics provides the physical accessibility to public goods and services including, through the use of special levies, a reduction in the use of vehicles, and therefore reduced congestion. At present, we can distinguish between six types of charges associated with congestion occurring on ring roads [16]:

- a toll road, for routes which demonstrate high levels of congestion on a regular basis,
- restricted Zones, restricting free access to the urban area,
- charges taken at various points to enter the urban area,
- charges for the route of travel,
- charges for stopping vehicles,
- charges taken in the event of an alternative route and class.

Examples are the authorities in London, who decided to limit the number of private vehicles traveling in the center and differentiate between private vehicles and public transport by introducing charges for entry to the city. The fee is charged for entry to the designated zones and spaces between the hours of 07:00 to 18:30 from Monday to Friday, excluding holidays. The level of fees is set at £5, which is for drivers going into the center or passing through, and is paid only once a day. Images are collected by 230 cameras that monitor 98% of the zone. Thanks to the special technical solutions, even with minimal light they can read license plates of moving vehicles. The images from the cameras are transmitted to the Transport for London (TfL) control center, where, after analysis, they are associated with the entries in the database of drivers who paid the charge [31].

Another example is Oslo, which reduced congestion through the introduction of environmental charges for entry to the city center by car. The fee is collected at 19 points by cashiers or by coin machines. 20% of the revenue generated is earmarked for improving the operation of public transport. The next example comes from Japan, where congestion was limited by the introduction of congestion charges for environmental impact and long distance travel. In 2001, an electronic toll system was introduced on expressways. Within the group of financial tools that affect the level of congestion in cities we can also consider North American cities. In the United States, since the early 90's, congestion charging has been an essential element of traffic control (more than 1,000 points collected fees. The main topic of discussion is the level of traffic management fees (variable pricing) [16].

Another area of implementation of logistics solutions in city management is telematics. Telematics solutions were used in the public transport system in Helsinki. Priorities for public transport were established on traffic signals, and they introduced live information for passengers. The effects of the system are visible in the form of increased levels of public transport services, particularly travel time and punctuality, as well as improvements in the use of rolling stock and a reduction of harmful impacts on the environment of the city.

Another city that has introduced a similar solution is Curitiba in Brazil, where public transport has been given absolute priority over individual transport. Besides the traditional characteristics of a public transport system, it is worth noting that every person seeking to obtain or extend their authorization for economic activity must take into account the impact of the projects activities on the traffic and transport infrastructure.

Another city that has implemented a solution to rationalize collective and individual communications is Madrid. There are separate lanes for passenger vehicles, with bus lanes which are separated from other lanes by impassable barriers [16].

Increasingly, you can see urban logistics projects companies and the consolidation of carriers. In Germany, delivery system projects are promoted, with the supply of goods made by a partnership between logistics operators, which reduces the number of vehicles and improves the quality of the environment of the city. This partnership, called the German "City Logistics Companies" has been running in Berlin, Bremen, Ulm, Kassel and Freiburg. The system of consolidation of carriers has also been implemented in Japan in Tenjin. Canada has also managed to successfully implement a system of urban freight transport logistics. An example might be consolidation in the urban centers of Vancouver and Saskatoon. A program was developed in Canada for transportation planning, to help transporters make optimal decisions and operational planning related to the consolidation of cargo, transport and choice of carrier and the common use of resources [24].

You can also see examples of "modernization" of routes through the city in the form of measures such as reduced speed zones, road narrowing, chicanes, "islands", speed limits, and many other solutions used in order to improve road safety.

SUSTAINABLE TRANSPORT IN PRACTICE

Sustainable transport systems make a positive contribution to the environmental, social and economic sustainability of the communities they serve. Transport systems exist to provide social and economic connections, and people quickly take up the opportunities offered by increased mobility.[14] The advantages of increased mobility need to be weighed against the environmental, social and economic costs that transport systems pose.

The term sustainable transport came into use as a logical follow-on from sustainable development, and is used to describe modes of transport, and systems of transport planning, which are consistent with wider concerns of sustainability. There are many definitions of the sustainable transport, and of the related terms sustainable transportation and sustainable mobility. One such definition, from the European Union Council of Ministers of Transport, defines a sustainable transportation system as one that:[*21]*

- Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.
- Is affordable, operates fairly and efficiently, offers a choice of transport modes, and supports a competitive economy, as well as balanced regional development.
- Limits emissions and waste within the planet’s ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimising the impact on the use of land and the generation of noise.

Nowadays the number of motor vehicles on our roads is huge, and growing all the time. The result is more carbon emissions and other pollutants that damage the environment, add to global warming and reduce air quality for local residents. It also means more congestion, longer delays, increased parking problems, and reduced road safety.

There are some examples to solve the problem. One of them is an initiative of the TfL (Transport for London) which provides us with new technologies implemented in public transport. They have started to buy new fleet of buses – hybrid buses. Combining a conventional engine with an electric motor, hybrid buses are quieter, cleaner and more fuel efficient than standard diesel buses. These vehicles reduce emissions of local pollutants and carbon dioxide by at least 30 per cent compared to conventional diesel buses. Compared with conventional diesel buses, hybrids deliver considerable environmental benefits, including:[31]

- 89 % reduction in oxides of nitrogen
- 83 % reduction in carbon monoxide
- 40 % reduction in fuel use
- 38 % reduction in carbon dioxide
- 30 % reduction in perceived sound levels (noise reduced from 78 to 74 decibels)

There are also new buses powered by hydrogen fuel. hydrogen technology will play a major role in helping to reduce the impact of the Capital's public transport network on the environment. Hydrogen fuel cell vehicles are clean and efficient, producing no tailpipe emissions other than water vapour. Hydrogen technology offers the following key benefits:[31]

- The fuel cell vehicles only emit water vapour, completely cutting out CO2 and other harmful emissions from the exhaust
- They'll be quieter than diesel buses
- They'll be more comfortable for passengers as acceleration is smooth and progressive, thanks to the electric motor.

Taking into account the methods of hydrogen production, it is expected that overall the fuel cell vehicles will produce 50 per cent less CO2 than a diesel vehicle.

The results show that these buses produce fewer greenhouse gas emissions and harmful local pollutants, as well as having lower noise levels.

One of the key objectives of the Seventh Framework Programme for Research and Technological Development for the period of 2007-2013 (FP7) is to contribute to sustainable development. In 2007 and 2008, around 44% of the total budget devoted to cooperative research was allocated to sustainable development-related projects. Two of the Joint Technology Initiatives (JTI) established under FP7, "Clean Sky" and the "Hydrogen and Fuel Cells", are also linked to sustainability. The total EU contribution amounts to €1.3 billion. Moreover, in the European economic recovery plan, the Commission proposed three major public-private partnerships (PPPs) around three key issues for sustainability: "green cars", "energy-efficient buildings", and "factories of the future". The Commission is striving to ensure that the whole European Research Area is responsive to sustainable development objectives. The challenge ahead is to build on the promising first steps and to enhance the contribution of research to sustainable development.

CONCLUSIONS

The above-mentioned systems contribute significantly to the realization of goals of city logistics in the range of its most important elements, i.e. transport of goods and passengers in cities, deliveries and export, but also transit through cities. Additional benefits will be obtained if such an integrated system is an intelligent system, which means that it should facilitate a broad automation of traffic management tasks in a dynamically changeable environment within the given criteria and scenarios [19]. Simplistically, it concerns the means to achieve freight distribution in urban areas, by improving the efficiency of urban freight transportation, reducing traffic congestion and mitigating environmental impacts.

By fulfilling its function of supporting the city, the infrastructure provides its residents with appropriate living conditions and by improving the efficiency of actions and quality of services it increases the level of life of the population. The improvement of the living conditions, often described as the results of prosperity, may lead to the infrastructure acting as a factor of social stability and supporting the attachement of people to their dwelling place. At the same time, however, the development of e.g. educational infrastructure may lead to the so-called escape effect. The increase of level of education and qualifications may cause a migration of the population to the centres that are better developed and that provide more profitable opportunities of work and life. In a situation of a complex use of infrastructure in order to improve the investment attraction of a particular area, one may lead to the influx of investors who shall create attractive workplaces for well-prepared personnel.

Logistics could play the key role in implementing such ideas into practice. The idea of monitoring the realisation of logistics strategy based on the observation of the control variables, determination of concordance of the actual level of the assigned indexes included in the strategic plan, and finally specification of methods of processing and channels of information flow, complies with the concepts of the object (functional) early warning systems. It should be noticed that the objective control of the logistics strategy should also use indexes concerning the organisation, technology, product, suppliers, competition and logistics service providers.

Logistics has always played and it still does play a significant part in competitive strategies based on leadership within costs, differentiation (also within logistics service), shortening time cycles and the use of the company's capacities.

The management-oriented integration of all logistics functions and processes becomes more important, because it is conditioning not only effective organisation and enterprise modernisation, but it is also opening new possibilities of solving problems and using potential effects in the operating and strategic activity.

In recent years, the evolution of a view on assigning a bigger and bigger part in the entire social and economic development has become relatively common. By adopting a thesis on a significant influence of the existing devices of infrastructure on the conditions, scale, rate and location of industrial investments, one may expect an opposite effect, i.e. an influence of the production sphere, especially of industry, on the particular elements of infrastructure. One can present numerous examples of new investments in locations where in the first place the conditions for the functioning of enterprises have been created, the infrastructure in the form of waterworks, sewage system, power and gas networks has been created and roads have been built. The districts that would encourage by lower taxes have become an object of interest of many enterprises.

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A HIERARCHICAL DECISION SUPPORT SYSTEM TO DISTRIBUTION NETWORK DESIGN: POLAROID CASE STUDY

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Abstract — *Design and performance analysis of logistics systems have an increasing importance nowadays, regarding efficiency studies and competitiveness throughout the World. For this reason, there are several papers on the analysis of logistics systems. Also, distribution network design as one of the most important component of supply chains is widely invastigated. On the other hand, design of distribution networks is a very complicated and hardly modeled process which also considers a number of different performance measures. This paper describes a hierarchical decision support system to distribution network design problem. The proposed DSS (Decision Support System) takes not only the quantitative but also the qualitative factors into account. The DSS firstly constructs cost optimum network by using a mathematical model, after that; A multicriteria decision making technique is applied to find the most desired network according to qualitative factors. The proposed DSS is applied to a well-known case study: "Polaroid: European Distribution System", after that the efficiency of the procedure and future studies are discussed.*

Keywords — *Distribution Network Design, Decision Support Systems, Multicriteria decisions making*

INTRODUCTION

Nowadays, companies are continuously looking for the ways to improve their performance and stay competitive in their markets [1]. The impact of global competition has forced all of the contributing partners in the supply chain to collaborate with each other and to do so, planning of activities become very vital for the whole supply chain network. In this respect, companies themselves can't focus on a pre-determined point that includes company's aspect on a major problem. Planning activities in the supply chain have been divided into three main categories [2]. These categories are related to the impact of given decision. Reference [2] has categorized these planning activities as Long, Medium and Short term decisions. The major topic of this paper (distribution network design problem) is listed as a medium term planning activity which has a very important effect on the efficiency and competitiveness of the supply chain. The model in paper is intended to take tactical decisions for designing distribution networks, or more specifically, for designing the flow of products from the manufacturing plants to the customers. Distribution network design is a highly complex problem containing not only the quantitative but also the qualitative factors in its nature. Before trying to form the flow of the algorithm, it is necessary to review the fundamentals of distribution network design problem.

Distribution networks are helpful to show relations in between the supply chain partners. The relations are mostly reflected by arcs and the components of the chain by nodes. The arcs which illustrate flow within the chain depends on demand and supply with respect to capacity. Distribution network design looks at the strategies finalized to efficient distribution of the products at the lowest costs. On the other hand, focusing just on the cost aspect might cause a lower service level which may cause unpredictable results like loss of good will. Ferretti et. al [4] has established six fundamental decisions in distribution network design. These may be listed as:

How many different levels should be studied? (Production facility, Distributors, Wholesalers etc.)

How many main Hubs should be planned?

How many Distribution Centers should be planned?

Where should DCs be located?

Which group of customers should be served by each DC?

Which transportation method should be used?[1]

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In addition to these decisions, some other major questions can be added to the list. For example; centralization or decentralization decisions, inventory holding places, distribution frequency, and assignment of customers to proper warehouses. The main factors influencing distribution network design can be divided into two groups: [3]

Customer service influence

Cost minimization influence

Cost minimization influence can easily be reflected in the mathematical model, while customer service influence is a hardly modeled factor. Cost minimization parameter includes transportation cost, inventory holding cost, fixed and variable cost of plant rental, handling cost within the chain, personnel hire/fire cost.

LITERATURE REVIEW

The design of a distribution network can be quite broad; many different decisions have to be taken when planning the supply chain. While this paper is intended to select the most compromising distribution assignments to supply the customers' demands, many researchers have considered other aspects in the distribution network design process.

One of the most familiar researches in literature to ours was published by Cintron et. al. in 2010.In this paper, a multicriteria mathematical model for designing distribution network of a consumer goods company was formed and an optimum solution to network design problem was proposed [1]. Model objectives included maximizing profit, minimizing lead time, maximize power, maximize credit performance and maximize distributors' reputation. The model proposed an optimal arrangement of customers and distributors in the supply chain network. A case study was used to show the feasibility of the model. This application used real data. Another application formed with real data on network design was published by Afshari et. al in 2010. In that paper an approach to apply inventory decisions in distribution network location problem is presented [9]. The contribution was to minimize total establishment, transportation and inventory costs in a multi-commodity single-period distribution system and was supported by a case study.

Distribution network design problem is highly studied with production network decisions as well. Jang et. al in 2002 proposed a combined model of network design for production/distribution planning in a supply network, it is based on a mathematical model, so quantitative facts are reflected in the solution space[6]. Also, Ding et. al. in 2009 addressed the design of production-distribution network including both supply chain configuration and related operational decisions such as order splitting, transportation allocation and inventory control. [10]

What is more, demand stochasticity is a very common search area in network design. It was invastigated by Ferretti et. al in 2005 [4]. Distribution network design under uncertain demand was analyzed and it was found out that network performance is totally sensitive to changes in lead time and demand variations. Network performance parameters were also deeply analyzed. These performance criterias may be listed as sustainability, robustness, stability, smoothness etc. Neto et. al [11] published the paper on designing and evaluating sustainable logistics network, in this paper, the effect and meaning of sustainability in network design was discussed. And they reviewed the main family of activities influencing the environment and costs in logistic network, namely: transportation, manufacturing, product use, testing and end-of-use alternatives. Mo and Harrison [7] invastigated robustness in network design and related performance measures. It was found out that, fluctuations in input factors for network design affects the performance of network adversely. So, different kinds of precautions were taken to reduce risk in the supply chain. Finally, stability in network design and related performance criterias are listed by Synder in 2005 [8]. The proposed framework was built on the fact that lower cost fluctuations results in more stable network. So, with a prior aim of lowering number of warehouses, it was formed as a solution to given situation. The routing problem is not taken into consideration in this paper since it is considered an operational decisions problem that can be solved using the results obtained from this paper. Aghezzaf et. al. (2006) [12] studied the inventory routing problem with a

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Dynamic planning horizon, determines the distribution plan that minimizes fleet operating costs and average distribution and inventory holding costs without causing a stock-out at any of the sales-points.

HIERARCHICAL ALGORITHM TO DISTRIBUTION NETWORK DESIGN

In this paper, we have presented a hierarchical decision support system to distribution design network problem. The reason why it is called as hierarchical is the information flow between phases of the algorithm. The DSS is based on determining analytical input and performance parameters, and deciding which alternative to opt among different network design alternatives. The proposed DSS (Decision Support System) takes not only the quantitative but also the qualitative factors into account. The DSS firstly constructs cost optimum network by using a mathematical model, after that; A multi criteria decision making technique is applied to find the most desired network according to qualitative factors. The phases of algorithm are listed as:

Problem Definition

The detailed analysis of current distribution network is applied in this section. The input parameters that can be modeled are determined and estimations of each are made. In addition to that, the mathematical model outputs are listed as solutions to distribution network design problem. This helps to determine the scope of mathematical model. And, the listing of qualitative parameters that will be invastigated in Multicriteria decision making phase may be formed easily.

The characteristics of input parameters vary with different papers. Some of them include stochastic nature of inputs while others include fuzzy input parameters for models. The complexity of mathematical model and the nature of input parameters are helpful to determine the scope of invastigated problem. Problem definition phase has the fallowing questions to answer:

Which of the input parameters can be reflected in the mathematical model? (Rest is qualitative factors)

What are the input parameters and estimation of values of each (Stochasticity, fuzziness, exact values)

Which output parameters are calculated by solving mathematical model (Scope of mathematical model)

Forming Mathematical Model

The mathematical model of invastigated network can be formed with the information gathered in problem definition phase. The model may be constructed as a minimization or maximization problem. If it is a minimization problem, the objective function can be minimization of cost or risk. The constraints of the proposed model depend on the original network structure and special framework of the given problem. One of the most known papers is written by Jang et. al (2005). The objective function in that paper was combination of transportation, inventory holding, warehouse operation, staff hire/fire cost, while constraints formed as demand satisfaction, warehouse capacity, transportation capacity, production capacity and network constraints. The output parameters of mathematical model can't be applied in the real world, because model just reflects quantitative factors. So, alternative solution space should be widened after the modeling phase.

Alternative Solutions

In this phase, new alternative solutions should be added to solution space. Solution space should not include infeasible solutions, but should consider pros and cons of mathematical model and satisfy qualitative factors. The proposed solution space is input for Multicriteria decision making phase. The solution space should contain mathematical model output and various different hybrid alternative solutions (3rd party logistics alternative, centralization, decentralization, hybrid approaches etc.)

Multicriteria Decision Making Application

The alternatives determined in previous phase are inputs for this phase. Decision factors that cannot be reflected in mathematical model are added to Multicriteria decision making procedure. So, cost is just a decision factor with a pre-determined rate to be used in decision making. Most of the papers published in this issue accept stability and robustness as a critical factor. The weights of each factor are determined with decision maker. Another important decision is the selection of multicriteria decision making technique. Most of papers use discrete optimization techniques. The result of this phase is decision to be applied by considering both qualitative and quantitative factors. Detailed implementation of network decisions is next step of the given algorithm. The scope of mathematical model would give information about which design parameters to be decided.

Result Analysis

The assessment of decision taken in previous step is made in this phase. What is more, detailed decisions such as transportation mode selection, customer assignment to DCs, routing in distribution network are taken and implementation is monitored by decision makers. The proposed algorithm has a hierarchical structure, because every decision taken in one phase is an input for another phase. The algorithm selects most compromising solution among a number of alternatives. It is accepted as a compromising solution, because there are so many goals and criterions within the decision problem.

CASE STUDY: "Polaroid: European Distribution System"

The proposed algorithm is applied to a well-known distribution network design problem called Polaroid. It was first published by Harvard Business School in 1995 [5]. Polaroid Company is a global photographic film and equipment producer which is headquartered in Cambridge, Massachusetts. The company marketed a wide variety of instant photographic products to consumers and commercial customers around the World. Products have been categorized mainly as amateur and industrial products. Amateur products approximately have a price range of $50 to $200, while industrial films are retailed at about $1. Polaroid operations in Europe has accounted for a quarter of company sales. In Europe, company was organized into twelve national subsidiaries each headed by a General Manager. Each subsidiary has its own management board. And, Polaroid's largest subsidiaries were in France, Germany, Italy and UK which together accounted for an estimated %70-80 of European sales.

Polaroid production facilities were located in United States, Scotland and the Netherlands. Factory in Scotland mostly produced consumer cameras and industrial films. The factory in Enschede, Netherlands, operated as subcomponent producer. Most of types of cameras and films were produced in US factory. Each component and product was supplied from a pre-determined facility. Each European subsidiary had been operating a separate warehouse to serve its national market. What is more, two of facilities (Scotland, Enschede) had its warehouse adjacent to factories. The site at Enschede also known as IDSC served as a distribution center for import and export products. Products coming from USA and Scotland were first unloaded to IDSC, and then transported to proper subsidiaries within a predetermined time interval. The frequency of supplies might change with demand changes. Products unloaded in IDSC were sent to national subsidiaries warehouses and the national subsidiaries warehouses broke the bulk, and then picked and packed products for customer specific orders. The subsidiaries then arranged products to be shipped via independent carriers (3rd party logistics provider) to customer locations.

Each European Market had a different characteristic of demand. In TABLE 1, shipment percentage from IDSC to each national market is presented. Germany, France, Italy and UK shipments constitute %68 percent of total freights. So, these markets should be deeply invastigated.

TABLE 1

Destination of Freights from IDSC to European Subsidiaries (%)

Countries	Ger.	Ita.	Fra.	UK	Spa.	Nth.	Swdn.	Bel.	Swtz	Aus.	Dnk.	Nor.
Rate (%)	23	16	15	14	10	4	4	3	3	3	3	1

French market: Polaroid consumer products were distributed through three main channels: 1.) specialty photograph dealers that accounted for %70 of sales. Dealers did not have any warehouses so each of them demands shipments to individual retail establishments. 2.) Hypermarkets that accounted for %20 of Polaroid sales. Hypermarkets had a number of consolidation centers. So, the number of shipments from national warehouses to consolidation center is low, but the amount to be shipped is very large. 3.) Wholesaler with huge warehouses that constituted %10 of sales.

The German subsidiary was the largest of European market. The biggest portion of market with a %60 percent of sales was huge hypermarkets. Hypermarkets had so many consolidation centers so direct shipment to customers could be applied from IDSC to related warehouses. What is more, wholesalers constituted %15 of German sales. The remaining %25 percent varied among different alternatives. So, %75 of German market is proper for direct distribution, but German customers are well known for their punctual characteristics. This characteristic may cause trouble in direct distribution.

In Italy, Polaroid consumer products were distributed through Dealers (%50 of Italian sales), wholesalers (%40 of sales), and hypermarkets (% 10 of Italian sales). Italian customers were known for their lazy characteristics. Half of total customers in Italy were dealers, so each of them demands shipments to individual retail establishments. One of the biggest problems in Italy was the danger of product thefts in warehouse region.

In UK subsidiary, %45 of products was distributed through wholesalers. Polaroid directly serviced large national accounts with a rate of %20 percent. The remaining %35 was dealers. British national accounts were considered to be extremely demanding in service requirements such as packages, sizes, product safety etc.

Polaroid first started its continuous improvement process in USA. Inventory centralization was applied as a solution to high inventory holding costs. It was very convenient to implement such decisions in USA because most of the American customers were ordering just for one time in a month. After this process, a similar improvement strategy was implemented in Euro zone. To do that, a number of cost parameter was collected. Comparison tables for direct distribution and current situation are listed below. The current situation alternative represents keeping each national subsidiaries warehouse open, while planning alternative reflects direct distribution from IDSC to customers without any subsidiaries warehouses. TABLE 2, 3, 4 and 5 gave information about cost parameters before and after direct distribution application.

TABLE 2

Planned Staffing (number) and Costs of Shipping Staff ($ in 000s)

Countries	Aus.	Bel.	Dan.	Fra.	Ger.	Ita.	Nth.	Nor.	Spn.	Swz.	Swdn.	UK.
Current Personnel	6	0,5	3,5	13	13	9	1	1	5	4	5	10
Current Cost	$191	22	164	529	617	273	47	68	149	196	324	255
Planned Personnel (After D.D)	0,5	0,5	0,5	1	1	1	0,5	0,5	0,5	0,5	0,5	1
Planned Cost (After Direct D.)	$16	22	23	41	47	30	23	33	15	25	33	13

TABLE 3

Current Inventory Values by Subsidiaries ($ in millions)

Countries	Aus.	Bel.	Dan.	Fra.	Ger.	Ita.	Nth.	Nor.	Spn.	Swz.	Swdn	UK.
Current Inventory	$1,39	0	0,84	0	6,21	4,53	6,28	0,7	1,74	1,32	2,93	4,32

TABLE 4

Estimated Annual Renting Savings ($ in 000s)

Countries	Rental	Aus.	Bel.	Dan.	Nth.	Fra.	Nor.	Spn.	Swdn.	Swz.	Owned	UK	Ger.	İta.
Current Rental Cost		$100	189	47	120	1062	85	258	140	400		-	-	-
Planned Savings		$30	0	15	300	0	25	77	40	120		150	150	100

TABLE 5

Current and Planned Values of Performance Factors

Before Direct Distribution	France	Germany	UK	Italy	After Direct Distribution	France	Germany	UK	Italy
Order Fill Rate	97%	92	92	76	Planned	95%	95	94	88
Line Fill Rate	91%	69	75	51		90%	81	77	62

Before planning operational aspect of direct distribution, analysis of backorder reasons was made. According to the initial reports, most of backorders took place with product availability within Europe but located in the wrong place. For this reason, it was allowed to transfer products between different subsidiaries. What is more, another core reason of backorders was considered to be 3rd party logistics company allowance. For this reason, each subsidiary conducted its own way of transportation to customers. Implementation of direct distribution from IDSC required initial investments such as new packaging line implementation, new conveyor systems implementation, area enlargement etc. Although, direct distribution seems to be feasible, there are some doubts in managers' minds. These were strikes due to layoffs in warehouses, loss of flexibility, and loss of market share. After analyzing current situation, managers decided to rebuild distribution network. So in this respect, decisions on warehouse locations, distribution network, freight plans were reviewed by management committee.

SOLUTION PHASE

The given case study can be resolved via proposed decision support system. Because, the given situation contains both qualitative and quantitative factors in decision making procedure and a number of factors are influencing the given decision. Given case study is iteratively solved via proposed algorithm. The phases of algorithm are listed as:

Problem Analysis

The detailed analysis of current distribution network is made in this phase, and parameters that can be used as an input factor to mathematical model are determined. All of the information about cost parameters is given, so the mathematical model can be formed as a cost minimization problem. What is more, percentage of customers which requires a national subsidiary warehouse may be calculated by using the information about markets and customer profiles. For example; French market's core customers are dealers with %70 of total French sales. So, keeping warehouse open in France would satisfy %70 of customer profile in France. Huge hypermarkets and wholesalers do not require any warehouse in their subsidiaries, so direct distribution is a proper alternative for such markets. Another parameter that can be modeled is the number of employees. The number of employees before direct shipment and after direct shipment is listed in Table-, so it may be reflected as constraint to mathematical model. After determining quantitative parameters, values of each parameter can be estimated. In the given case study, values of each parameter are listed in tables.

Final decision of this phase is determining scope of mathematical model (which output parameters will be formed by mathematical model). Products unloaded in IDSC may directly ship to customer establishment or warehouse. This option is called as direct distribution. The mathematical model outputs may give information on direct distribution, number of warehouses, and location of warehouses. The planned mathematical model cannot give any information on transportation mode and customer-warehouse mapping.

Forming Mathematical Model

The proposed model has an objective of cost minimization. Objective function is a combination of transportation, inventory holding, staff hire and fire, and warehouse operations cost. Decision variables depend on keeping each subsidiary warehouse open or not. If it takes a value of 1, then it means the warehouse will be kept open, otherwise, warehouse of that subsidiary will be closed and direct shipment will be implemented from IDSC to related warehouse. So, decision variables will take 0-1 values. The constraints can be understood from case study easily. Due to the strike risk, at least 15 employees should still work. What is more, order fill rate and line fill rate for biggest markets are listed in tables. %80 and %91 values are accepted as lower bounds for each performance parameter. These values are determined by calculating averages of each performance measure. Flexibility in market which is brought by subsidiary warehouse is one of the most important factors in supply chain. So, European market satisfaction is set as a constraint with lower bound value of %40. It is found out that warehouse rental cost savings is a very important improvement in cost savings. So, 1,390,000$ is set as a minimum rental cost saving, and reflected in the model with a constraint. The subsidiary warehouses that have been closed by mathematical model will be fed by IDSC, so under any circumstance, IDSC should be kept open, decision variable that represent IDSC should take a value of 1. Notations that are used:

D: Decenteral indices

C: Central indices

X_i : 0-1 decision variable (open-closed)

S_D , S_C : Staff cost

R_D , R_C : Rental cost

I_D , I_C : Inventory cost

O_D , O_C : Order fill rate

L_D , L_C : Line fill rate

P_D , P_C : Number of staff

M_i : Market proportion

W_i : Rate of satisfaction

With the information given above, mathematical model is formulated as:

$$\textbf{Min} \quad \sum_{i=1}^{12} \llbracket[\llbracket(S\rrbracket_D)_i\rrbracket + \llbracket(R\rrbracket_D)_i\llbracket+(I\rrbracket_D)_i]X_i$$

$$\textbf{s.t.} \quad \sum_{i=1}^{12} \llbracket[\llbracket(P\rrbracket_D)_i\rrbracket X_i + \llbracket(P\rrbracket_C)_i(1 - X_i)] \geq 15$$

$$[\![(O]\!]_D)_4 X_4 + [\![(O]\!]_C)_4 (1 - X_4) + [\![(O]\!]_D)_5 X_5 + [\![(O]\!]_C)_5 (1 - X_5) + [\![(O]\!]_D)_6 X_6 + [\![(O]\!]_C)_6 (1 - X_6)[\![+(O]\!]_D)_{12} X$$

$$[\![(L]\!]_D)_4 X_4 + [\![(L]\!]_C)_4 (1 - X_4) + [\![(L]\!]_D)_5 X_5 + [\![(L]\!]_C)_5 (1 - X_5) + [\![(L]\!]_D)_5 X_5 + [\![(L]\!]_C)_5 (1 - X_5) + [\![(L]\!]_D)_{12} X_{12} + [\![\ (L$$

$$M_4 W_4 X_4 + M_4 (1 - W_4)(1 - X_4) + M_5 W_5 X_5 + M_5 (1 - W_5)(1 - X_5) + M_6 W_6 X_6 + M_6 (1 - W_6)(1 - X_6) + M_{12} W$$

$$X_7 = 1$$

$$\sum_{i=1}^{12} [\![[[\![(R]\!]_C)_i]\!](1 - X_i)] \geq 1{,}392{,}000$$

$$\sum_{i=1}^{12} (X_i) \leq 11$$

$$X_i \geq 0 \ \ and \ integer$$

The related mathematical model is solved via LINDO package program. Each country is represented with an incidence within the model. The related decision variables are alphabetically ordered and the ones which take a value of 1 can be listed. TABLE 6 shows whether each warehouse may be kept open or closed.

TABLE 6

Outputs of Mathematical Model

Dec. Var.	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
Country	Aus.	Bel.	Dan.	Fra.	Ger.	Ita.	Nth.	Nor.	Spn.	Swz.	Swdn.	UK.
Value	0	0	0	0	0	1	1	0	0	0	0	1

The results above show that in addition to IDSC (The Netherlands), Italian and English warehouses should be kept open. The rest of the warehouses are closed and direct distribution from IDSC to each market policy is launched. But, as mentioned above mathematical model may just reflect parameters that can be formulated. So, results are just representing cost minimization goal and given constraints. This result may not represent a compromising solution.

In the next phase, alternative space with different aims is widened. The proposed solution is cost oriented so this may cause real life problems. For example; %70 of French sales are made through dealers and each dealer demands an exact shipment to its individual warehouse. But, mathematical model closed French warehouse because of the cost aspect. So, IDSC has to send all shipments to individual company warehouse. It is totally wrong due to the fact of economics of scale (FTL policy, routing problems etc.). In next step, in addition to this network alternative, new ones are formed, and decision will be made among alternative space.

Alternative Solutions

Alternative space should contain different types of options that reflect both pros and cons of the mathematical model. Due to the fact that mathematical model is based on cost minimization, alternatives based on customer satisfaction, transport optimization, and hybrid systems are added to solution space. In addition to mathematical model result, direct distribution from IDSC to each customer by closing all subsidiary warehouses, direct distribution application in predetermined pilot countries, decentralized current system with all of warehouses kept open, hybrid distribution networks are added to alternatives space. Hybrid distribution network alternative takes both cost optimization and customer satisfaction into account. According to hybrid alternative, IDSC is kept open and distribution from IDSC to countries without warehouse is centralized. As model proposed UK warehouse is kept open and French warehouse is considered as a satellite warehouse and will serve to neighborhood countries.

Multicriteria Decisions Making

After determining alternatives and criterias, technique to be used should be decided. There are so many qualitative performance factors that cannot be reflected in the mathematical model, so all factors influencing network design should be integrated in performance criterias. Performance criterias should be selected among parameters with no correlation. These criterias are: meet the need of warehouse, service level (customer specific requirements, place, timing, package style), full truck load applicability, cost reduction tradeoff, ease of constructing network (regional problems, Italy example), manageability of network, management of inventory (ABC analysis, visual management, JIT applicability), room for improvement (optimization), order/line fill rate, preclearance opportunity in customs.

The technique to be used should be determined according to nature of performance criterias. AHP is one of the most common multicriteria decision making technique, but in the given case study, the number of criterias are not convenient for AHP. So, weighted ranking method is applied as decision making technique. The criteria weights are determined by brainstorms within the project group. TABLE 7 represents criteria weights of each factor.

TABLE 7

Factor Weights

Factors	Weights
Meet the need of warehouse	9
Service level	8
Cost reduction tradeoff	8
FTL applicability	8
Ease of constructing network	6
Manageability of network	7
Preclearance opportunity	6
Management of Inventory	7
Order/Line fill rate	7
Room for improvement	6

After determining factors and their weights, score of each alternative on behalf of given performance criteria is discussed and the summation of weighted products is listed in TABLE 8, the notation p in table represents related score while Σ represent total score of given alternative. Rating of each alternative is made via dual comparisons. For example; direct shipment and pilot application alternative take minimum score in FTL criterion, because in both situation shipments from IDSC to warehouses are made whenever customer order occurs. So, number of shipments will increase and FTL capability will decrease. It is easier in hybrid systems, because satellite warehouses in UK and France would serve as a proper channel and IDSC may send shipments to most of its markets with full truck load. Another example may be the highest point to direct distribution in respect to inventory management criteria. Proper visual control techniques, JIT applications, ABC analysis may easily applied when SKUs are located in one center by direct distribution from IDSC.

TABLE 8

Decisions Table

	ALTERNATIVES:	Cost Optimum		Direct Shipment		Hybrid Alternative		Current Application (Decenteral)		Pilot Application (Direct Dist.)	
Weights	Factors	P	Σ	p	Σ	p	Σ	P	Σ	p	Σ
9	Meet the need of warehouse	6	54	4	36	7	63	9	81	9	81
8	Service level	6	48	5	40	7	56	9	72	9	72
8	Cost reduction tradeoff	8	64	10	80	7	56	3	24	4	32
5	FTL applicability	9	45	7	35	9	45	8	40	5	25
6	Ease of constructing network	7	42	5	30	6	36	5	30	5	30
7	Manageability of network	5	35	3	21	4	28	6	42	6	42
6	Preclearance opportunity	7	42	6	36	7	42	4	24	4	24
7	Management of Inventory	7	49	9	63	8	56	5	35	5	35
7	Order/Line fill rate	8	56	6	42	8	56	5	35	5	35
6	Room for improvement	7	42	8	48	8	48	6	36	3	18
			477		431		486		419		394

TABLE 8 gives information about the most compromising solution within the alternatives space. Hybrid Distribution Network is selected as implementation project. According to this alternative, satellite warehouse kept open in France will serve to Italy, France and Spain. It seems geographically feasible to consolidate the warehouse needs of the given markets. Markets with high dealer rate (need of warehouse) are served by satellite warehouse, so products will be sent from IDSC to France, after that shipments to each customer will be made from satellite warehouse. And, IDSC may implement FTL for satellite warehouse products. The main reason why satellite warehouse is opened in France is the danger of theft activities in Italy, what is more it is more convenient for transport activities. Other satellite warehouse in UK will serve to English market. That would help IDSC on overseas shipments. Order batching will be applied, and FTL shipments from IDSC to satellite warehouses will be made frequently due to the high demand rate. So, safety inventory will be kept in satellite warehouses, and this would increase service level and help to absorb demand fluctuations. The remaining markets are served by IDSC by direct distribution. %46 of all shipments will be made by IDSC via direct distribution. The German percentage is the half of %46, and Germany with %75 of its customer with huge consolidation centers do not require any warehouse in their region. In the last phase, results of given case study will be explained.

Result Analysis

Satellite warehouses are going to work like IDSC. In the proposed system, there is no obligation for all of products unloaded in IDSC. In other words, production facilities may send products directly to satellite warehouses. This may lead container congestion, but proper planning activities would solve this problem. Each satellite warehouse will work with a 3rd party logistics provider to distribute products within the market.

Markets with no warehouse will be served directly from IDSC. In these markets, regional management will be responsible for collecting orders from customers and sending them to IDSC. Due to the fact that, distribution will be made to the large wholesalers or hypermarkets' warehouses, there will be no need for a 3rd party logistics provider. What is more, centralized inventory in IDSC may be optimized, and analyzed deeply.

The problems that may be faced up with: rush orders problem, route changing problems, lack of staff ability in IDSC, coordination between partners, integrated computer system failures, strike risk, hardness of constructing network, management of network, container content variations, and regional obstacles. To prevent those problems coordination and planning of direct distribution in regional aspect will be made by subsidiary team (routing, regional problems, preclearance, rush orders etc.).

As a result, FIGURE 1 and FIGURE 2 show container flow and product flow within the European market. The triangles represent warehouses, and rectangles represent production facilities.

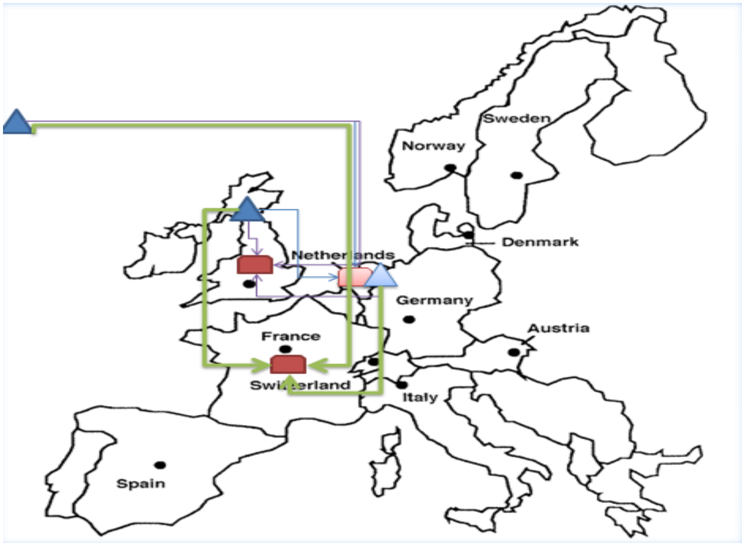

FIGURE 1

Shipments from Production Facilities to Warehouses

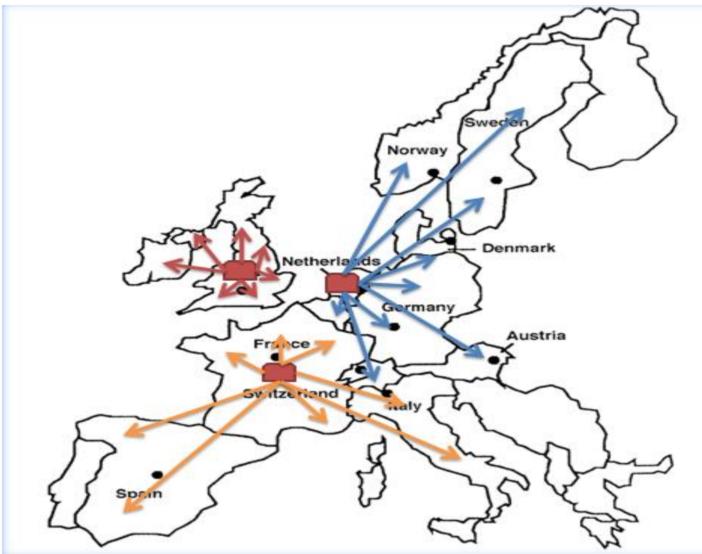

FIGURE 2

Shipments from Warehouses to Customers around Europe

CONCLUSION

A decision support system algorithm is developed to design a distribution network regarding both qualitative and quantitative factors. The algorithm can be applied to various types of distribution network design problems, so that may be considered as a generic flow. The model proposed a compromising solution by considering a number of criterias in respect to distribution network design problem. A very well known case study published by Harvard Business School is solved by the proposed algorithm. Finally, this model can be expanded to more specific performance criterias and more convenient multicriteria technique may be applied.

As a result, this paper describes a generic hierarchical decision support system to distribution network design problem. The proposed DSS (Decision Support System) takes not only the quantitative but also the qualitative factors into account. The DSS firstly constructs cost optimum network by using a mathematical model, after that; A multicriteria decision making technique is applied to find the most desired network according to qualitative factors. The proposed DSS is applied to a well-known case study: “Polaroid: European Distribution System”, after that the efficiency of the procedure and future studies are discussed.

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OPTIMIZING FLEXIBLE SUPPLY CHAIN NETWORKS WITH IMPLICATIONS OF CROSS-DOCKING AND CONSOLIDATION SERVICES

Turan Paksoy [1], Eren Özceylan [2]

Abstract — *Enterprises desire to decrease their supply costs and increase the customer satisfaction to cope the pressures caused by globalization. To provide and keep the efficient of supply chains, there are some techniques that can improve the overall efficiencies of the logistics and distribution operations. Building the supply chains in a flexible structure which provides integrated decision making among the chain members with effective knowledge sharing is one of these techniques. Besides maximizing the competitive advantage, flexible supply chains with nonadjacent structure have advantages such as short response time and delivery path, less transportation costs and bullwhip effect. To expand the benefits of flexible networks, cross-docking and consolidation services should be embedded to chain. Because consolidation provides reducing the inventory levels and improving on time delivery via combining shipments into truckload. Also cross-docking ensures continuous flow of the items from resource to customer via receiving goods and quickly preparing them for re-shipment (less handling, no inventory). In this study, we developed a mathematical model to prove the practicality of these techniques in the supply chain networks. We showed the benefits of cross-docking and consolidation services on the whole network performance via an illustrative example. Getting the optimized results of the model demonstrates the robustness of the proposed model.*

Keywords — *Consolidation, cross-docking, flexible supply chains, network optimization.*

INTRODUCTION

As the development of economic globalization and extension of global electronic marketing, global enterprise services supported by universal supply chain and worldwide logistics become imperative for business world. How to manage logistics system efficiently thus has become a key issue for many companies to control their costs [1]. For managing the logistics system effectively, decisions about the distribution system are a strategic issue for almost every company. The problem of locating facilities and allocating customers (optimization the supply chain) covers the core components of distribution system design [2].

Optimization the supply chain flow is the problem of determining the configuration of a supply chain, i.e., what suppliers, parts, processes and transportation options (modes) to select at each stage in the supply chain. Raw material can be procured from different suppliers; products can be manufactured or assembled on different machines; finished goods can be shipped through different modes. Each option differs in lead time and cost reflecting the time-cost trade-off. The goal of supply chain optimization is to select the options and thus the configuration of supply chain so that some supply chain metric is minimized [3].

Traditional supply chains are not sufficient anymore to meet the customer's demands. So the decision makers have to develop their chains to flexible ones. Flexibility is further broken into the capabilities of promptness and the degree to which a firm can adjust its supply chain speed, destinations and volumes. In supply chains, where material moves sequentially from one trading partner to the next, firms have recognized that to be responsive to end customer demand, all partners in the chain must be flexible in responding to change [4].

The role of logistics in the distribution side is becoming more significant in light of continuously increasing consumer demand; the volume of orders decreases while their frequency increases, and the time for receiving goods becomes shorter. Fast moving consumer goods practices have attracted considerable interest

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from consumers and policy-makers because a well-functioning retail sector is essential for daily provision of consumers demand at high quality and low cost [5]. Cross-docking, consolidation, milk-run systems, warehouse management etc. are some of the applications which provide better cost, lead time, quality, responsiveness for the whole chain.

In this paper cross-docking and consolidation services are considered to achieve optimal operational performance in a supply chain, production and distribution functions. Besides, significant cost savings in transportation and consequently in logistics can be obtained through shipment consolidation considerations by means of the better utilization of transportation vehicle capacities. A simple definition of cross-docking is as followings: receiving product from a supplier or manufacturer for several end destinations and consolidating this product for common final delivery destinations. The key to the process is trans-shipping, not holding stick [6]. The aim of this study is to show the significance difference between traditional supply chain network and a new network added cross-docking and consolidation. This study concerns with shipment consolidation policy in a cross-dock, which consolidates different product items produced and used at different locations and different times, into single vehicle loads in order to get the benefit of the economy of the scale and utilization truck capacity. We show the benefits of cross-docking and consolidation services on distribution network via developing a nonlinear mixed integer programming model. A numerical example is solved to demonstrate the feasibility of applying the proposed model to show the benefits of cross-dock and consolidation services, and also different scenarios are discussed.

The outline of the work is as follows: In Section 2 gives a small literature reviews on cross-docking and consolidation. Section 3 provides the proposed nonlinear mixed integer programming model. Then, Section 4 covers a variety of applications with hypothetical data. Finally, we close the paper with conclusion and suggestions.

LITERATURE REVIEW

Cross-docking is a relatively new warehousing strategy in logistics. It is defined as the consolidation of products from incoming shipments so that they can be easily sorted at a distribution center for outgoing shipments (Fig. 1). The distribution center in this case is referred to as a cross-dock. It essentially eliminates the inventory holding function of a traditional warehouse while still allowing consolidation. The shipments arriving from disparate sources are regrouped and dispatched directly by the outgoing trailers without being stored. Shipments typically spend less than 24 hours at the cross-dock, sometimes less than an hour [7].

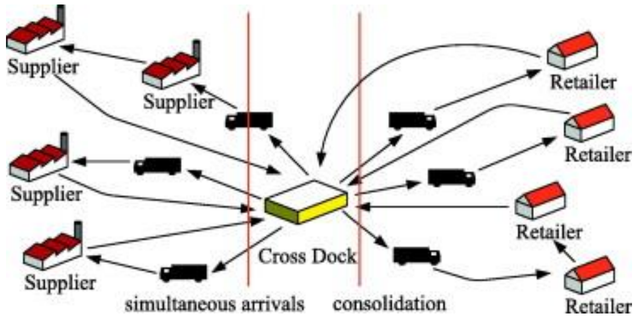

FIGURE 1
The Concept of Cross-Docking [8]

The cross-docking service mode has attracted a great attention in both academic research and industrial practice in recent years. Due to its remarkable benefits, cross-docking has been widely adopted in practice by manufacturing and retailing companies. A successful application of cross docking is found at Wal-Mart, the largest and highest profit retailer in the world. In the system used by this company, products are continuously delivered to Wal-Mart's cross-docks, where they are selected, repacked, and then dispatched to stores, often without ever sitting in inventory. By avoiding spending valuable time and handling inventory cost, cross-docking has enabled Wal-Mart to adopt an everyday low price strategy and has helped the company improve its market share and profitability [7].

Most studies on cross-docking discuss the concept of cross-docking, its physical design, or location determination. The decision problems to be solved during the life cycle of a cross docking terminal ordered from strategic to operational are as follows [9]:

(i) Location of cross docking terminal(s).
(ii) Layout of the terminal.
(iii) Assignment of destinations to dock doors.
(iv) Vehicle routing.
(v) Truck Scheduling.
(vi) Resource scheduling inside the terminal.
(vii) (Un-) Packing loads into (from) trucks.

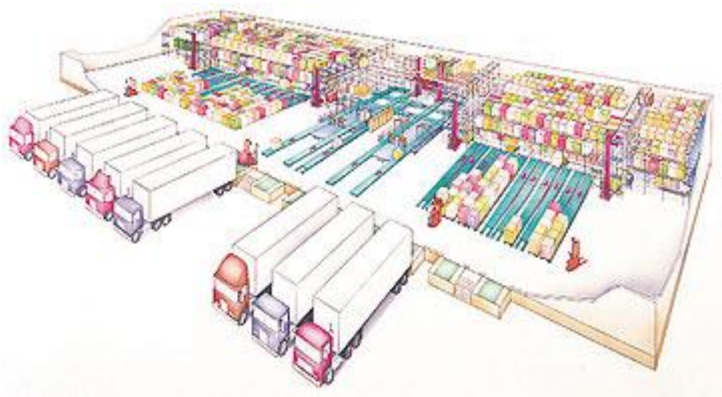

FIGURE 2
Inside of a Cross-Dock [10]

Harrington [11] argue that cross-docking works best with goods that have large volumes and relatively predictable demand, and that there are also risks, such as shortage and customer service degradation for cross-docking if it is poorly executed. Li et al. [12] study a problem central to cross-docking that aims to eliminate or minimize storage and order picking activity using JIT scheduling. The problem is modelled naturally as a machine scheduling problem. As the problem is NP-hard, and for real-time applications, they designed and implemented two heuristics. In order to consider cross-docking from an operational viewpoint, an integrated model considering both cross-docking and vehicle routing scheduling is treated in Lee et al. [13]'s study. Since this problem is known as NP-hard, a heuristic algorithm based on a tabu search algorithm is proposed. In the numerical example, their proposed algorithm found a good solution whose average percentage error was less than 5% within a reasonable amount of time.

Vis and Roodbergen [14] focus on the process of short-term storage of unit-loads in a cross-docking environment. The goal is to determine temporary storage locations for incoming unit load such that the travel distances of the forklift trucks with these unit loads are minimised. They model this problem as a novel application of the minimum cost flow problem and show the applicability of the model for different types of layouts and priorities. Ross and Jayaraman [15] address an evaluation of new heuristics solution procedures for the location of cross-docks and distribution centers in supply chain network design. The model is characterized by multiple product families, a central manufacturing plant site, multiple cross-docking and distribution center sites, and retail outlets which demand multiple units of several commodities. They describe two heuristics that generate globally feasible, near optimal distribution system design and utilization strategies utilizing the simulated annealing methodology.

Boysen and Fliedner [9] introduce a classification of deterministic truck scheduling. With the help of this classification, existing literature is reviewed and future research needs are identified. Moreover, they represent a yet unexplored class of truck scheduling problems which is highly relevant in real-world distribution networks. Vahdeni and Zandieh [16] apply five meta-heuristic algorithms: genetic algorithm (GA), tabu search (TS), simulated annealing (SA), electromagnetism-like algorithm (EMA) and variable neighbourhood search (VNS) to schedule the trucks in cross-dock systems such that minimize total operation time when a temporary storage buffer to hold items temporarily is located at the shipping dock. The proposed procedure is based on the response surface methodology. Two different types of objective functions are considered to develop multiple objective decision making model. Liao et al. [8] consider a model that integrates cross-docking into the vehicle routing problem. In the model, a set of identical vehicles are used to transport goods from supplies to retailers through a cross-dock and the whole process must be completed in the planning horizon. Each supplier and retailer can be visited only once and the total quantity of goods in a vehicle must be less than its capacity. The objective of the problem is to determine the number of vehicles and a set of vehicle schedules with a minimum sum of operational cost and transportation cost.

Besides aforementioned studies, the contribution of this paper is to present and illustrate benefits of cross-docking and consolidation centers in optimizing the supply chain networks. Proposed model proves that the network optimization with cross-dock provides better cost savings and truck capacity utilization than non cross-dock network. A new nonlinear mixed integer programming model is developed to obtain significant cost savings in transportation and consequently in logistics through shipment consolidation considerations by means of the better utilization of transportation vehicle capacities.

PROBLEM DEFINITION

In this section, the proposed model is given with its mathematical formulation. The beginning model is developed for a single echelon supply chain network which consists of manufacturing facilities and retailers. After giving the basic model, the supply chain network is re-structured via embedding a cross-dock and new model is developed. The aim of the proposed approach is the cost minimization of the production and transportation activities simultaneously, while satisfying the demand requirements with consolidated shipments. The following notations are used to formulate the mathematical model;

Indices

i *the set of manufacturing facilities; i: 1,……, I.*
j *the set of retailers; j: 1,….., J.*
p *the set of product items; p: 1,….., P.*

Parameters

I *number of manufacturing facilities.*
J *number of retailers.*
P *number of product items.*
C *a per-mile operating cost of truck ($).*
d_{ij} *the distance from node i and node j (mile).*
r_{jp} *the demand of retailer j for product p (unit).*
Ca_{ip} *the production capacity of manufacturer i for product p (unit).*
V_p *the volume of product p* (m^3).
Vol *the volume of truck* (m^3).

Decision Variables

Y_{ijp} *the shipment number between manufacturer i and retailer j of product p; 1 if assigned between i and j, otherwise 0.*
Q_{ijp} *the amount of product p transported from manufacturer i to retailer j.*
S_{ijp} *slack variable for* ijp^{th} *constraint.*
P_{ip} *the production amount of product p at manufacturer i.*

The mathematical representation for the problem is then formulated in a nonlinear mixed integer programming model as follows. The objective function is to minimize the total logistics cost, including transportation costs according to number of shipments between manufacturer *i* and retailer *j*.

Objective Function

$$Min \sum_i \sum_j \sum_p Y_{ijp} \cdot d_{ij} \cdot C \tag{1}$$

Constraints

$$P_{ip} - \sum_j Q_{ijp} \qquad \forall_{i,p} \tag{2}$$

$$\sum_i Q_{ijp} = r_{jp} \qquad \forall_{j,p} \tag{3}$$

$$P_{ip} \le Ca_{ip} \qquad \forall_{i,p} \tag{4}$$

$$Y_{ijp} \ge V_p \cdot Q_{ijp} / Vol \qquad \forall_{i,j,p} \tag{5}$$

$$V_p \cdot Q_{ijp} / Vol - Y_{ijp} + S_{ijp} = 0 \qquad \forall_{i,j,p} \tag{6}$$

$$P_{ip}, Q_{ijp}, Y_{ijp} \geq 0 \qquad \forall_{i,j,p} \qquad (7)$$

Equation (2) is the constraint that equals the total production amounts to the product amounts which are transported from manufacturers to retailers. Equation (3) is the constraint that provides production satisfies demand by determining production quantities. Equation (4) is the production capacity constraint. It guarantees that the production capacity can not be exceeded. Equation (5) determines the number of shipments between node *i* and *j* while dividing the shipments volume to truck volume. Equation (6) guarantees that the number of shipments (Y_{ijp}) is an integer. Finally, Equation (7) assures all variables are positive integer.

Extended Model with Cross-Docking

The previous model is a basic supply chain network design problem with multi products and single stage. In this section, the extended mathematical model which a cross-dock is added into the network is given with its formulation.

For the first model of the proposed approach, extended cross-docking model is developed by modifying the previously defined model. The new model considers production, distribution issues, consolidation, cross-docking while determining the production volumes and allocation of this production to demands. In addition, direct shipments are considered between manufacturer-cross dock and cross dock-retailers instead of direct shipments between manufacturer-retailers. The shipment consolidation of different retailers is considered in the extended model with vehicle assignments. Vehicle assignments between two echelons are done by considering the amount of production shipped, vehicle capacities, demands and product's volumes.

The objective function is still minimization of the total cost. But the new model is applied to a new network which is consisting of two stages. So the new model's objective function is;

$$Min \sum_i T_i \cdot d_i \cdot C + \sum_j S_j \cdot d_j \cdot C \qquad (8)$$

The objective function (8) minimizes the transportation cost via realizing the shipments with minimum number of shipments if there are shipments from *i* to cross-dock and from cross-dock to *j*. While T_i and S_j are the number of shipments from manufacturer *i* to cross-dock and from cross-dock to retailer *j*; d_i and d_j are the distances between nodes, respectively.

The production capacities and demands constraints (2, 3 and 4) are still the same with the firstly developed model.

$$T_i \geq V_p \cdot \sum_j \sum_p Q_{ijp} / Vol \qquad \forall_i \qquad (9)$$

$$V_p \cdot \sum_j \sum_p Q_{ijp} / Vol - T_i + F_i = 0 \qquad \forall_i \qquad (10)$$

$$S_j \geq V_p \cdot \sum_i \sum_p Q_{ijp} / Vol \qquad \forall_j \qquad (11)$$

$$V_p \cdot \sum_i \sum_p Q_{ijp} / Vol - S_j + H_j \qquad \forall_j \qquad (12)$$

$$P_{ip}, Q_{ijp}, T_i, S_j \geq 0 \qquad \forall_{i,j,p} \qquad (13)$$

Equation (9) determines the number of shipments between node *i* and cross-dock while dividing the shipments volume to truck volume. Equation (10) guarantees that the number of shipments (T_i) is an integer via slack variable F_i. Equation (11) determines the number of shipments between cross-dock and node *j* while dividing the shipments volume to truck volume. Equation (12) guarantees that the number of shipments (S_j) is an integer via slack variable H_j. Finally, Equation (13) assures all variables are positive integer.

ILLUSTRATIVE EXAMPLE

In order to illustrate the proposed methodology, an example with 3 manufacturing facilities and 9 retailers, where manufacturer's produce 2 different products is used (Fig. 3).

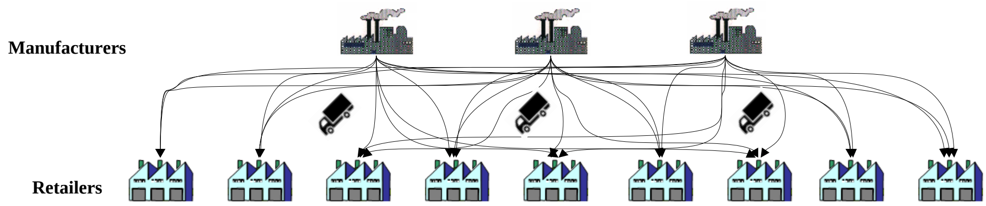

FIGURE 3
Before the Cross-Docking

The location coordinates of manufacturing facilities and retailers are given in Table 1. Euclidian distances are used as in Equation (14) for the nodes with given 2D coordinates where X_i and X_j are the X-axis values of node i and j respectively. Similarly, Y_i and Y_j are the Y-axis of node i and j. d_{ij} denotes the distance between node i and node j. The unit of distance is considered as miles.

$$d_{ij} = \sqrt{\left(\left(X_i - X_j^{\ 2}\right) + \left(Y_i - Y_j^{\ 2}\right)\right)} \qquad \forall_{ij} \qquad (14)$$

TABLE 1
Coordinates of Manufacturers and Retailers [17]

Coordinates	Manufacturers			Retailers								
	1	2	3	1	2	3	4	5	6	7	8	9
X	292	336	314	298	309	307	320	321	322	335	305	323
Y	495	475	435	427	445	464	439	470	437	450	453	429

The locations of the manufacturers and retailers are shown in Fig. 4, where manufacturers illustrated with quadrilaterals and retailers with squares. The capacity of vehicle is 35 m^3 (*Vol*). A per-mile operating cost (*C*) of vehicle is \$1.25 [18]. Volume of product A is 0.48 m^3 (V_1); volume of product B is 0.192 m^3 (V_2).

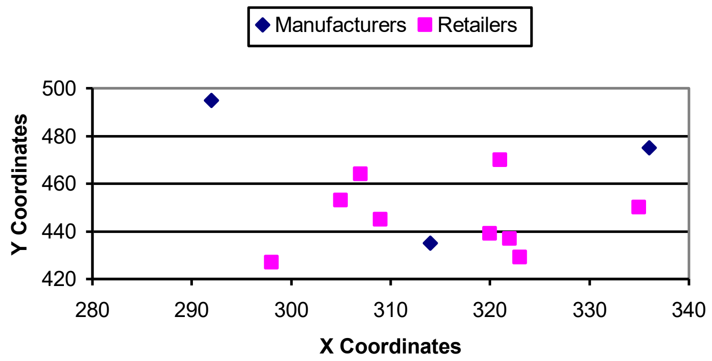

FIGURE 4
Location of Manufacturers and Retailers

Additionally, the demands of retailers and capacities of manufacturers for different type of products are shown below.

TABLE 2
Demands of Retailers and Capacities of Manufacturers

	Retailers									Manufacturers		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**1**	**2**	**3**
Product A	40	45	44	44	43	43	49	47	47	140	130	140
Product B	42	46	43	45	42	45	48	46	48	150	150	150

The model is solved by using LINGO 11.0 solver on a Pentium IV 3 GHz 4 GB Ram personal computer for the parameters presented above, with the intention of obtaining optimal values. Obtained optimal solution with 169 variables and 140 constraints under 22 seconds elapsed time is given in Table 3.

TABLE 3
Optimization Results

Variable	Value	Variable	Value	Variable	Value	Variable	Value	Variable	Value
Y_{121}	1	**Y_{252}**	1	**Y_{392}**	1	**Q_{251}**	43	**Q_{391}**	47
Y_{122}	1	**Y_{271}**	1	**Q_{121}**	45	**Q_{252}**	42	**Q_{392}**	48
Y_{131}	1	**Y_{272}**	1	**Q_{122}**	46	**Q_{271}**	49	**P_{11}**	136
Y_{132}	1	**Y_{311}**	1	**Q_{131}**	44	**Q_{272}**	48	**P_{12}**	135
Y_{181}	1	**Y_{312}**	1	**Q_{132}**	43	**Q_{311}**	40	**P_{21}**	126
Y_{182}	1	**Y_{341}**	1	**Q_{181}**	47	**Q_{312}**	42	**P_{22}**	135
Y_{241}	1	**Y_{361}**	1	**Q_{182}**	46	**Q_{341}**	10	**P_{31}**	140
Y_{242}	1	**Y_{362}**	1	**Q_{241}**	34	**Q_{361}**	43	**P_{32}**	135
Y_{251}	1	**Y_{391}**	1	**Q_{242}**	45	**Q_{362}**	45	**Cost**	629.50 $

When the proposed model is solved for the given example, total cost is found out to be 629.50$. All retailers' demands are satisfied. Totally 19 different shipments are actualized between facilities. The optimal results are also illustrated in Fig. 5. The produced quantities of each product type in manufacturers along with the transported quantities between sites in the optimal solution, number of shipments and also the utilization ratio of each truck (%) can also be seen in Fig. 5. Without a cross-dock, total utilization ration of 19 shipments is % 40.

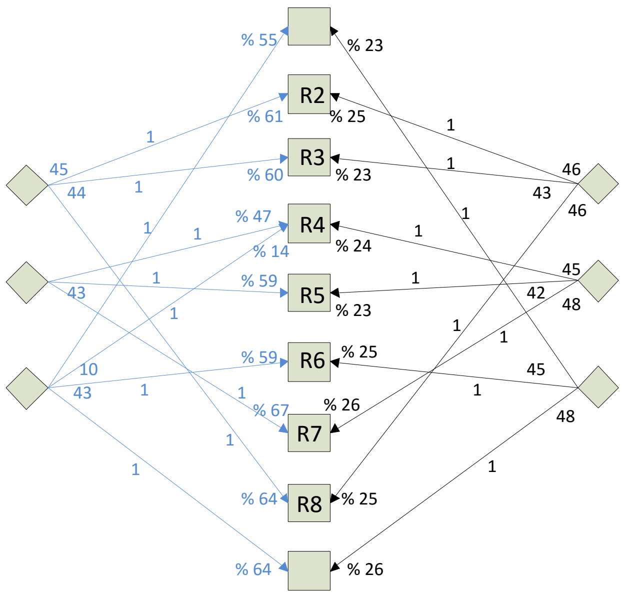

FIGURE 5
Optimum Distribution Network

Under the same capacities and demands, we try to decrease total transportation cost and increase total utilization ratio of shipments with a cross-dock and consolidation service. We use Equation (15) to locate a cross-dock in current network. Thus, the cross-dock is located on a location which is closest to the market with high demand.

$$X = \frac{\sum_j \sum_p r_{jp} \cdot X_j}{\sum_j \sum_p r_{jp}} \qquad Y = \frac{\sum_j \sum_p r_{jp} \cdot Y_j}{\sum_j \sum_p r_{jp}} \tag{15}$$

Cross-dock's location coordinates are obtained from Equation (15) as (X: 316; Y: 446) seen Fig. 6.

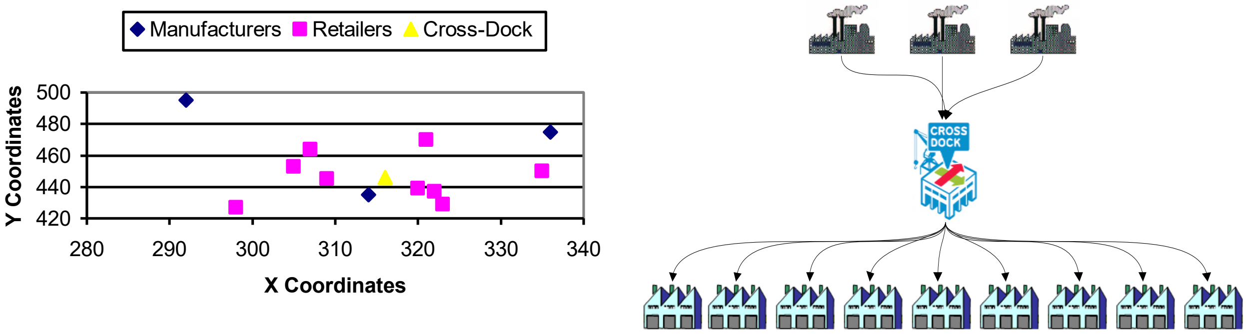

FIGURE 6
Location of Manufacturers, Retailers and Cross-Dock

Cross-Dock model is also solved by using LINGO 11.0 solver on a Pentium IV 3 GHz 4 GB Ram personal computer for the parameters presented previous, with the intention of obtaining better cost and utilization ratios. Obtained optimal solution with 96 variables and 79 constraints under 4 seconds elapsed time is given in Table 4.

TABLE 4
Optimization Results of Cross-Dock Model

Variable	Value	Variable	Value	Variable	Value	Variable	Value	Variable	Value
T_1	3	S_8	1	Q_{181}	40	Q_{271}	49	Q_{191}	11
T_2	3	S_9	1	Q_{191}	13	Q_{281}	7	Q_{322}	43
T_3	3	P_{11}	140	Q_{112}	42	Q_{291}	23	Q_{332}	42
S_1	1	P_{12}	150	Q_{122}	3	Q_{252}	24	Q_{372}	47
S_2	1	P_{21}	122	Q_{132}	1	Q_{262}	5	Q_{382}	12
S_3	1	P_{22}	110	Q_{142}	45	Q_{282}	34	Q_{392}	1
S_4	1	P_{31}	140	Q_{152}	18	Q_{292}	47	**Cost**	562.01 $
S_5	1	P_{32}	145	Q_{162}	40	Q_{311}	40		
S_6	1	Q_{141}	44	Q_{172}	1	Q_{321}	45		
S_7	1	Q_{161}	43	Q_{251}	43	Q_{331}	44		

When the cross-dock model is solved for the given example, total cost is found out to be 562.01$. All retailers' demands are satisfied. Totally 18 different shipments are actualized between facilities. The optimal results are also illustrated in Fig. 7. The produced quantities of each product type in manufacturers along with the transported quantities between sites in the optimal solution, number of shipments and also the utilization ratio of each truck (%) can also be seen in Fig. 7. With a cross-dock, total utilization ration of 18 shipments is % 86.

Optimal solutions show that cross-dock and consolidation services pull the transportation costs from 629.50$ to 562.01$ with a % 10.7 difference. Also the utilization ratio of shipments capacity is increased from % 40 to % 86.

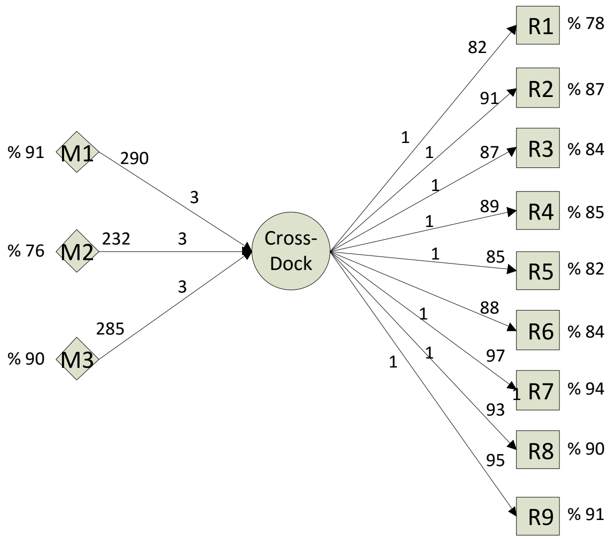

FIGURE 7
Optimum Distribution of Cross-Dock Model

Performance Evaluation of the Proposed Models

When the results are examined, it is seen that some capacity restrictions for trucks or volumes of products affect the model directly. By changing the capacity limitations of vehicles and products volumes, different scenarios can be applied to the model to examine the relations and trade-offs among basic and cross-dock model. Therefore, the solution of the model without any scenario and the results of the developed 4 scenarios are compared in this section. The scenarios are listed below:

Scenario 1: Increasing 8 times the capacity of vehicle from 15 m^3 to 50 m^3 for the first model.

Scenario 2: Increasing 6 times the volume of products from % 25 to % 150 for the first model.

Scenario 3: Increasing 8 times the capacity of vehicle from 15 m^3 to 50 m^3 for the cross-dock model.

Scenario 4: Increasing 6 times the volume of products from % 25 to % 150 for the cross-dock model.

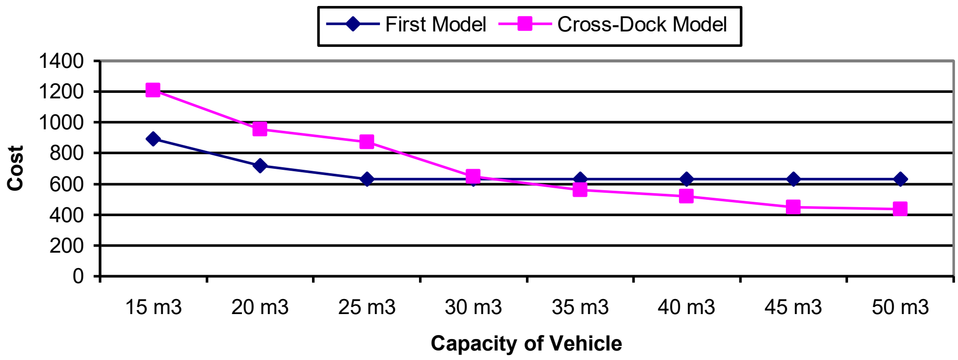

FIGURE 8
Scenario 1 and 3 on Costs

Fig. 8 shows the effects of changing vehicle capacity on transportation costs of first model and cross-dock model. According to Scenario 1 and 3, increasing the capacity of vehicle does not affect transportation cost of first model. At first, there is a bit reduction but after it is 25 m^3, the transportation cost of first model follows a smooth way. After the point (30 m^3) which is both transportation costs are the same, cross-dock model gives a better solution. This analysis shows that cross-docking and consolidation services provide more benefits when the trucks capacity is high.

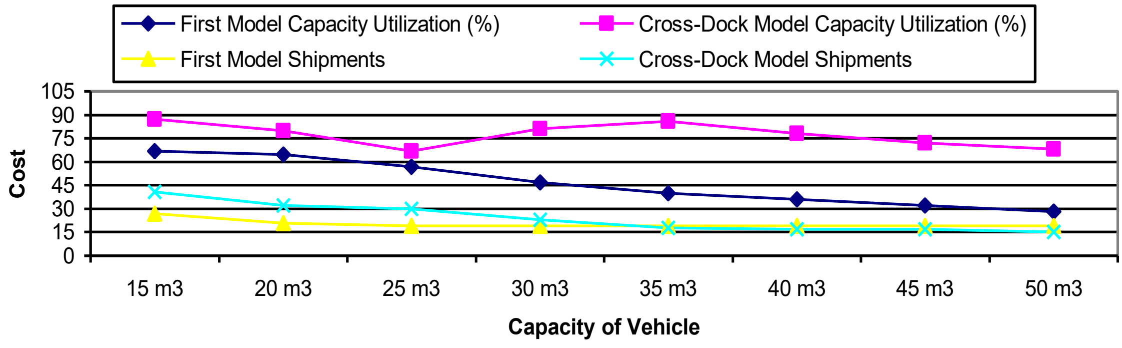

FIGURE 9
Scenario 1 and 3 on Shipments and Capacity Utilization

Fig. 9 shows that there is a better vehicle capacity utilization rates in cross-docking model according to first model. While increasing the capacity of vehicle, vehicle utilization is decreased continuously in the first model. Because of no changes on demand or product volume, the number of shipments is constant in the first model. But, total shipments are decreasing in cross-dock model because of consolidation.

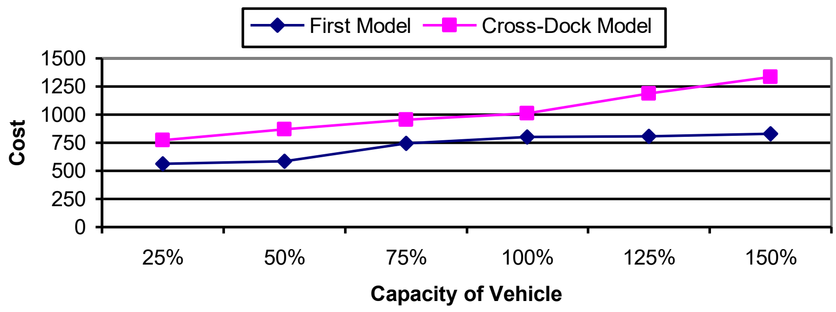

FIGURE 10
Scenario 2 and 4 on Costs

Figures 10 and 11 show that increasing the volume of products also increase the transportation costs for two models due to increased shipments. According to increased products volume, cross-dock model provides a better vehicle capacity utilization ratio than the first model.

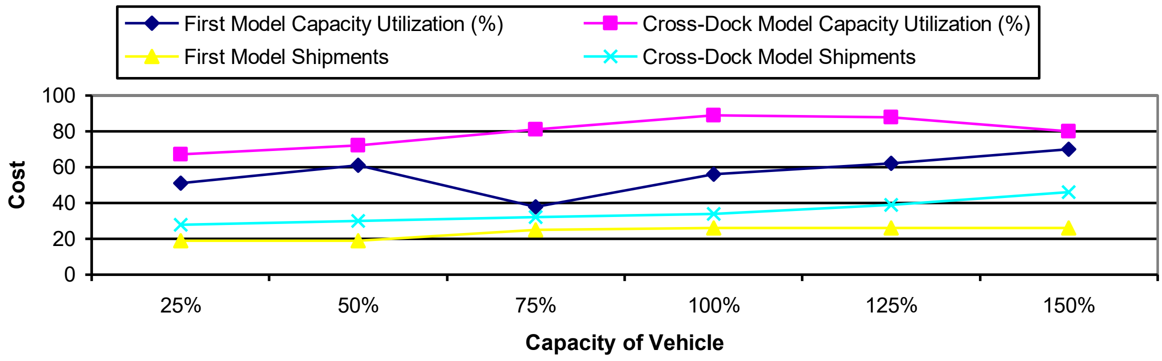

FIGURE 11
Scenario 2 and 4 on Shipments and Capacity Utilization

CONCLUSION

In this study, a supply chain network optimization problem is handled. We have presented a cross-dock and consolidation services and have illustrated its worth. To cope with this issue, a two step solution methodology is proposed. At first step, a nonlinear mixed integer programming model is developed. It is applied to determine the transported quantities between manufacturers and retailers in one stage-multi product network problem. The second step considers with the transportation of the allocated production to the retailers with lower transportation cost, location a cross-dock involving consolidation. In order to present affects of cross-docking, an illustrative example and scenario analyses are used. In conclusion, according to results of various trials, proposed approach gives when cross-docking have good quality solutions in which truck's and product's volumes.

In future, truck scheduling, truck-to-door assignment and inventory problems can be handled in cross-docking activities. And also some heuristics methods should be proposed for large scale instances due to the high complexity and real-time nature of cross-docking operations for reducing the computing time needed to optimize solutions to these problems.

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METHODS USED IN LOGISTIC NETWORK DESIGN

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Abstract — *As the competition among global supply chains get tougher, more focus is given to the optimization of logistic network in order to create competitive advantages. A logistics network consists of suppliers, warehouses, distribution centers and retail stores through which raw materials and products flow. Logistic Network Design allows decisions on numbers, location and capacities of facilities; selection of suppliers; assignment of products to facilities; designation of distribution channels and definition of raw material and product flows, with the objectives to minimize purchasing, production, warehousing and transportation costs. This study aims to analyze deterministic, heuristic and stochastic methods used in design. The studies are clustered in terms of search space, search process, adaptation and dynamism achieved by adaptation of changes in design. It is observed that there is a gap in effective adaptation to change which can be filled by using a recent technique called Hyperheuristic, which provides advantages for adaptation of changes in Logistic Network Design.*

Keywords —Logistic Network Design Problem, Hyperheuristic Methods, Facility Allocation, Distribution

INTRODUCTION

Today's global world encourages enterprises to raise their customer satisfaction along with the control and reduction in all cost items. Based on this point, companies managing supply chain efficiently and regularly, gain competitive advantage over rivals by lowering costs and meeting customer demands. One of the most important decisions in Supply Chain Management is the planning and design of logistic networks.

Logistic Network Design (LND) generally deals with potential facility locations, capacities, allocation of customer regions, determination of distribution channels, supplier selection, inventory strategies and vehicle routing [1]. In literature, recent studies are highly motivated from sub sections of LND by implementing Exact, Heuristic and Metaheuristic methods. These techniques produce high quality solutions under deterministic and static circumstances; however as for dynamic real life implementations they are not robust and adaptive enough for generating applicable results. Hyperheuristic Algorithms provide a brief problem independent structure and abstraction from solution space for responding this requirement [3]. This paper is so organized that, firstly LND will be explained in summary, then literature survey for LND based on [2] will be presented and Hyperheuristic methods will be examined as a starting task for dissertation project.

LOGISTIC NETWORK DESIGN (LND)

A firm's logistic network consists of elements like supplier facilities, factories, warehouses, distribution centers, customers and flows between these elements for raw material and product transportation [2]. The traditional LND problem is defined as the following: given a set of facilities including potential suppliers, potential manufacturing facilities and distribution centers with multiple possible configurations and a set of customers with deterministic demands, determine the configuration of the production-distribution system between various subsidiaries of the corporation such that seasonal customer demands and service requirements are met and the profit of the corporation is maximized or the total cost is minimized [28]. It is an

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important and strategic operations management problem in Supply Chain Management. In LND, the following issues have to be given high consideration as to strategic, tactic or operational decisions [8]:

- Location selection for factories, distribution centers and warehouses from alternative places
- Supplier selection, assignment of raw materials to suppliers
- Allocation of production, warehousing and distribution facilities for each product
- Selection of distribution channels and transportation types

Figure 1 shows an integrated LND that consists of forward and reverse logistics, which has four layers of transportation. From Graph Theory point of view, this structure is a graph with facilities and customers as nodes and flows as directed arcs [25]. LND problem can be generally defined as decision of opening facilities and establishing linkage between nodes regarding facilities' capacity, in order to fulfill customer demands.

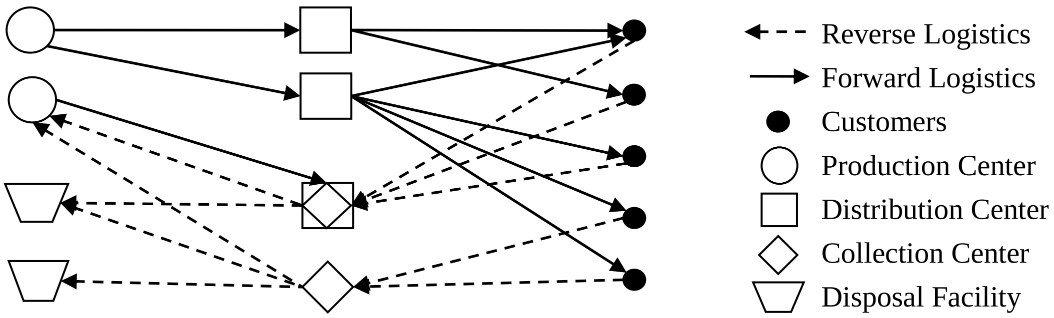

FIGURE 1
Forward and Reverse Logistic Network Design

General objective of LND is to minimize supply chain costs including fixed, procurement, production, warehousing and transportation costs through meeting customer demands fully. In literature, improving robustness ([34], [44]) and responsiveness are also taken into account. Other possible objectives include, but are not limited to maximization of market share, return on investment, asset utilization, or minimization of inventory, etc. Table 2 gives a summary for LND literature through attributes, methods and implementations. Abbreviations used in this table are described in Table 1. Considering Table 2, LND problems can be evaluated in four dimensions. First dimension is the decision level including strategic, tactic and operational. For instance, selection location from potential places is a strategic and routing vehicles is an operational decision. Second dimension is the functional level such as facility allocation, stock policy and routing between customers. Third dimension is about Exact and Heuristic methods used for solving LND problem and the last dimension is the application field like automotive sector.

TABLE 1
Abbreviations for Logistic Network Design Literature Survey

Description / Header	Abbreviation	Description / Header	Abbreviation
Logistics Network Stages	LNS	**Problem Definition**	
Forward Logistics Stages	F	**Period**	
Distribution Centers	DisC	Multi Period	MPr
Production Centers	PC	Single Period	SPr
Supply Centers	SC	**Number of Facilities Opened**	
Reverse Logistics Stages	R	Endogenous (undetermined)	En
Redistribution Centers	RdisC	Exogenous (determined)	Ex
Disposal Centers	DC	**Product**	
Recycling Centers	RYC	Single-Product	SP
Recovery Centers	RCC	Multi-Product	MP
Collection/Inspection Centers	CIC	**Flow capacity**	
Integrate Logistics Stages	E	Uncapacitated Flow	UCF
Objectives	Obj.	Capacitated Flow	CF
Max Robustness	Ro	**Demand**	
Max Responsiveness	Res	Stochastic	S
Min Cost/Max Profit	C	Deterministic	D
Output		**Facility Capacity**	
Inventory	I	Uncapacitated	UC
Number of Vehicles	NV	Capacitated	Ca
Demand Satisfaction Quantity	DS		
Price of Products	P	**Modeling**	
Transportation Amount	TA	Continuous Approximation	CA
Service Region	SR	Stochastic Mixed Integer Programming	SMIP
Facility Capacity	FC	Mixed Integer Non-Linear Programming	MINLP
Location/Allocation	L	Mixed Integer Linear Programming	MILP

TABLE 2
Logistic Network Design Problem Literature Survey

Authors	Year	LNS	Facilities	Sector	Problem Description	Model	Output	Obj.	Method
Marin and Pelegrin [33]	1998	R	PC	Virtual	UC, D, UCF, SP, En, SPr	MILP	L, TA	C	Lagrangian Relaxation
Jayaraman et al. [16]	1999	R	CIC, RCC, RdisC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C	Exact Methods
Krikke et al. [23]	1999	R	CIC, RCC, RdisC	Electronics	UC, D, UCF, SP, Ex, SPr	MILP	L, TA, I	C	Exact Methods
Sabri and Beamon [44]	2000	F	SC, PC, DisC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C, Ro	Exact Methods
Jayaraman and Pirkul [18]	2001	F	SC, PC, DisC	Health	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C	Lagrangian Relaxation
Dasci and Verter [9]	2001	F	PC	NA	UC, D, UCF, SP, En, SPr	CA	L, SR	C	Continous Approximation
Fleischmann et al. [13]	2001	E	CIC, RCC, PC, DisC	Electronics	UC, D, UCF, SP, En, SPr	MILP	L, TA, DS	C	Exact Methods
Syarif et al. [51]	2002	F	SC, PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Genetic Algorithm
Zapfel and Wasner [56]	2002	F	SC, PC, DisC	Packaging	Ca, D, CF, SP, En, SPr	MILP	L, TA	C	Exact Methods
Jayaraman and Ross [19]	2003	F	PC, DisC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C	Tabu Search
Sung and Song [50]	2003	F	PC, DisC	Virtual	UC, D, UCF, SP, En, SPr	MILP	L, NV	C	Simulated Annealing
Jayaraman et al. [17]	2003	R	PC, RCC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Simple Heuristic
Miranda and Garrido [40]	2004	F	PC, DisC	Virtual	Ca, S, UCF, SP, En, MPr	MINLP	L, TA	C	Lagrangian Relaxation
Yeh [54]	2005	F	SC, PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Simple Heuristic
Melachrinoudis et al. [35]	2005	F	SC, PC, DisC	Packaging	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C, Res	Exact Methods
Listes and Dekker [29]	2005	R	CIC, RYC	Construction	Ca, S, UCF, MP, En, SPr	SMIP	L, TA	C	Exact Methods
Amiri [5]	2006	F	PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, FC, TA	C	Lagrangian Relaxation
Gen et al. [14]	2006	F	PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Genetic Algorithm
Altiparmak et al. [4]	2006	F	SC, PC, DisC	Plastics	Ca, D, UCF, SP, En, SPr	MINLP	L, TA	C, Res	Genetic Algorithm
Min et al. [37]	2006	R	CIC, RCC	Virtual	UC, D, UCF, SP, En, MPr	MINLP	L, TA	C	Genetic Algorithm
Salema et al. [45]	2006	E	CIC, RCC, PC, DisC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, TA, DS	C	Lagrangian Relaxation
Cordeau et al. [1]	2006	F	SC, PC, DisC	Virtual	Ca, D, CF, SP, En, SPr	MILP	L, FC, TA	C	Benders Decomposition
Shimizu et al. [49]	2006	F	SC, PC, DisC	Virtual	Ca, S, UCF, SP, Ex, SPr	MILP	L, TA	C	Tabu Search
Meepetchdee and Shah [34]	2007	F	PC, DisC	Virtual	UC, D, UCF, SP, Ex, SPr	MILP	L, TA	C, Ro	Exact Methods
Üster et al. [53]	2007	R	CIC, RCC, PC, DisC	Automative	UC, D, UCF, MP, En, SPr	MILP	L, TA	C	Benders Decomposition
Lu and Bostel [32]	2007	E	CIC, RCC, DC, PC, DisC	Virtual	UC, D, UCF, SP, En, SPr	MILP	L, TA	C	Exact Methods
Ko and Evans [22]	2007	E	RCC, PC, DisC	Virtual	Ca, D, UCF, MP, En, MPr	MINLP	L, TA	C	Genetic Algorithm
Salema et al. [46]	2007	E	CIC, RCC, PC, DisC	Electronics	Ca, S, UCF, MP, En, SPr	SKTP	L, TA, DS	C	Exact Methods
Lieckens and Vandaele [27]	2007	R	CIC, RCC	Virtual	Ca, D, UCF, SP, En, SPr	MINLP	L, FC, TA	C	Genetic Algorithm

Authors	Year	LNS	Facilities	Sector	Problem Description	Model	Output	Obj.	Method
Hui et al. [15]	2007	E	PC, DisC, CIC, RCC,	Virtual	Ca, S, UCF, SP, En, MPr	MILP	L, TA	C	Genetic Algorithm
Tsiakis and Papageorgiou [52]	2008	F	PC, DisC	Chemical	Ca, D, CF, MP, En, SPr	MILP	L, FC, TA	C	Exact Methods
Demirel and Gökçen [10]	2008	R	CIC, RCC, PC, DisC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C	Exact Methods
Aras et al. [6]	2008	R	CIC	Virtual	UC, D, UCF, MP, Ex, SPr	MINLP	L, TA, NV, P	C	Tabu Search
Du and Evans [12]	2008	R	RCC, PC, DisC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, FC, TA	C, Res	Scatter Search
Min and Ko [38]	2008	E	CIC, RCC, PC, DisC	Logistics	Ca, D, UCF, MP, En, MPr	MINLP	L, TA	C	Genetic Algorithm
Lee and Dong [25]	2008	E	CIC, RCC, PC, DisC	Computer	Ca, D, CF, SP, Ex, SPr	MILP	L, TA	C	Tabu Search
Peng and Zhong [41]	2008	E	CIC, RCC, DC, PC, DisC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C	Exact Methods
Zhou et al. [58]	2008	R	CIC, RCC	Virtual	Ca, D, UCF, SP, En, MPr	MINLP	L, TA	C, Res	Genetic Algorithm
Kengpol [21]	2008	F	SC, PC, DisC	Logistics	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Exact Methods
Qin and Qin [43]	2008	F	PC, DisC	Automative	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Particle Swarm
Cordeau et al. [8]	2008	F	SC, PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP, MINLP	L, TA	C	Local Search
Liu [30]	2008	R	SC, PC, DisC	Virtual	Ca, S, UCF, MP, En, SPr	MILP	L, TA	C, Res	Genetic Algorithm
Shanshan and Kejing [48]	2008	R	CIC, RCC	Electronics	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C	Exact Methods
Men and Weng [36]	2008	F	PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Particle Swarm
Lu et al. [31]	2008	R	PC, CIC, RCC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C, Res	Particle Swarm
Lin et al. [28]	2009	F	SC, PC, DisC	Virtual	Ca, D, UCF, SP, Ex, SPr	MILP	L, I, TA	C	Genetic Algorithm
Du et al. [11]	2009	E	RCC, DC, PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MINLP	L, TA	C	Genetic Algorithm
Zhao [57]	2009	E	RCC, DC, PC, DisC	Virtual	Ca, D, UCF, MP, En, MPr	MILP	L, TA	C	Exact Methods
Miranda et al. [39]	2009	F	SC, PC, DisC	Virtual	Ca, S, CF, SP, En, SPr	MINLP	L, I, TA	C	Simple Heuristics
Chiou [7]	2009	F	PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Hill Climbing
Jin and Xin [20]	2009	F	PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Simulated Annealing
Yi and Dong [55]	2009	F	SC, PC, DisC	NA	Ca, D, UCF, MP, En, SPr	MILP	L, I, TA	C	Particle Swarm
Lee and Dong [26]	2009	R	PC, CIC, RCC	Virtual	Ca, S, UCF, MP, En, MPr	MILP	L, TA	C	Simulated Annealing
Pishvaee et al. [2]	2009	E	CIC, RCC, DC, PC, DisC	Virtual	Ca, D, UCF, SP, En, SPr	MINLP	L, FC, TA	C, Res	Genetic Algorithm
Sayed et al. [47]	2009	E	CIC, RCC, DC, SC, PC, DisC	Virtual	Ca, S, UCF, MP, En, SPr	SMIP	L, I, TA	C	Exact Methods
Lee et al. [24]	2009	R	PC, CIC, RCC	Virtual	Ca, D, UCF, MP, En, SPr	MILP	L, TA	C	Genetic Algorithm
Qin and Ji [42]	2010	R	PC, CIC	Virtual	Ca, D, UCF, SP, En, SPr	MILP	L, TA	C	Genetic Algorithm

HYPERHEURISTIC METHODS

Definition, Advantages and Key Factors

"Hyperheuristic" term firstly introduced by Cowling et al. in 2000 on sales scheduling problem [60] and defined as an approach that manages the choice of which lower level heuristic method should be applied at any given time of algorithm step and operates at a higher level of abstraction than Metaheuristic approaches. This means that Hyperheuristic doesnot search for a better solution to the problem. Instead, it selects at each step of the solution the most promising process with simple low-level heuristic (or combination of heuristics) which is potentially able to improve the solution. On the other hand, if there is no improvement, i.e., a locally optimal solution is found, the Hyperheuristic diversifies the search to another area of the solution space by selecting appropriate heuristics from the given set [61].

A Hyperheuristic acts as a heuristic scheduler over a set of heuristics that does the scheduling in a deterministic or a non-deterministic way. For example, the deterministic round-robin strategy schedules the next heuristic in a queue at each turn. A non-deterministic strategy schedules the next heuristic based on some probability distribution. More complicated and viable Hyperheuristic can be designed by making use of a learning mechanism that gets feedback from the previous choices to select the right heuristic at each step [59].

Hyperheuristics have been used in solving search and optimization problems increasingly especially on scheduling and time tabling problems. The main objective of Hyperheuristic method is not to output near optimum solutions like Heuristic techniques, Hyperheuristics firstly aims to produce feasible and applicable results by putting forward a general flexible framework that guides how to choose and implement simple heuristics. Through this learning mechanism, Hyperheuristic algorithms can be classified such that:

- Simple Hyperheuristics that selects each simple heuristic randomly.
- Hyperheuristics with choose functions that scores each simple heuristic
- Hyperheuristics hybridized with Metaheuristics for determining heuristic implementation sequence.
- Hyperheuristics used with learning procedures like Reinforcement learning.

In general, motivation for development of Hyperheuristics comes from the fact that performance of different heuristics may vary significantly depending on the specific characteristics of the problem. Moreover, individual heuristics may be particularly effective at certain stages of the solution process while performing poorly at any other stages. Therefore, it is fair to expect that several heuristics combined in a proper way may produce better solutions then if they are applied separately. Hyperheuristic methods are higher level heuristics which manages a set of low level heuristics that searches for a good method to solve the problem rather than for a good solution. Hyperheuristics have these advantages over other methods [63] [59]:

- It is more practical to use Hyperheuristics owing to easier for modeling and developing.
- Same Hyperheuristic structure can be applied to different Non-Polynomial problems.
- Against variations, Hyperheuristic output performance is less sensitive as to other methods.
- Hyperheuristic methods generate feasible and applicable solutions faster than other methods.
- Hyperheuristic algorithms are more robust driven towards heuristics and problem search space.

Hyperheuristic Method Benefits to Logistic Network Design Problems

Economic conditions force companies to solve large size LND problems more efficiently. Due to difficulties in developing exact models and reaching global optimum solutions in long periods, Heuristic and Metaheuristic methods like Genetic Algorithm, Simulated Annealing, i.e. are more convenient that provide near optimal results. However, Heuristics and Metaheuristics are not flexible enough for real life dynamism and mostly dependent to algorithm designer [59]. These circumstances motivate Hyperheuristic Algorithms executing on a heuristic space which is abstract and independent from search space. Problem dependent heuristics like sweep, branch & bound, 2-opt or independent such as insert, remove and reverse heuristics can be gradually used in Hyperheuristic implementations for LND problems running on dynamic environments.

CONCLUSION

In today's rapidly changing economic and political conditions, global corporations face a continuous challenge to constantly evaluate and optimally configure their supply chain operations to achieve key performance indicators (KPIs) either it is profitability cost reduction, innovation or customer service. In this environment operations managers and planners need to address accurately questions such as which plants to operate, what product mix per plant, which distribution center supplies which customer, what inventory levels are necessary to maintain service levels, which suppliers are to be used [52]. Day to day, LND plays more important role in Supply Chain Management. According to literature survey presented in this paper, studies mostly focus on sub sections of virtual LND problems that are not taking place in real life and not including complete LND issues. In addition, Metaheuristic methods dominated by hybridization with simple local search techniques and implemented with minimum cost, maximum profit objective. In references, Mixed Interger Programming models also developed to explain the related LND problem more clearly.

Considering literature review, there is no study dealing with todays' dynamic conditions, adapting changes easily and producing efficient results in real life problems. From this point, Hyperheuristics can be a key function for dynamic LND problems providing abstraction between problem space and search space. Hyperheuristic supports Graph Theoretic approach to design problems solving with multi threaded computer programs that is concordant with LND. This study obtains a start point and a base for our future work about solving real life LND problems with Hyperheuristic methods.

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A FUZZY LOGIC CONTROLLER WITH A MULTIOBJECTIVE ANT COLONY OPTIMIZATION ALGORITHM FOR ASSEMBLY LINES DESIGN

Hicham Chehade [1], Farouk Yalaoui[2] and Lionel Amodeo[3]

Abstract *— The literature presents a lack in the studies regarding the assembly lines design taking in consideration simultaneously the buffers sizing and the equipment selection. Those assembly lines, which constitute an important element in a given supply chain, must have the lowest prices with the highest performances. To solve this multiobjective optimization problem, we first develop a multiobjective ant colony optimization algorithm (MOACS). Then, in order to enhance the performances, we try to better set the different parameters of the proposed algorithm. For that, we develop a fuzzy logic controller coupled to the MOACS algorithm to set in an optimal way the parameters α and β which define the relative importance of pheromones versus the visibility. We carry out several tests to assess the impact of the fuzzy logic controller. The numerical results show that the fuzzy logic controller with the multiobjective ant colony algorithm (FLC-MOACS) presents more advantages than the classical MOACS algorithm.*

Keywords — Ant colony, Assembly lines, Buffers sizing, Equipment selection, Fuzzy logic controllers, Multiobjective optimization.

INTRODUCTION

In this work, we are interested in the optimization of assembly lines design. Assembly lines have an essential role in any supply chain. Thus manufacturers are looking to have the most performed lines with the lowest costs to afford rough competition. Based on that, several studies in the literature **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.** are interested in solving the different types of the lines design problem such as line balancing, buffers sizing, equipment selection ... In these studies, one **Hata! Başvuru kaynağı bulunamadı.** or several **Hata! Başvuru kaynağı bulunamadı.** objective functions may be taken in consideration simultaneously. The last case is more and more studied as the multiobjective optimization allows being more close to real industrial problems.

This paper deals with a global assembly line design problem trying to solve simultaneously the buffers sizing and the equipment selection problems. Those two sub problems have been largely discussed in the literature and different resolution methods have been proposed whether they are exact methods **Hata! Başvuru kaynağı bulunamadı.** or based on metaheuristics **Hata! Başvuru kaynağı bulunamadı.**. However, we have noticed a lack in the number of studies where the two considered sub-problems are studied simultaneously. Until recently, the paper of Jeong and Kim **Hata! Başvuru kaynağı bulunamadı.** was the only one in that field. In previous works, we have tried to study these two sub-problems simulatneously in a deeper way. Thus, we have proposed different papers to solve the problem with one **Hata! Başvuru kaynağı bulunamadı.** or two **Hata! Başvuru kaynağı bulunamadı.** optimization criterion. In these studies, we have proposed simple and hybrid metaheuristics to solve the studied problem as it is a hard computational one. However, in this paper, our contribution is to solve the studied problem using a metaheuristic which is a multiobjective ant colony algorithm coupled to a fuzzy logic controller.

Despite the efficiency of metaheuristics to solve complex problems, some difficulties may be encountered while setting their different parameters. In fact, an efficient metaheuristic requires a good parameter setting. Based on that, some studies have recently started to present the use of fuzzy logic controllers to better set the parameters of those metaheuristics. Fuzzy logic was first proposed by Zadeh **Hata! Başvuru kaynağı**

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bulunamadı. for system control. In the works of King *et al.* **Hata! Başvuru kaynağı bulunamadı.**, Lotfi and Kashani **Hata! Başvuru kaynağı bulunamadı.** and Song *et al.* **Hata! Başvuru kaynağı bulunamadı.**, fuzzy logic controllers have been used used to guide genetic algorithms to solve single objective problems. Lau *et al.* **Hata! Başvuru kaynağı bulunamadı.** have proposed fuzzy logic controllers with the second version of a non dominated sorting genetic algorithm (FL-NSGA2), then with the second version of a strength Pareto evolutionary algorithm (FL-SPEA2) to sovle vehicle routing problems . Yalaoui *et al.* **Hata! Başvuru kaynağı bulunamadı.** have solved a reentrant scheduling problem with fuzzy logic controllers coupled to a genetic algorithm (FLC-GA) and to a non dominated sorting genetic algorithm (FLC-NSGA2).

The remainder of this paper is organized as follow. The second section presents a literature review about the studied problem before the problem formulation and description in the third section. The applied resolution method and the presentation of the fuzzy logic controller are developed in the fourth section. Computational experiments and numerical results are presented in the fifth section before ending the paper by a conclusion and perspectives for future works.

PROBLEM DESCRIPTION AND MATHEMATICAL FORMULATION

Description

As mentioned in the introduction, we are interested in solving a multiobjective packaging line design problem. The considered lines are composed by unreliable machines on workstations and by finite intermediate buffers. Each buffer links two consecutive workstations. Thus, each line has N workstations and N-1 intermediate buffers. Only one machine has to be assigned to each workstation. This machine belongs to a set of candidate ones and has its own technical and financial characteristics. Therefore, we have different kinds of machines varying from type 1 to type H. The times between failures and the times to repair for the machines as well as the processing times are exponentially distributed. The other studied sub problem is the buffers sizing. The size of each buffer is considered to be bounded by a lower (l) and an upper value (u).

Therefore, the optimal configurations of this multiobjective problem are the lines configurations or the set of solutions that give the highest throughput rates with the lowest costs subject to a space constraint. In fact, we consider that the total space covered by the selected machines and the sized buffers must not exceed a given available space that may be covered by the packaging line. The cost of the line is computed based on the selected machines and the buffers sizes.

Mathematical formulation

The mathematical formulation of this multiobjective design problem can be stated as in (1-3). The decision variables are X_{ij} (the machine i to affect to station j) and Y_{ij} (the size i of buffer j).

Optimize $Z = (O1, O2)$ (1)

$$O1 : Maximize(E) \quad (2)$$

$$O2 : Minimize(\sum_{j=1}^{N}\sum_{i=1}^{M} X_{ij}.C_{ij} + U_{BC}.\sum_{j=1}^{N-1}\sum_{i=1}^{B} Y_{ij}.b_{ij}) \quad (3)$$

Subject to

$$E = f(X_{ij}, Y_{ij}) \quad (1.1)$$

$$\sum_{j=1}^{N}\sum_{i=1}^{M} X_{ij}.S_{ij}^{M} + \sum_{j=1}^{N-1}\sum_{i=1}^{B} Y_{ij}.S_{ij}^{B} \le S_m \quad (1.2)$$

$$E_{lj}^{B} \le E_{ij}^{B} \le E_{uj}^{B}; \forall i = 1,\ldots,B; \forall j = 1,\ldots,N-1 \quad (1.3)$$

$$E_{1j}^{M} \le E_{ij}^{M} \le E_{Hj}^{M}; \forall i = 1,\ldots,M; \forall j = 1,\ldots,N \quad (1.4)$$

$$\sum_{i=1}^{M} X_{ij} = 1; \forall j = 1,\ldots,N \quad (1.5)$$

$$\sum_{i=1}^{B} Y_{ij} = 1; \forall j = 1,\ldots,N-1 \quad (1.6)$$

$$X_{ij} \in \{0,1\}; \forall i = 1,\ldots,M; \forall j = 1,\ldots,N \tag{1.7}$$

$$Y_{ij} \in \{0,1\}; \forall i = 1,\ldots,B; \forall j = 1,\ldots,N-1 \tag{1.8}$$

Notation:

N: the number of workstations in the line.
N-1: the number of intermediate buffers in the line.
M: the number of candidate machines to a workstation i.e. $M = H$.
B: the number of the possible sizes of a buffer i.e. $B = u - l + 1$.
X_{ij}: a binary variable equals 1 if machine i is assigned to workstation j and 0 otherwise.
Y_{ij}: a binary variable equals 1 if buffer size i is assigned to buffer j and 0 otherwise.
C_{ij}: cost of machine i when assigned to workstation j.
U_{BC}: one unit buffer cost i.e. the cost of a buffer of size one.
b_{ij}: the size i of buffer j.
E_{ij}^{M} : the throughput rate of a machine of type i when assigned to workstation j.
E_{ij}^{B} : the throughput rate of a buffer j while having a size i.
E_{lj}^{B} : the lower bound for the throughput rate of a buffer j.
E_{uj}^{B} : the upper bound for the throughput rate of a buffer j.
E_{1j}^{M} : the lower bound for the throughput rate of a machine assigned on workstation j.
E_{Hj}^{M} : the upper bound for the throughput rate of a machine assigned on workstation j.
S_{ij}^{M} : the space covered by a machine of type i when assigned to workstation j.
S_{ij}^{B} : the space covered by a buffer j while having a size i.
S_m: the maximum available space that could be covered by the line.

Constraint (1.1) indicates that the throughput rate E of the line is a function of the assigned machines and the sizes of the buffers. Constraint (1.2) means that the space covered by the machines assigned to the stations and the space covered by the intermediate buffer must not exceed the available space for the line. Constraint (1.3) shows that the size of each buffer is bounded by a lower (l) and an upper value (u). Constraint (1.4) indicates that the candidate machines could be from different types varying from type 1 (the less performed and the less expensive machines) to type H (the most performed and the most expensive machines). Constraints (1.5) and (1.6) impose that only one machine must be assigned to each station and a unique size must be assigned to each buffer. Constraints (1.7) and (1.8) define the binary decision variables.

RESOLUTION METHODS

In this section, we present the resolution methods that we have developed to solve the considered design problem. We will first start by presenting the main structure of the Multiobjective Ant Colony System algorithm (MOACS) followed by a detailed presentation of the application of the fuzzy logic controller and ending by our method: A Multiobjective Ant colony System guided by a Fuzzy Logic Controller (FLC-MOACS).

Multiobjective Ant Colony System (MOACS)

In this section, we present the multiobjective ant colony system algorithm that we have applied in this work. Its principal is based on the general structure of a classical ant colony optimization algorithm by being based on four main steps: the solutions encoding, the ants tours construction, the local pheromone updates and the global pheromone updates. The only difference is related to the number of the pheromone matrices.

In fact, knowing that the multi objective optimization takes in consideration different criterion simultaneously, we consider that the total number of pheromone matrices should be equal to the number of objectives to be optimized. Therefore, we have in this work two pheromone matrices.

Station *1*	1	…	H
Station *2*	1	…	H
:		:	
Station *N*	1	…	H

Buffer *1*	l_1	$l_1 + 1$	…	u_1 - 1	u_1
Buffer *2*	l_2	$l_2 + 1$	…	u_2 - 1	u_2
:			:		
Buffer *N-1*	l_n	$l_n + 1$	…	u_n - 1	u_n

FIGURE 1

Encoding representations for stations and buffers **Hata! Başvuru kaynağı bulunamadı.**

Solutions encoding

This encoding is presented in figure 1 where we consider that we have N stations and N-1 intermediate buffers. A set of M machines (type 1 to type H) are candidate to be assigned to each station i. A lower (l_j) and an upper (u_j) value bound the capacity of each buffer j.

Tours construction

First, each ant is deposited randomly on a starting point which represents either the machine to assign to the first workstation or the size that has to be assigned to the first buffer. After that, an ant k chooses to move from a point r to another point s based on (4).

$$s = \begin{cases} \arg\max_{u \in J_k(r)} \left\{ \left[\sum_{o=1}^{O} w_o . \tau_{r,u}^{o} \right]^{\alpha} . \eta_{r,u}^{\beta} \right\} & if\ q \le q_0 \\ S^{*} & otherwise \end{cases} \tag{4}$$

Where:

O : the number of the considered objectives.

$\tau_{r,s}^{o}$: the quantity of pheromone between the points r and s based on objective o.

w_o : the coefficient of importance granted to each objective (we consider that $w_1 = w_2 = 0.5$).

q : is a random number generated between 0 and 1.

q_0 : is a parameter ($0 \le q_0 \le 1$) which determines the relative importance of exploitation against exploration.

S^* : is a random variable chosen based on a probability given by (5).

$\eta_{r,s}$: is a static value used as a heuristic of innate desirability to choose s starting from r and is also called the ant visibility to choose a point starting from another point.

α and β are used to determine the relative importance of pheromones versus the visibility.

$J_k(r)$: is the set of points not yet visited by ant k.

$$S^{*} = \begin{cases} \dfrac{\left[\sum_{o=1}^{O} w_o \tau_{r,s}^{o} \right]^{\alpha} \left[\eta_{r,s} \right]^{\beta}}{\sum_{u \in J_k(r)} \left[\sum_{o=1}^{O} w_o \tau_{r,u}^{o} \right]^{\alpha} \left[\eta_{r,u} \right]^{\beta}} & if\ s \in J_k(r) \\ 0 & otherwise \end{cases} \tag{5}$$

Local pheromone updates

The local pheromone update is applied once all ants have finished their tours. It is computed based on (6).

$$\tau_{r,s}^{o} = (1 - \rho)\, \tau_{r,s}^{o} + \rho\, \tau_0 \tag{6}$$

Global pheromone updates

The global pheromone update is realized according to (7) while being based on the non dominated solutions obtained at each generation.

$$\tau_{r,s}^{o} = (1 - \rho)\, \tau_{r,s}^{o} + \rho\, \Delta\tau_{r,s}^{o} \tag{7}$$

$\Delta\tau_{r,s}^{o}$ consists on supporting the non dominated solutions found so far. It is computed based on (8) and (9) where C_{gb} and E_{gb} represent, respectively, the lowest cost and the highest throughput rate found so far by ants.

$$\Delta\tau^{1}_{r,s} = \begin{cases} (C_{gb})^{-1} & if\ r,s \in non-dominated-solutions \\ 0 & otherwise \end{cases} \tag{8}$$

$$\Delta\tau^{2}_{r,s} = \begin{cases} E_{gb} & if\ r,s \in non-dominated-solutions \\ 0 & otherwise \end{cases} \tag{9}$$

The Fuzzy Logic Controller (FLC)

Usually, an ant colony optimization algorithm uses many parameters (the number of ants k, α, β, q, q_0, ...). Since the setting of those parameters is very difficult, a fuzzy logic controller (FLC) is proposed. It is used to better set the values of two parameters which are : α, β. In this study, the average objective values of the solutions in the non-dominated front and their diversity are considered as the inputs of the fuzzy logic controller. The modifications in the values of the two parameters are guided by the output of the FLC. Appropriate values of these parameters can produce better results, by avoiding premature convergence and falling into local optimum. This enhancement is carried out every ten consecutive generations **Hata! Başvuru kaynağı bulunamadı.** in order to provide sufficient required time for the modification in the algorithm.

Fuzzy logic was firstly presented by Zadeh **Hata! Başvuru kaynağı bulunamadı.**, as a powerful and useful tool applied in many area. A FLC consists of 3 parts: fuzzification, decision making, and defuzzification. We have used here a similar FLC of Lau *et al.* **Hata! Başvuru kaynağı bulunamadı.** to guide the ant colony optimization algorithm, with a difference in the parameters of the membership functions. The details are described below.

Fuzzification

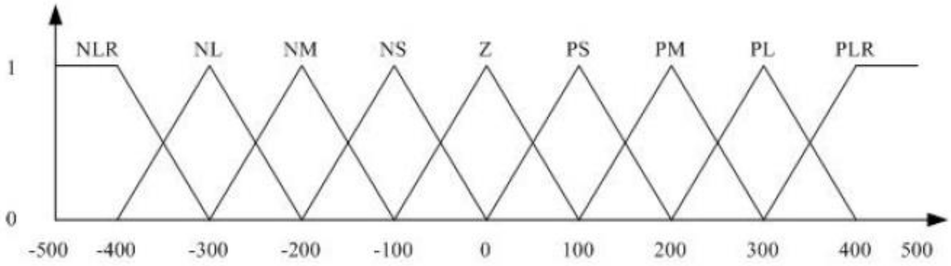
The membership functions are in order to associate the system input and output values with the fuzzy input and output membership values. In this study, the values of $f_a(t) = f(t-1) - f(t-2)$ and $d(t-1)$ are considered as the system input values where $f(t-1)$ and $f(t-2)$ are the average values of the objective function and $d(t-1)$ is the sum of the hamming distance between the individuals of the entire generation. Then $\Delta p_\alpha(t)$ and $\Delta p_\beta(t)$ are considered as the system output values. The membership functions are presented in figure 2. They are usually chosen based on the expert knowledge and experience. The triangular membership functions are used in this study, and the parameters are defined according to several tests. The meanings of each linguistic term are presented in table 1.

TABLE 1
Meanings of the linguistic terms

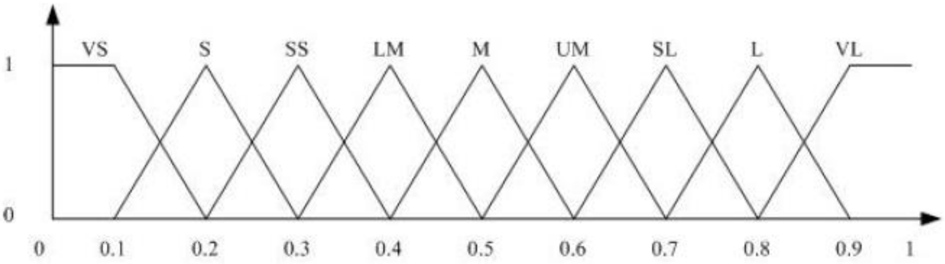
Linguistic terms for $f_a(t)$, $\Delta p_\alpha(t)$, $\Delta p_\beta(t)$	Meaning	Linguistic terms for $d(t-1)$	Meaning
NLR	Negative larger	VS	Very small
NL	Negative large	S	Small
NM	Negative medium	SS	Slightly small
NS	Negative small	LM	Lower medium
Z	Zero	M	Medium
PS	Positive small	UM	Upper medium
PM	Positive medium	SL	Slightly large
PL	Positive large	L	Large
PLR	Positive larger	VL	Very large

Decision making

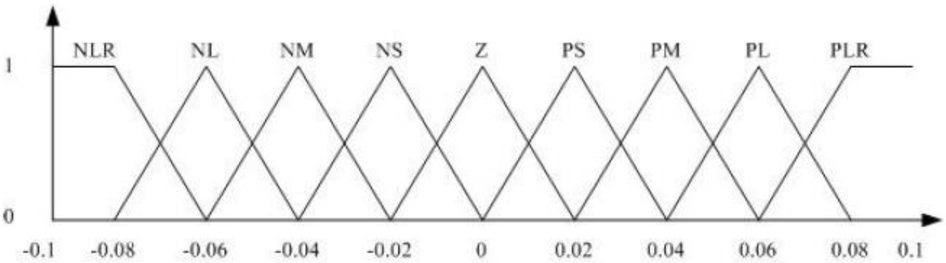
When the system input values are transferred into the fuzzy input by the membership functions, a number of IF-THEN rules are applied to get the output membership values. These rules are based on the expert knowledge and experience. We have chosen the decision tables of **Hata! Başvuru kaynağı bulunamadı.** in our work, they are presented in tables 2 and 3.



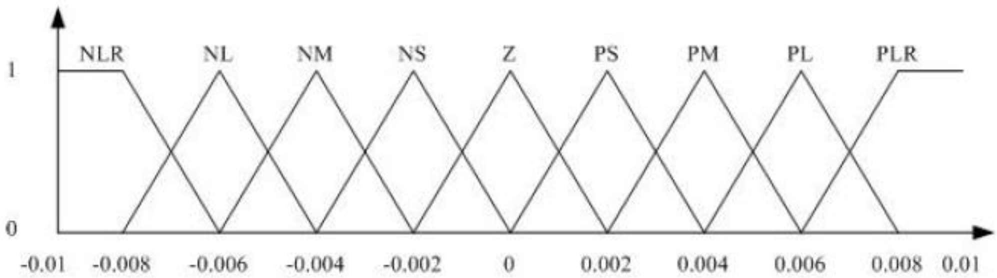
f(t-1) - f(t-2)



d(t-1)



$\Delta p_{\alpha}(t)$



$\Delta p_{\beta}(t)$

FIGURE 2
Membership functions

TABLE 2
Decision table of $\Delta p_\alpha(t)$

$d(t-1) \setminus f_a(t)$	NLR	NL	NM	NS	Z	PS	PM	PL	PLR
VL	PLR	PLR	PL	PL	PM	PM	PS	PS	Z
L	PLR	PL	PL	PM	PM	PS	PS	Z	NS
SL	PL	PL	PM	PM	PS	PS	Z	NS	NS
UM	PL	PM	PM	PS	PS	Z	NS	NS	NM
M	PM	PM	PS	PS	Z	NS	NS	NM	NM
LM	PM	PS	PS	Z	NS	NS	NM	NM	NL
SS	PS	PS	Z	NS	NS	NM	NM	NL	NL
S	PS	Z	NS	NS	NM	NM	NL	NL	NLR
VS	Z	NS	NS	NM	NM	NL	NL	NLR	NLR

TABLE 3
Decision table of $\Delta p_\beta(t)$

$d(t-1) \setminus f_a(t)$	NLR	NL	NM	NS	Z	PS	PM	PL	PLR
VL	NLR	NLR	NL	NL	NM	NM	NS	NS	Z
L	NLR	NL	NL	NM	NM	NS	NS	Z	PS
SL	NL	NL	NM	NM	NS	NS	Z	PS	PS
UM	NL	NM	NM	NS	NS	Z	PS	PS	PM
M	NM	NM	NS	NS	Z	PS	PS	PM	PM
LM	NM	NS	NS	Z	PS	PS	PM	PM	PL
SS	NS	NS	Z	PS	PS	PM	PM	PL	PL
S	NS	Z	PS	PS	PM	PM	PL	PL	PLR
VS	Z	PS	PS	PM	PM	PL	PL	PLR	PLR

Defuzzification

The aim of the defuzzification is to calculate the deviation values of the parameters (α, β) by the fuzzy output membership values and the membership functions of $\Delta p_\alpha(t)$ and $\Delta p_\beta(t)$. There are many defuzzification methods such as AI (adaptive integration), COA (center of area), CDD (constraint decision defuzzification) and COG (center of gravity). The COG defuzzification method is adopted here, as it is the best known defuzzification operator **Hata! Başvuru kaynağı bulunamadı.**. This method computes the gravity center of the area under the membership function.

Example

An example is provided here to explain the three steps of the fuzzy logic. In this example, $f(t-1) - f(t-2) =$ 330, which means that the difference of average values of the two objectives (maximizing the throughput rate and minimizing the line cost) over the solutions at generation *t-1* and *t-2* is negative and equal to 330. We have therefore NLR with a proportion of 0.3 and NL with a proportion of 0.7 by the membership functions of $f(t-1) - f(t-2)$ (see figure 2). The value of $d(t-1)$ is equal to 0.25 which also provides the inputs of S with 0.5

and SS with 0.5. These steps are shown in figure 3.

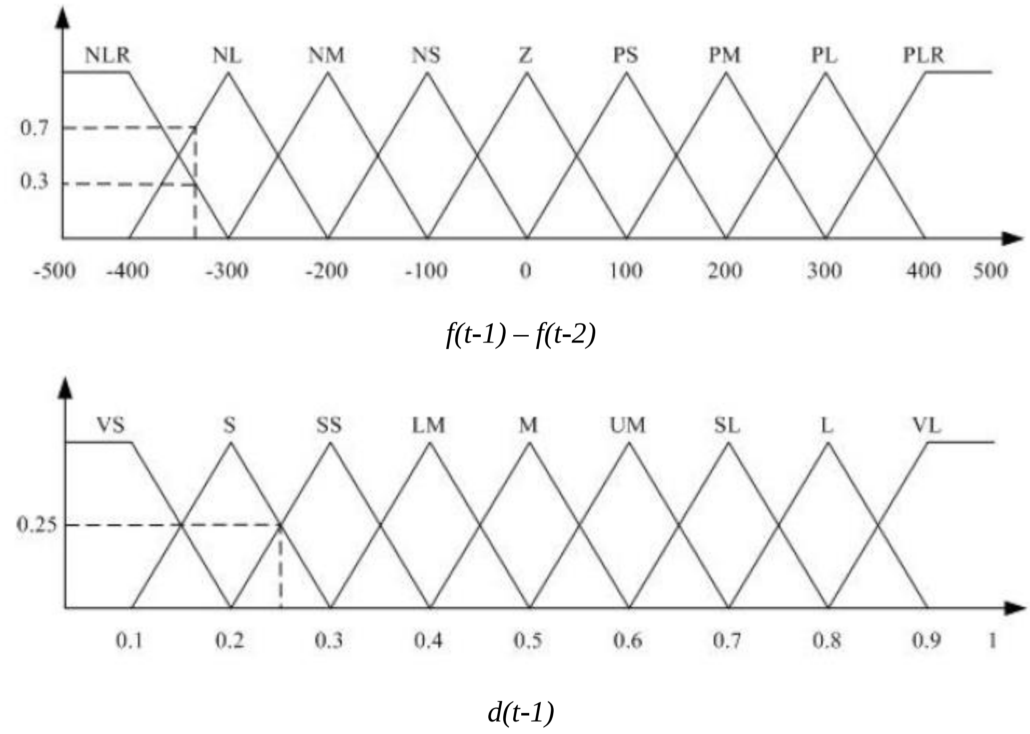


FIGURE 3
An example of the fuzzification process

After obtaining the input membership values, the decision tables are used to get the output membership values. We only explain the computation of Δp_c here, which is guided by the decision table of Δp_α (Table 2). The same steps are applied for Δp_β. There exists four possibilities: NLR(0.3) and S(0.5), NLR(0.3) and SS(0.5), NL(0.7) and S(0.5), NL(0.7) and SS(0.5). For the first case, we can get that the combination of NLR and S provides PS. Moreover the minimum value between two proportion values (0.3 and 0.5) is kept. Then, we have obtained PS(0.3). We can also obtain PS(0.3), Z(0.5) and PS(0.5) for the 3 remaining cases.

The final step is the defuzzification by using the membership fuction of figure 4. We should compute the sum of PS(0.3), PS(0.3), Z(0.5) and PS(0.5). The COG (center of gravity) method is adopted. We have obtained the value of Δp_α which is equal to 0.01. It means that if an initial value of the parameter α at generation *t-1* is equal to 0.5, then its value is set to 0.51.

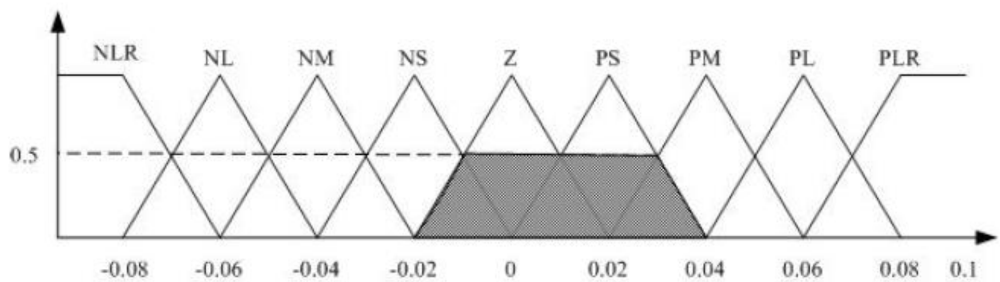


FIGURE 4
An example of the defuzzification process

A Multiobjective Ant Colony System guided by a Fuzzy Logic Controller (FLC-MOACS)

As mentioned before, the Multiobjective Ant Colony System algorithm with the Fuzzy Logic Controller (FLC-MOACS) is based on a multiobjective ant colony system algorithm using a fuzzy logic controller to better set the parameters α and β. Therefore, each ten generations and once all ants have constructed their tours and that local pheromone updates are applied, we apply the fuzzy logic operations. The aim is to provide sufficient times for the MOACS to respond the changes. The average fitness value of the solutions of each generation and the diversity are taken as the input of the fuzzy controller. In fact, appropriate values of the parameters α and β can provide good convergence and diversity of the obtained results.

Since the studied problem is a multiobjective optimization problem, the average fitness value *f(t)* is the average value of the throughput rate and the total tardiness of the solutions at generation *t*. The value of *d(t)* is the degree of population diversity at iteration *t*. It is the average of the difference of all pairs of solutions in the generation and it can be computed as shown in (10).

$$d(t)=\frac{1}{\frac{K(K-1)}{2}}\sum_{i=1}^{K}\sum_{j=1}^{K}\sum_{l=1}^{2N-1}\frac{\delta(g_{il},g_{jl})}{2N-1} \qquad (10)$$

Where K is the number of ants, 2N-1 is the sum of the number of stations N and the number of buffers N-1, g_{il} is the values of three elements of the l^{th} station or buffer of the i^{th} solution, and $\delta(g_{il}, g_{jl}) = 1$ if the two stations or buffers are not the same, 0 otherwise.

The same parameters of the MOACS are used for setting the FLC-MOACS as shown in the next section.

The overall FLC-MOACS algorithm is shown in algorithm 1.

Algorithm 1: FLC-MOACS algorithm
Step 1: Initialization of parameters, t=0
Step 2: For all ants
Assign machines to the different stations and attribute sizes to buffers
Local pheromone updates
Identification of the non dominated solutions
Global pheromone updates
Step 3: If t mod 10 = 0 then
The values of f(t-1)-f(t-2) and d(t-1) are considered as the input of FLC, update the values of α and β with the FLC
Go to step 4
Else
Return to step 2
t = t +1
Step 4: Return to step 2 until a stopping criterion is satisfied

Comparison criteria

In this section, we describe the methods used to compare the two optimal fronts (F1 and F2) obtained by the FLC-MOACS and the MOACS algorithms in order to get an idea and to evaluate the performances of the solutions of each algorithm. Three comparison criteria are used:

N_i: the number of solutions in an optimal front i

μ: the distance proposed by Riise **Hata! Başvuru kaynağı bulunamadı.**

C_i: the Zitlzler measure **Hata! Başvuru kaynağı bulunamadı.**

The distance of Riise, μ, is computed as the sum of the distances d_x between a solution x belonging to front F1 and its orthogonal projection on front F2 ($\mu = \sum_{x=1}^{N} d_x$). μ is negative if F1 is under F2 and positive otherwise. As the value of μ depends on the number of solutions N_i in each front, a normalized value ($\mu^* = \mu / N_i$) is generally taken in consideration.

The Zitzler measure C_1 represents the percentage of solutions in F1 dominated by at least one solution in F2. Taking in consideration that the measure is not symmetric, it is advised to compute C_2 as well. In conclusion, a front F1 is better than another front F2 if C_1 is smaller than C_2.

COMPUTATIONAL EXPERIMENTS

In order to assess the performances of our Multiobjective Ant Colony System with the Fuzzy Logic Controller (FLC-MOACS) and to compare it to a classical Multiobjective Ant Colony System (MOACS), we realize computational experiments by studying assembly lines with three different structures. The first structure (S1) represents an assembly line with 3 workstations and 2 intermediate buffers whereas the second and the third structure refer, respectively, to assembly lines with 7 and 9 workstations. As an evaluation tool, we use a decomposition algorithm that has been proposed by Jeong and Kim in 1998 **Hata! Başvuru kaynağı bulunamadı.** based on the decomposition method that has been initially developed by Gershwin in 1987 **Hata! Başvuru kaynağı bulunamadı.**. For the three tested structures, we consider that the machines time between failures, the times to repair and the processing times are exponentially distributed as it has been proposed by Jeong and Kim **Hata! Başvuru kaynağı bulunamadı.**. The lower and upper bounds for all the buffers capacities are 5 and 15 respectively and the buffer cost is 1.0206 as it has been proposed in the work of Jeong and Kim **Hata! Başvuru kaynağı bulunamadı.**. The number of candidate machines which can be used in a station is 3. The costs of the different machines, as well as their characteristics, are taken from those used in the paper of Jeong and Kim **Hata! Başvuru kaynağı bulunamadı.** as shown in table 4.

We compare the FLC-MOACS with a MOACS algorithm. In order to realize the parameters settings and to fix them (other than parameters α and β), several tests have been realized. In each test, we have tried to find the best value for each parameter while the others are fixed. Final values are determined as a compromise between the quality of the final solutions and the convergence time needed. Those final values are as follow: $k = 20$, $\rho = 0.7$, $q_0 = 0.7$, $\tau_0 = 2$. The stopping criterion is a given number of generations and is fixed to 100. The algorithms are tested on three structures and for three different allowed available spaces (S_m) for each structure.

Table 5 presents a comparison between the optimal fronts with the non dominated solutions of the two algorithms showing the three measuring criterion: N_i, μ^* and C_i. On the 9 tested instances, and taking in consideration the three adopted comparison criteria, we can deduce that the FLC-MOACS algorithm presents some advantages over the MOACS algorithm. For the first criterion, we may notice that the number of solutions in the optimal front obtained with the MOACS algorithm, N_2, is lower than that of the optimal front obtained with the FLC-MOACS algorithm N_1. In what concerns the Riise distance, we have a mean value with a negative sign which means that the FLC-MOACS front is under that of the MOACS algorithm which does suit with our two objectives: maximizing the throughput rate and minimizing the costs. As for the third criterion, it is clear that the number of solutions in the different FLC-MOACS fronts that are dominated by at least one solution in the other fronts is lower than that of dominated solutions obtained by the MOACS.

TABLE 4
Input data

Station	Machine	Cost	Space	Failure rate	Repair rate	Processing rate
	1	36.56	6.47	0.0050	0.1016	0.9552
1	2	41.72	5.63	0.0042	0.1092	1.0537
	3	45.44	5.35	0.0034	0.1220	1.0696
	1	43.62	5.53	0.0051	0.1010	1.0443
2	2	50.10	5.01	0.0042	0.1015	1.2251
	3	55.74	4.65	0.0038	0.1149	1.4452
	1	39.74	5.65	0.0049	0.1071	1.0490
3	2	40.20	5.11	0.0041	0.1137	1.0966
	3	47.14	5.05	0.0037	0.1327	1.1712
	1	38.47	6.38	0.0054	0.1057	0.9058
4	2	40.62	5.53	0.0053	0.1201	1.0074
	3	46.39	4.20	0.0045	0.1309	1.0254
	1	37.42	6.33	0.0052	0.1047	0.9987
5	2	44.89	5.70	0.0044	0.1210	1.0199
	3	51.53	4.44	0.0040	0.1287	1.1026
	1	41.42	6.33	0.0054	0.1099	0.9534
6	2	42.41	5.32	0.0052	0.1254	1.1224
	3	43.15	5.06	0.0048	0.1350	1.3341
	1	38.55	6.46	0.0050	0.1041	0.9223
7	2	39.10	6.01	0.0041	0.1070	1.0178
	3	44.37	5.28	0.0035	0.1255	1.0632
	1	40.56	6.46	0.0052	0.1073	0.9492
8	2	41.49	5.02	0.0043	0.1141	1.0946
	3	45.72	4.88	0.0037	0.1299	1.2885

	1	39.04	6.47	0.0053	0.1065	0.9324
9	2	42.15	5.34	0.0044	0.1072	1.0172
	3	43.76	4.87	0.0036	0.1266	1.0641

TABLE 5
Numerical results

Configuration	S_m	N_1	N_2	μ^*	C_1	C_2
S1	23.75	15	15	-0.02	13.33	26.67
	21.00	17	17	-0.01	11.76	23.53
	18.25	18	17	-0.04	5.56	47.06
S2	60.75	15	15	-0.03	6.67	33.33
	52.50	16	15	-0.05	6.25	46.67
	45.25	19	16	-0.10	0.00	68.75
S3	80.00	19	14	-0.11	0.00	64.29
	70.00	18	15	-0.09	5.56	53.33
	60.00	19	16	-0.13	0.00	75.00
Mean	-	17.62	15.55	-0.06	5.45	48.73

CONCLUSION

In this paper, we have introduced the application of a fuzzy logic controller to a multiobjective ant colony optimization algorithm. Thus, a multiobjective ant colony algorithm with a fuzzy logic controller (FLC-MOACS) is developed to solve an assembly line design problem. The goals of the design problem are to assign machines to workstations and to size the intermediate buffers. The two objectives of our study are the maximization of the performances rates and the costs minimization of assembly lines. Computational experiments have been realized on different lines configurations and we have compared our algorithm to a classical multiobjective ant colony algorithm (MOACS). We have noticed that the FLC-MOACS performances are better than those of the MOACS. Regarding the perspectives of this work, other methods to be coupled with the fuzzy logic controllers may be tested such as genetic algorithms. Other hybridization techniques of the developed algorithms may also be tested in order to see the impact on the achieved solutions. Finally, exact methods may be developed to compare the optimal solutions with those of the above metaheuristics.

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DEGREES OF FREEDOM IN CALCULATING INVENTORY-CARRYING COSTS: A SIMULATION STUDY ON THE IMPACT OF DIFFERENT WAYS OF CALCULATING THE AVERAGE CAPITAL TIED UP IN STORAGE

Christoph Siepermann[1]

Abstract — *Inventory-carrying costs represent an important type of logistics costs, not only with regard to their height, but also with respect to their application in logistical decision models. The determination of these costs, nevertheless, causes serious problems which result, on the one hand, from margins in fixing the rate of interest and, on the other hand, from different ways of calculating the average capital tied up in storage. This paper picks up the latter aspect and tries to estimate, by means of a simulation study, the extent of differences between the various ways of determining the average value of inventory as they can occur in practice. The simulation study will show that, compared to the valuation margins which result from different rates of interest, the consequences of the different ways of calculating the average capital tied up in storage for the determination of inventory-carrying costs are of minor significance. But under certain circumstances, the different formulas for calculating the average value of inventory can lead to quite different results and therefore are also responsible for degrees of freedom in determining inventory-carrying costs.*

Keywords — *costs of working capital, inventory-carrying costs, logistics controlling, logistics costs, stock valuation*

MOTIVATION

According to empirical studies among industrial and commercial enterprises of different sectors, inventory-carrying costs (= costs for capital tied up in storage) account for approximately 20% of a firm's total logistics costs **Hata! Başvuru kaynağı bulunamadı.**. For several logistical decision models (e.g. lot sizing, service level determination etc.), they represent an important input parameter. In the context of Supply Chain Management, they play an important role in dividing the savings resulting from inventory reductions among the supply chain partners. The exact determination of a period's inventory-carrying costs, nevertheless, causes serious problems which result, on the one hand, from margins in fixing the rate of interest and, on the other hand, from different ways of calculating the average capital tied up in storage **Hata! Başvuru kaynağı bulunamadı.**. While the problems in fixing the "correct" rate of interest have already been explored in detail **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**, the impact of the different ways of calculating the average capital tied up in storage on the resulting inventory-carrying costs has not yet attracted much attention in literature. The paper therefore picks up this aspect and tries to estimate, by means of a simulation study, the extent of differences between the various ways of determining the average value of inventory by computing the average stock value according to the different valuation methods in each simulation run and statistically analysing the differences between the largest and the smallest value over all simulation runs.

THEORETICAL BASICS

A period's inventory-carrying costs are calculated by multiplying the average capital tied up in storage with a certain rate of interest which can vary in practice between under 6% and over 30%. The reason for this enormous span will not be discussed here **Hata! Başvuru kaynağı bulunamadı.**. The average capital tied up in storage is computed as the mean of the stock value at the beginning and at the end of the period. Degrees of freedom in the determination of the average capital tied up in storage result on the one hand from different valuation rates for opening and closing stock and on the other hand from different ways of averaging opening and closing stock value.

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In order to analyse the first aspect, we initially have to differentiate between externally procured and self-provided goods (see Figure 1). Externally provided goods can be valuated either at acquisition or replacement costs. When valuating at acquisition costs we have to take into account that the inventory of a certain good normally consists of subsets which have been procured at different acquisition prices. To solve this problem, different inventory valuation procedures have been developed **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.** (see Figure 2). Self-provided goods are usually valuated at production costs which can be assumed to fluctuate much less than the acquisition prices of externally procured goods because a great deal of production costs are cost elements which are rather constant over time (e.g. wages, depreciation etc). Therefore, the following statements focus on externally procured goods.

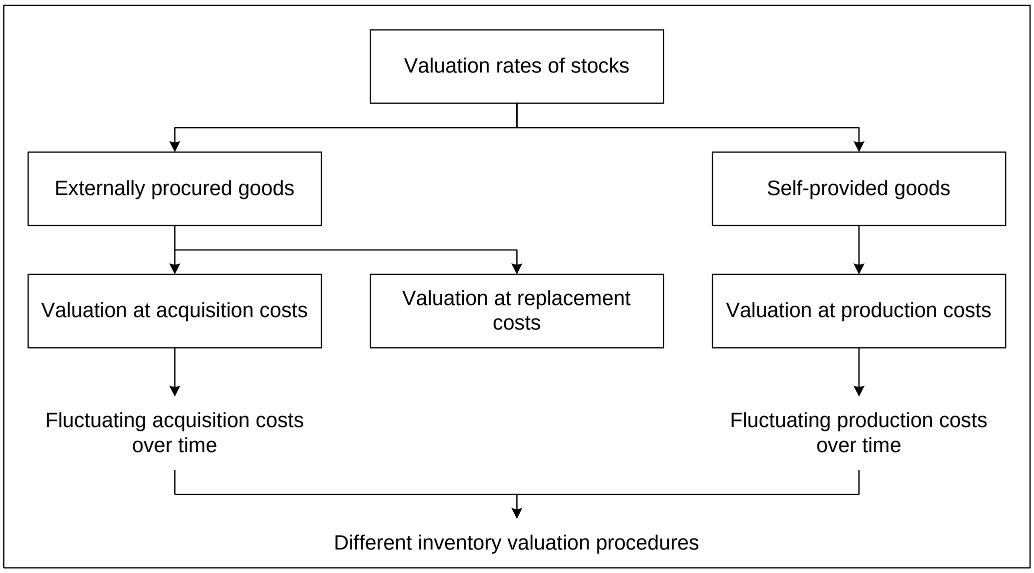

FIGURE 1
Valuation rates of stocks

	Average cost methods	**Cost flow assumptions**	
Period-oriented methods	Weighted average cost method	Period-oriented LIFO-method	FIFO-method
Permanent methods	Moving average cost method	Permanent LIFO-method	

FIGURE 2
Inventory valuation procedures

The inventory valuation procedures shown in Figure 2 determine the stock value at a certain *point of time*, but for calculating a period's inventory-carrying costs we need the *average* stock value within a *space of time*, namely the considered period. Averaging opening and closing stock value can again be done in different ways **Hata! Başvuru kaynağı bulunamadı.**:

- ½ • (opening stock value + closing stock value), where opening and closing stock value can be computed by each inventory valuation procedure shown in Figure 2
- $\frac{1}{n}\sum_{i=1}^{n}\left(\frac{OSV_i + CSV_i}{2}\right)$ with n = number of sub-periods
  OSV = opening stock value
  CSV = closing stock value

Instead of averaging opening and closing stock *value* of a (total or sub-) period, we alternatively can determine quantity and value structure separately by valuating the quantitatively averaged opening and closing

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stock at a joint valuation rate for opening and closing stock.

Figure 3 summarises the formulas for calculating the average stock value within a certain period as they result from all these calculation variants. Obviously, the formulas based on sub-periods (3, 4a-e and 6) lead to more precise results than the formulas based upon the total period (1, 2a-e and 5). And it is also evident that the accuracy level increases with the number of sub-periods (n), into which the total period is subdivided. But even when we choose a very large n, the degrees of freedom resulting from the existence of different inventory valuation procedures persist. In the following, their possible extent in practice will be examined by means of a simulation study. The study is limited to the valuation at acquisition costs, while the valuation at replacement costs is neglected as the differences to the acquisition cost-based valuation directly result from the development of the acquisition prices.

		Formula based on the total period	Formula based on n sub-periods
Valuation at acquisition costs	**Seperate determination of quantity and value structure**	1) $\frac{OS+CS}{2} \cdot$ weighted AP of the total period	3) $\frac{1}{n} \cdot \sum_{i=1}^{n} \left(\frac{OS_i + CS_i}{2} \right) \cdot$ weighted AP of each sub-period
	Integrated determination of quantity and value structure	2) $\frac{OSV+CSV}{2}$ Determination of OSV and CSV via a) weighted average cost method b) moving average cost method c) FIFO-method d) period-oriented LIFO-method e) permanent LIFO-method each for the total period	4) $\frac{1}{n} \cdot \sum_{i=1}^{n} \left(\frac{OSV_i + CSV_i}{2} \right)$ Determination of OSV_i and CSV_i via a) weighted average cost method b) moving average cost method c) FIFO-method d) period-oriented LIFO-method e) permanent LIFO-method each for the respective sub-period
Valuation at replacement costs		5) $\frac{OS+CS}{2} \cdot RP$	6) $\frac{1}{n} \cdot \sum_{i=1}^{n} \left(\frac{OS_i + CS_i}{2} \right) \cdot RP$
Legend		OS = opening stock CS = closing stock AP = average (acquisition) price	OSV = opening stock value CSV = closing stock value RP = replacement price

FIGURE 3
Formulas for the average stock value of a period

THE SIMULATION MODEL

The simulation model which shall help to answer the research question expressed above was coded in Delphi 7 and consists of two parts. In the first part, we consider the raw materials warehouse of a single enterprise, and in the second part, we will examine a whole supply chain.

The enterprise-related part of the simulation model acts on the following assumptions:

We consider a (total) period of one year with 365 days. The shortest sub-period is one day.

There is (at most) one inward and one outward stock movement per day, where the inward stock movement precedes the outward one. As the aim of the study is not to examine shortfalls, this simplifying assumption seems to be arguable.

A day's opening stock represents the stock level before the inward stock movement, the closing stock is determined after the outward stock movement. The replenishment decision is taken on the basis of the closing stock, i.e. after all stock movements of the day (see Figure 4).

Demand per day (which determines the outward stock movements) is modelled as a normally distributed random variable with average μ_D and standard deviation σ_D, where negative values are replaced by 0 so that the probability of no demand at one day is slightly increased. Although assuming a normally distributed demand is not completely conform with reality **Hata! Başvuru kaynağı bulunamadı.**, this assumption nevertheless seems to be acceptable according to prevailing literature opinion **Hata! Başvuru kaynağı bulunamadı.**, as the studies of Silver et al. concerning the probability of shortfalls have shown that different probability distributions lead to only slightly different results **Hata! Başvuru kaynağı bulunamadı.**.

Shortfalls are back-ordered as soon as possible.

Order quantities, i.e. the inward stock movements are calculated from the outward stock movements under consideration of the opening stock according to the rules of the three most important replenishment systems, namely (t, S)-, (s, S)- and (s, q)-system. The other three replenishment systems ((t, q), (t, s, q) and (t, s, S)) are of minor interest in practice and therefore neglected here because of their increased shortfall probability or their need of an increased safety stock in order to guarantee a fixed service level, respectively **Hata! Başvuru kaynağı bulunamadı.**.

The replenishment time is assumed to be well-known and fixed. The minimum replenishment time is one day. A replenishment time of one day means that supply arrives the next day.

Opening stock, order quantities and other parameters of the applied replenishment system are calculated from the average outward stock movement μ_D, its standard deviation σ_D, the order cycle t, the replenishment time t_R and a fixed α-service level (see Figure 5) **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**. Some remarks are necessary concerning the formulas: (1) The opening stock of the total period has to cover demand until the first receipt. When we presume that the first order is placed in period t, the first supply arrives in period $t + t_R$. As the inward stock movement always preceeds the outward one, the opening stock has to be enough for $(t + t_R – 1)$ days. (2) In the context of (s, q)- and (s, S)-system, the order cycle t has to be interpreted as an aspired average order cycle, i.e. the stock level after replenishment shall cover demand of t days on average. (3) In the context of (t, q)-, (s, q)- and (t, s, q)-system, the order quantity q is not calculated as customary based on a lot-sizing model, but results (amongst others) from the (average) order cycle t. The advantage of this simplification is that the impact of parameters such as ordering and storage costs on the order quantity can be eliminated easily. This is desirable as their inclusion into the model only would complicate the analysis.

The acquisition prices are assumed to be normally distributed between a certain minimum and maximum price. The average price is μ_P, the standard deviation is σ_P.

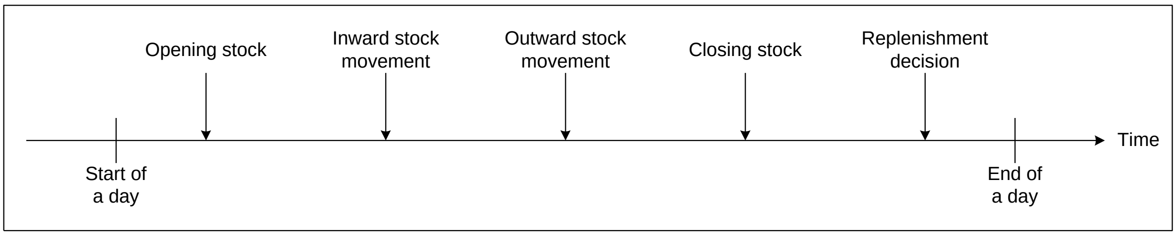

FIGURE 4
Sequence of stock movements and decisions in the simulation model

Replenishment system	**Parameters**
(t, S)	$OS = \mu_D \bullet (t + t_R - 1) + x_\alpha \bullet \sqrt{t + t_R - 1} \bullet \sigma_D$ $S = \mu_D \bullet t + x_\alpha \bullet \sqrt{t + t_R - 1} \bullet \sigma_D$
(s, q)	$OS = \mu_D \bullet (t + t_R - 1) + x_\alpha \bullet \sqrt{t_R} \bullet \sigma_D$ $s = \mu_D \bullet t_R + x_\alpha \bullet \sqrt{t_R} \bullet \sigma_A$ $q = \mu_D \bullet t + x_\alpha \bullet \sqrt{t_R} \bullet \sigma_D$

(s, S)	$OS = \mu_D \bullet (t + t_R - 1) + x_\alpha \bullet \sqrt{t_R} \bullet \sigma_D$ $s = \mu_D \bullet t_R + x_\alpha \bullet \sqrt{t_R} \bullet \sigma_D$ $S = \mu_D \bullet t + x_\alpha \bullet \sqrt{t_R} \bullet \sigma_D$
Legend	OS = opening stock of the total period S = target stock s = reorder level q = order quantity t = (average) order cycle t_R = replenishment time, t_R = const., $t_R \leq t$ μ_D = average demand per day σ_D = standard deviation of demand x_α = α-fractile of the normal distribution

FIGURE 5
Formulas for the parameters of the replenishment systems

The supply chain-related part of the simulation study is based on the beer distribution game as developed by the Massachusetts Institute of Technology (MIT) **Hata! Başvuru kaynağı bulunamadı.**. We consider a supply chain consisting of four tiers: raw materials supplier, manufacturer, wholesaler and retailer. In order to ensure that results are comparable to the first part of the simulation study, the following modifications and specifications of the game have been made:

The game runs for 365 periods, where one period represents one day.

End customer demand per day is normally distributed with average μ_D and standard deviation σ_D, where negative values again are replaced by 0.

An order is placed when the forecasted demand for the next day (including back orders) exceeds the available stock at that day (= current inventory + receipt). The order quantity equates to the forecasted demand.

Prices are again normally distributed with μ_P and σ_P and cut at a certain minimum or maximum value, respectively.

In the following section we will present the results of the four most important simulation experiments, where the first three experiments are related to a single enterprise and the last one refers to a supply chain. Each experiment consists of 5,000 simulation runs. For each simulation run the average values of inventory are calculated via formulas 3 and 4a-e from Figure 3. (The other formulas from Figure 3 are not included in the simulation study for the reasons already presented). After that, the difference between the maximum and the minimum of these values is computed and divided by the minimum. The resulting percentage, in the following called "percental range of the average stock value" or shortly "percental range", is averaged over all 5,000 simulation runs. Additionally, maximum, minimum and standard deviation of the percental ranges are computed and shown in the tables. As the percental range is a percentage, average, maximum and minimum are percentages, too. The dimension of the standard deviation is percentage points.

RESULTS OF THE SIMULATION STUDY

When acquisition prices are constant, all inventory valuation procedures and therefore also formulas 3 and 4a-e from Figure 3 lead to the same result. Significant differences between the different calculation variants for the average stock value are only possible when the fluctuation of the acquisition prices is more or less strong. In the following, we therefore will assume a rather high price fluctuation of 25% of the average price, i.e. the coefficient of variation $v_p = \sigma_P/\mu_P$ is 0.25. The minimum price is 50% of the average price, the maximum one 150%. These parameters comply with the price fluctuation of some important quoted raw materials (fuel oil, lead, nickel and wheat) in the year 2007 (see www.handelsblatt.com/rohstoffe). Furthermore, we can assume that the different calculation variants for the average capital tied up in storage will especially then lead to strongly differing results when also the stock level is subject to more or less strong oscillations. This oscillation will accelerate with increasing irregularity of demand and outward stock movements. In the enterprise-related simulation experiments (first part of the simulation study, experiments 1-3) we therefore will assume demand to oscillate by 30% around the average demand μ_D, i.e. $v_D = \sigma_D/\mu_D = 0.3$. This is a typical value for stock material **Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**. The α-service level during the replenishment periods will be 98%, i.e. x_α=2.

By contrast, in the supply chain-related part of the simulation study (second part, experiment 4), we will presume an only slightly floating end customer demand in the amount of 5% of average demand ($v_D = \sigma_D/\mu_D$ = 0.05) and observe the impact of the bullwhip effect on the percental range of the average stock value. As price oscillation commonly decreases downstream, we have to allow for this fact by underlying different coefficients of variation for the price on each tier of the supply chain (see Table 1). The applied forecasting method is exponential smoothing with $\alpha = 0.3$ throughout the whole supply chain.

TABLE 1
Price fluctuation depending on the supply chain tier

Tier	v_P	Maximum range of μ_P
Retailer	0.05	$0.1\mu_P \le \mu_P \le 1.1\mu_P$
Wholesaler	0.10	$0.2\mu_P \le \mu_P \le 1.2\mu_P$
Manufacturer	0.20	$0.3\mu_P \le \mu_P \le 1.3\mu_P$
Raw materials supplier	0.25	$0.5\mu_P \le \mu_P \le 1.5\mu_P$

Simulation experiment 1

We start the analysis with an (average) order cycle t of five days and a replenishment time t_R of two days and explore the percental range of the average stock value against the different replenishment systems. As Table 2 shows, the resulting percental ranges of the average stock value and therefore the margins concerning the average capital tied up in storage are negligible, even with additional consideration of the statistical spread expressed by the standard deviation. This result can be explained by the fact that, due to the relatively short periods between two receipts, lower and upper stock level are always rather close to each other and the stock level run is very steady, even when demand and the outward stock movements are subject to relatively strong oscillations.

TABLE 2
Results of simulation experiment 1

Parameters: $v_D = 0.3$; $v_P = 0.25$; $0.5\mu_P \le \mu_P \le 1.5\mu_P$; $x_\alpha = 2$; n = 365; t = 5; $t_R = 2$				
Percental range → Reorder system ↓	Average [%]	Maximum [%]	Minimum [%]	Standard dev. [%-points]
(t, S)	0.63	2.63	0.01	0.37
(s, S)	0.52	2.10	0.01	0.30
(s, q)	0.52	2.25	0.01	0.32

Simulation experiment 2

When we gradually increase the time between two receipts, the differences between lower and upper stock level are growing larger, too, and the stock level run becomes more volatile. Therefore we can presume that the percental ranges of the average stock value will reach higher dimensions with increasing (average) order cycles and replenishment times. This question is explored in the second simulation experiment for the frequently used (s, S)-system. Although the results shown in Table 3 confirm our presumption, they are still of minor significance.

TABLE 3
Results of simulation experiment 2

Parameters: $v_D = 0.3$; $v_P = 0.25$; $0.5\mu_P \leq \mu_P \leq 1.5\mu_P$; $x_\alpha = 2$; $n = 365$; (s, S)-system				
Percental range → $t + t_R$ ↓	Average [%]	Maximum [%]	Minimum [%]	Standard dev. [%-points]
15 + 1	0.53	3.07	0.01	0.40
30 + 2	0.83	5.10	0.01	0.69
60 + 3	2.01	10.02	0.01	1.80
90 + 4	2.78	20.51	0.00	2.81
120 + 5	3.25	25.38	0.00	3.71

Simulation experiment 3

In practice, the order quantity is not only a function of the parameters of the applied replenishment system, but it is also influenced by the actual acquisition price, especially when the latter is subject to a strong fluctuation as assumed here. When the price is low and rising prices are expected, the purchaser will order a higher quantity than usual and exercise speculative stock-keeping. In order to model this modified replenishment system, we take the (s, q)-system as a basis and augment the order quantity q depending on the achievable price advantage by the factor $\mu_P/p(t_O)$ to q*, where $p(t_O)$ represents the acquisition price which is valid at the moment when the order is placed (t_O): $q^* = \mu_P/p(t_O) \cdot q$. For example, if the actual acquisition price $p(t_O)$ is 50% of the average price μ_P, we would double the regular order quantity according to this formula. Since according to our assumptions a price of $0.5\mu_P$ is the lowest possible acquisition price, the regular order quantity at most can be doubled, i.e. $q^*_{max} = 2q$. Table 4 shows the results of this third simulation experiment, which are comparable to the second one. As the modified (s, q)-system applied here can only make an impact when orders are placed frequently, (average) order cycles and replenishment times are shorter than in the previous simulation experiment.

TABLE 4
Results of simulation experiment 3

Parameters: $v_D = 0.3$; $v_P = 0.25$; $0.5\mu_P \leq \mu_P \leq 1.5\mu_P$; $x_\alpha = 2$; $n = 365$; (s, q*)-system with $q^*_{max} = 2q$				
Percental range → $t + t_R$ ↓	Average [%]	Maximum [%]	Minimum [%]	Standard dev. [%-points]
5 + 2	3.99	8.92	0.04	1.25
10 + 2	4.30	11.27	0.03	1.75
15 + 2	4.32	13.21	0.02	2.09

Simulation experiment 4

The situation changes completely when we observe a whole supply chain which is subject to the bullwhip effect. As Table 5 shows, the percental ranges of the average stock value continuously increase from the retailer over the wholesaler and the manufacturer to the raw materials supplier where it reaches remarkable dimensions. This escalation is, on the one hand, due to upstream increasing price oscillation and, on the other hand, to the bullwhip effect.

TABLE 5
Results of simulation experiment 4

Parameters: $v_D = 0.05$ (end customer); $n = 365$; $\alpha = 0.3$				
Percental range → Tier ↓	Average [%]	Maximum [%]	Minimum [%]	Standard dev. [%-points]
Retailer	1.05	4.58	0.03	0.79
Wholesaler	2.41	13.26	0.01	1.88
Manufacturer	4.62	25.88	0.01	3.58
Raw mat. supplier	11.23	82.91	0.01	9.71

CONCLUSION

Compared to the valuation margins which result from different rates of interest, the consequences of the different ways of calculating the average capital tied up in storage for the determination of inventory-carrying costs are of minor significance. But under certain circumstances (strong fluctuation of acquisition costs, uneven stock level run) the different formulas for calculating the average value of inventory can lead to quite different results and therefore are also responsible for degrees of freedom in determining inventory-carrying costs. In situations where price fluctuations with a standard deviation amounting to 25% of the average price converge with the bullwhip effect, which especially applies to raw materials suppliers, the percental range of the average stock value can reach – according to the properties of the normal distribution – up to 20% (= average + standard deviation of the percental ranges) with a probability of 34%. In order to avoid arbitrary results in such cases, it is crucial to choose that inventory valuation procedure which best reflects the effective sequence of consumption.

NEED FOR FURTHER RESEARCH

In this paper, it was only shown *that* different ways of calculating the average value of inventory under certain circumstances can lead to very different results and therefore can be responsible for degrees of freedom in determining inventory-carrying costs. However, the influencing factors on the different results were not analysed. Here further research is still needed.

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A METAHEURISTIC ALGORITHMS FOR A SPECIFIC SCHEDULING PROBLEM

Naim Yalaoui[1,2], Lionel Amodeo[3], Farouk Yalaoui[4], Halim Mahdi[5]

Abstract *— We deal in this work with an operational decision level such as a scheduling problem. Regarding to the specification of the workshop, the solved problem is presented as an hybrid flow shop problem with a pre assignment of tasks on machines. This one has: some stages, each one contains different machines and the assignment of the tasks is known. Also each stage contain one fictive machine. For a large size of problems such us those of industrial cases, three metaheuristics are developed in this paper. These ones are a genetic algorithm (GA), a particle swarm optimization (PSO) and a genetic algorithm under fuzzy logic controller (FLCGA). The results of these methods are compared to an exact one which has been developed in our previous works. The results are presented and discussed. The interest and the effectiveness of these metaheuristics are shown.*

Keywords — Scheduling problem, Hybrid flow shop problem, Genetic algorithm, Particle swarm optimization, fuzzy logic controller.

INTRODUCTION

This work is an industrial case study with a specific configuration. This flow shop contains some stages with real parallel machines, and a fictive one in each stage. All products have to be processed through different stages and pre assigned in the machines. This aspect of the production presents an hybrid flow shop scheduling problem with a pre assignment of machines. The objective of the problem is to minimize the total tardiness. To solve it, different metaheuristic methods have been applied such us a genetic algorithm and a particle swarm optimisation. As known, these methods are very efficient but have some constraints regarding the parameters or the operators, the difficulty to define the probability of mutation or crossover for the genetic algorithm for example. To overcome this constraint, we propose a new approach using a genetic algorithm under control of fuzzy logic controllers. Those allow a continuous upgrading of the parameters. This method has been developed by us to solve another specific scheduling problem with re-entrant orders **Hata! Başvuru kaynağı bulunamadı.**. In this paper, we test its efficiency on the our new problem.

Since fuzzy sets theory has been introduced more than 20 years ago, it has had an unexpected growth. Coffin and Taylor **Hata! Başvuru kaynağı bulunamadı.** presented a multiple criteria model for scheduling. This model uses fuzzy logic and a standard beam search. The fuzzy beam search model is applied via a twenty project examples problem using three primary goals: maximizing expected profit, maximizing average success probability for the portfolio, and minimizing the makespan of the portfolio. The quality of the solutions is provided trough a comparison between the results from the model and those generated by a complete enumeration procedure.

The study shows that the fuzzy beam search model is able to generate high quality solutions, using very small beam widths; moreover it needs less computational efforts than exact methods.

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Bugnon *et al.* **Hata! Başvuru kaynağı bulunamadı.** described an approach based on a fuzzy rules controller which can be dynamically adapted following different perturbations in a shop. This method provides a dynamic approach to solve efficiently real-time scheduling problems.

Slany **Hata! Başvuru kaynağı bulunamadı.** developed a method which combines repair-based methods and fuzzy constraints. This algorithm can solve real-world multi-criteria decision making, especially scheduling problems. This method reaches a compromise between different criteria, moreover it asses priorities among fuzzy constraints. The results obtained from a steel making application indicate the efficiency of the proposed approach compared to constructive non-fuzzy methods in terms of modeling and performance.

Chan *et al.* **Hata! Başvuru kaynağı bulunamadı.** showed that scheduling of manufacturing system is made up of several decision points at which a decision rule should be applied: for example, the selection of an operation among several alternatives. A simple operation-selection rule, such as SNQ (Shortest Number of jobs in Queue), always blindly pursues a single objective, despite more than one objective are important. To fix this problem, the authors introduced an intelligent approach to a multi-objective real-time alternative operation. Each alternative operation is evaluated, and its contribution to system performance using membership functions is calculated. The proposed method is easy to apply in a simulation model. They mentioned that the objective set used in this paper is not exhaustive, but is a significant generic issue in machine selection. The results of the proposed method show a good improvement in some performance measures, such as net profit and average lead time.

Allet **Hata! Başvuru kaynağı bulunamadı.** interested in representing a practical case of a pharmaceutical company in 2003. This problem was already treated in the classical case (fixed data and strict constraints) and modeled as a generalized job shop problem. In this model, several aspects of this problem were neglected (existence of preference relations on the possible values of due dates and delay between successive operations of the same job). In this work, a new model is proposed, with use of fuzzy logic and flexibility on delay and due dates. A new method generalizing the previous ones is developed. The former considers the existence of the preference relation on each of the two parameters.

Suhail and Khan **Hata! Başvuru kaynağı bulunamadı.** studied the development procedure of a fuzzy control system (FCS) for production processes. The latter are perfectly balanced over time but need to be controlled due to the randomness involved by their functioning. The authors try to control it dynamically with FCS system in different configuration and in taking into account the randomness operator.

In this section, a state of the art has been presented. This one allows us to see the different works done on the scheduling problem under fuzzy control. The different works cited bellow show that the fuzzy logic controller can be used in different ways. As resumed, the FLC can be considered as a tool for decision support.

OPTIMIZATION METHOD

In this section, the hybrid flow shop scheduling problem is solved. The objective is to minimize the total tardiness. We solve the problem using a method which involves Genetic Algorithm guided by Fuzzy Logic Controllers (FLC-GA) and we improve the GA and PSO. Finally we compare all of these results to get efficiency of the different methods.

Fuzzy Genetic Algorithm

The basic methods presented hereafter is a Genetic Algorithm (GA) since the efficiency of this method is firmly established, we just recalled here that GA is a population based metaheuristic which combined different crossover and mutation of chromosomes in order to select efficient solutions for several problems

Encoding chromosome

Each chromosome in the population defines a solution for the scheduling problem. Each chromosome is composed of the sequence of tasks at each stage. **Hata! Başvuru kaynağı bulunamadı.** shows a chromosome which defines the scheduling of 3 tasks on three stages. The size (number of genes) of a chromosome is the product of the number of tasks multiplied by the number of stages. Each gene of a chromosome contains an integer number that represents the index of the task.

Figure 1 . Chromosome encoding

Stage 1	Stage 2	Stage 3

2	1	3	2	1	3	1	2	3

Crossover

The crossover operator consists to create two children by crossing one or more genes from two parents. For solving our problem, a *LX* procedure has been applied in each stage. The crossover is applied in each iteration reguarding the updated value of its probability operator for crossing *pc*. This probability parameter is initially set to: *pc* = 0.9. The update is made under the FLC (fuzzy logic control).

Mutation

The objective of the mutation is to prevent the algorithm from being trapped untimely in a local optimum. Two points are randomly selected on the chromosome. In our case, random mutation is generated at each stage of the chromosome to disturb solutions. As the crossover operator the mutation operator happens with a probability of *pm* which is also under the FLC. This parameter is set to: *pm* = 0.1, at the beginning of each algorithm.

Figure 2. Parents : select point for crossing

	Stage 1			Stage 2			Stage 3		
Parent 1	2	**1**	**3**	2	1	**3**	1	**3**	**2**
Parent 2	1	**3**	**2**	2	3	**1**	3	**2**	**1**

Figure 3 . Children : new chromosome

	Stage 1			Stage 2			Stage 3		
Enfant 1	1	**3**	**2**	2	3	**1**	3	**2**	**1**
Enfant 2	2	**1**	**3**	2	1	**3**	1	**3**	**2**

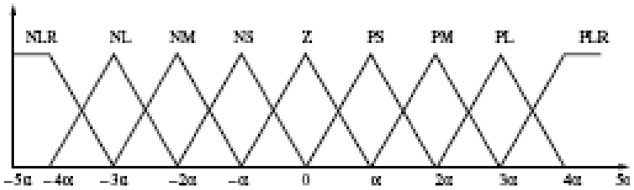
Stopping criteria

In the literature two types of stopping criteria exist: either the number of generations is fixed, or the search process stops when the best objective function is not improved for a fixed number of generations. In this study the two criteria are combined. The hard limit concerning the number of generations is set to: *Ngen* = 2000 generations.

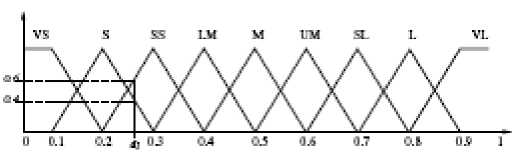
Fuzzy logic

As the previous section shows, the genetic algorithm (GA) used here has two probability parameters: the probability of mutation denoted by *pm* and the probability of crossover denoted by *pc* which are usually constant. In their paper Lau *et al.* **Hata! Başvuru kaynağı bulunamadı.** introduced a Fuzzy Logic Controller (FLC) which aimed to set proper parameter values in each iteration of the GA. In the present section, the FLC works is explained, hereafter this explanation is illustrated by an example.The fuzzy logic was introduced by Lotfi Zadeh [54], firstly as data processing and then used to control system. It consists in introducing noise trough membership function and making a decision by using a table. The functioning is explained below.

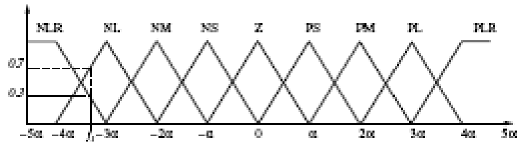
Figure 4. Membrship function of $f(t-1)-f(t-2), \Delta p_c, \Delta p_m$



The FLC is made up of 3 steps: *fuzzyfication*, *decision making* and *defuzzyfication*. In our algorithm two different FLCs exist: one dedicated to the probability of mutation *pm* and another one dedicated to the of the first [illegible] adapted to



d(t)



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The FLC which controls *pc* value uses some information and parameters are considered: the iteration denoted by *t*, the probability of crossover is denoted by *pc*(*t*) at this iteration and by *pc*($t-1$) and *pc*($t-2$) at the two former iterations. Parameter *pc* is calculated by *pc*(*t*) = *pc*($t-1$) + *Δpc*, FLC provides the value of *Δpc* by using the value of the difference between *f*($t-1$) and *f*($t-2$) which are the average value of the objective function (in this section the total tardiness) at the iteration $t-1$ and $t-2$ respectively. More over FLC uses the parameter $d(t)$ which is the sum of the hamming distance between each individuals of the entire population.

A value of $pc(t-1) = 0.5$ is considered in the following example. The aim is here to provide the value of $p(t)$ trough the FLC.

TABLE 1. Linguistic terms for $p_c, p_m, \Delta p_c, \Delta p_m$

linguistic term	meaning
NLR	Negative larger
NL	Negative large
NM	Negative medium
NS	Negative small
Z	Zero
PS	Positive small
PM	Positive medium
PL	Positive large
PLR	Positive larger

TABLE 2. Linguistic terms for d

linguistic term	meaning
VS	Very small
S	Small
SS	Slightly small
LM	Lower medium
M	Medium
UM	Upper medium
SL	Slightly large
L	Large
VL	Very large

The first step in the FLC is the fuzzyfication of the variables d and $f(t-1)-f(t-2)$ trough the membership functions described by **Hata! Başvuru kaynağı bulunamadı.** and **Hata! Başvuru kaynağı bulunamadı.**.

The different part (NLR, . . . , PLR) are called linguistic terms. This is a mean to describe the objective function (here the value of the total tardiness). For example, if a large value of the difference between $f(t-1)$ and $f(t-2)$ is considered and $f(t-2) > f(t-1)$ then the membership function will provides a value in NL (negative large) or NLR (negative larger), . . . All of the linguistic terms are defined in **Hata! Başvuru kaynağı bulunamadı.** and concerning $d(t)$ the linguistic terms (VS, . . . , VL) are in **Hata! Başvuru kaynağı bulunamadı.**.

Concerning the membership function of $f(t-1) - f(t-2)$, it must be noticed that a coefficient α exists. This coefficient is settled here for scaling the function to fit the difference $f(t-1)-f(t-2)$. Here a scale of α is equal to 1000.

An example is provided here: if the difference $f(t-1) - f(t-2) = f1 = -3300$, it means that the sum of the total tardiness over the entire population at iteration $(t-1)$ is 3300 less than this sum at iteration $(t-2)$.

Then the membership function of **Hata! Başvuru kaynağı bulunamadı.** is used, and the value $f()$ is placed: the function provides us NLR with a proportion of 0.3 and NL with a proportion of 0.7.

The same is done with $d(t) = d1 = 0.27$ which provides S with a proportion of 0.4 and SS with 0.6.

After the fuzzyfication comes the decision making. This step is achieved by the decision table denoted by **Hata! Başvuru kaynağı bulunamadı.**(respectively with **Hata! Başvuru kaynağı bulunamadı.** concerning *pm*). This table allows to make a decision with by using the value of the member ship function of $(f(t-1) - f(t-2))$ (NLR, ..., PLR) and that of $d(t)$ (VS, . . . , VL). It must be stressed here that this two tables are in conflict with each other. Indeed, **Hata! Başvuru kaynağı bulunamadı.** means that if the population is very different concerning the decision space ($f(t-1) - f(t-2)$ is NLR) as well as concerning the searching space ($d(t)$ is VL) the decision table increases the intensification in providing higher value for *Δpc* (indeed *Δpc* is set to PLR).

Concerning **Hata! Başvuru kaynağı bulunamadı.** if the same values are considered this table decreases the value of *pm* by providing NLR for *Δpm*.

TABLE 3. Decision table p_c

$d(t-1)$ f_a	NLR	NL	NM	NS	Z	PS	PM	PL	PLR
VL	PLR	PLR	PL	PL	PM	PM	PS	PS	Z
L	PLR	PL	PL	PM	PM	PS	PS	Z	NS
SL	PL	PL	PM	PM	PS	PS	Z	NS	NS
UM	PL	PM	PM	PS	PS	Z	NS	NS	NM
M	PM	PM	PS	PS	Z	NS	NS	NM	NM
LM	PM	PS	PS	Z	NS	NS	NM	NM	NL
SS	PS	PS	Z	NS	NS	NM	NM	NL	NL
S	PS	Z	NS	NS	NM	NM	NL	NL	NLR
VS	Z	NS	NS	NM	NM	NL	NL	NLR	NLR

TABLE 4. Decision table p_m

$d(t-1)$ f_a	NLR	NL	NM	NS	Z	PS	PM	PL	PLR
VL	NLR	NLR	NL	NL	NM	NM	NS	NS	Z
L	NLR	NL	NL	NM	NM	NS	NS	Z	PS
SL	NL	NL	NM	NM	NS	NS	Z	PS	PS
UM	NL	NM	NM	NS	NS	Z	PS	PS	PM
M	NM	NM	NS	NS	Z	PS	PS	PM	PM
LM	NM	NS	NS	Z	PS	PS	PM	PM	PL
SS	NS	NS	Z	PS	PS	PM	PM	PL	PL
S	NS	Z	PS	PS	PM	PM	PL	PL	PLR
VS	Z	PS	PS	PM	PM	PL	PL	PLR	PLR

The example of the previous paragraph to explain how using the decision table (depicted by **Hata! Başvuru kaynağı bulunamadı.**) is resumed as follow: Several possibilities exist:

NLR(0.3) or NL(0.7) and S(0.4) of SS(0.6).

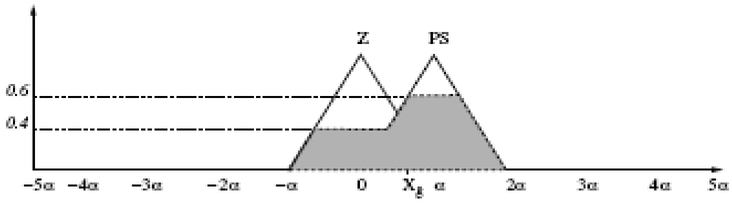
The first possibility is NLR (0.3) and S (0.4), knowing that the combination of NLR and S provides PS, moreover the minimum value between 0.3 and 0.4 is kept which is 0.3. Then PS (0.3) is kept.

The 3 remaining cases are:

$NLR(0.3) \otimes SS(0.6) \rightarrow PS(0.3)$, then $NL(0.7) \otimes S(0.4) \rightarrow Z(0.4)$ and finally $NL(0.7) \otimes SS(0.6) \rightarrow PS(0.6)$.

The final step is the defuzzyfication: this is done by using the membership function of **Hata! Başvuru kaynağı bulunamadı.**. Indeed depending of the value of parameter α this membership function concerns $f(t-1) - f(t-2)$, Δpc or Δpm. Here the aim is to compute the Δpc then $\alpha = 0.02$ (this value is determined after several experiments). The defuzzyfication begin with the sum of the maximum value for each linguistic term as NLR, NL, . . . , PLR.

Figure 7. example of defuzzification



Following the former example, the next step is to compute the sum of $PS(0.3)$, $PS(0.3)$, $Z(0.4)$, $PS(0.6)$. The result is shown in **Hata! Başvuru kaynağı bulunamadı.**. Then the last step is to compute the value of *Xg* the abscissa of the gravity center of the shaded area of **Hata! Başvuru kaynağı bulunamadı.**. Let x be the horizontal axis of **Hata! Başvuru kaynağı bulunamadı.** (from -5α to 5α), let $h(x)$ be *height* of the shaded area of **Hata! Başvuru kaynağı bulunamadı.** (for example $h(-5\alpha) = 0$ and $h(\alpha) = 0.6$), the abscissa *Xg* is computed by the following equation:

$$X_g = \int_{x=-5\alpha}^{5\alpha} x h(x) dx \quad (1)$$

In this example *Xg* is equal to 0.011, then $\Delta pc = 0.011$. The final step is to compute the value of $pc(t)$ concerning the iteration t from the value of $pc(t-1)$ and Δpc. The following equation is considered: $p_c(t) = p_c(t-1) + \Delta p$c. When a value of $p_c(t-1) = 0.5$ is considered, then $p_c(t-1) = 0.5 + 0.011 = 0.511$.

Finally it must be noticed that hard limit concerning *pc* and *pm* have been set: $pc \in [0.5,1]$ and $pm \in [0,0.25]$.

Main principles of the FLC mechanism have been illustrated, for more details the reader can refers to the works of Lau *et al.* [34].

PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization (PSO) is a techniques developed by Kennedy & Eberhart **Hata! Başvuru kaynağı bulunamadı.** for continuous optimization problems while recently, some work has been done on discrete optimization problems. The algorithm is inspired from the animal social behaviours such as fish schooling, bird flocking, etc.

This approach is based on swarm intelligence where each particle represents one solution of the studied problem. A particle moves around solution space using its velocity, a memory and informants. The algorithm starts by the initialization randomly the positions and the velocities of particles, after some iteration the future particles have the aim to find good solution using: the best solution found by their self positions (*Pbest*) and global best solution found by the best position of the best particle (*gbest*), incorporating a random number. The difference between the *Pbest* and *gbest* is that *Pbest* is used on all particles however *gbest* is used only by a particle itself.

As shown above, the movement corresponding to particle needs the following informations: its velocity, its best position, and its best position neighbours using three parameters *w*, *c1* and *c2* respectively. For our problem, each solution contains the positions of the machines in the workshop as described in **Hata! Başvuru kaynağı bulunamadı.**.

Figure 8. Particle encoding

Stage 1	Stage 2	Stage 3

2	1	3	2	1	3	1	2	3

$$V_p^{k+1} = w.V_p^k + c1.rnd_p().(X_{Pbest} - X_p^k) + c2.rnd_g().(X_{gbest} - X_p^k) \tag{2}$$

The position of each particle is updated using the following function:

$$X_p^{t+1} = X_p^t + V_p^{t+1} \tag{3}$$

Where:

X_p^{t+1} : The updated position of the particle, X_p^t : The previous position of the particle, V_p^{t+1} : The updated velocity obtained by the formula (2)

PSO algorithm

```
Generate initial solution randomly for all particles ( k ∈ K )
Assign X_i^k : initial solution
Assign the Pbest for all particles with initial solution
Find best among all particles and assign it to gbest
Generate initial velocities randomly for all particles
Assign V_p^k : initial speed
while Number of iterations is not reached do
    while Population of agents is not reached do
        Update speed using formula (2)
        Add speed to the corresponding particles using formula (3)
        if the solution is improved then
            Update the current Pbest
        end if
    end while
    if the solution is improved then
        Update the current gbest
    end if
end while
Return the best solution gbest
```

COMPUTATIONAL RESULTS

To test the quality and efficiency of the methods, a protocol test presented by Choi et al. **Hata! Başvuru kaynağı bulunamadı.** is applied. The method tests 250 instances with different size of problems. We have chosen for each instance 4 stages. For the due date, five couple of parameters (T, R) has been chosen. With each couple, five instances are generated. T and R are called the delay factor and the range one. The due dates are generated using the following function:

$$DU(P_{\max}(1 - T - \frac{R}{2}), P_{\max}(1 - T + \frac{R}{2})) \tag{4}$$

Where $DU(x, y)$ is a uniform discreet distribution in *[x, y]* and P_{max} defined as follow*:*

$$P_{\max} = \max_i \left\{ \sum_{k=1}^{K} P_{ik} \right\} \tag{5}$$

TABLE 5. Algorithms parameters

-	GA	FLCGA
Number of iteration	30000	30000
Size of population	100	100
P_crossing	0.9	FLController
P_mutation	0.2	FLController
Stopping criteria (sec)	120	120

-	PSO
Number of iteration	30000
Swarm size	100
w	0.978
c1	1.793
c2	1.793

The number of parallel machine is generated using DU (1; 4), where the number of the machines varies between one and four and *0* for the fictive machine. The methods are coded with C++ language, on a laptop with a processor Intel Duo Core with 2.00 GHz frequency.

$$RDI = \frac{(S_a - S_b)}{(S_w - S_b)} \quad (6)$$

Where : S_a: The value of objective function obtained bt algorithm, S_b: The best objective function among those obtained by all tested algorithms and S_w: The worst objective function among those obtained by all tested algorithms

TABLE 6. RDI comparison

	PSO	GA	FLCGA
GR1	0,16	0,93	0,01
GR2	0,23	1	0,00

In our test, the instances are grouped in two group size problem, were *GR1* and *GR2* represents *125* instances for each one. The comparison between the two methods is done using the four comparison criteria which are: the Relative Deviation Index (RDI), the sum of cases where each method is compared to the other ones (NBS). This one is described by the number and the percentage. The third one is the average difference between the objective function obtained by the PSO and the FLCGA (GAPPSO-FLCGA) and between GA and the FLCGA (GAPGA-FLCGA).

The **Hata! Başvuru kaynağı bulunamadı.** shows that for GR1 problem the best method is the FLCGA with RDI=0.01, not far from FLCGA, the PSO method presents also very interesting solution quality. The worst method is the GA.

For the second group *GR2*. The same remark can be made such as the FLCGA is better than the other methods. Its RDI is even better than that obtained for the *GR1*.

TABLE 7. NBS comparison

	PSO (%)	GA (%)	FLCGA (%)
GR1	50 (40)	7 (5)	120 (96)
GR2	0 (0)	0 (0)	125 (100)

The very good results obtained by the FLCGA are confirmed in the **Hata! Başvuru kaynağı bulunamadı.** were it obtained 96% of the best solutions for the *GR1* and 100% for the *GR2*. The PSO method shows interesting results for *GR1* with 40% of best solutions but far from the FLCGA. The worst results are obtained by the genetic algorithm without controller.

TABLE 8. GAP comparison

	GAPPSO-FLCGA (%)	GAPGA-GAFLC (%)
GR1	5	30
GR2	26	57

The **Hata! Başvuru kaynağı bulunamadı.** shows the GAP between the best method which is the FLCGA and the other methods. The comparison between the PSO method and FLCGA one shows that the first one gives interesting solutions compared to the best one with 5% and 26%.

The efficiency of the fuzzy logic controller is proved in the results of the comparison between GA and FLCGA, were the two methods having exactly the same configuration, the only difference is the FLControlleur integrated in FLCGA. We notice that the FLCGA improve the results of the GA with 57% for *GR1* and 30% for *GR2*.

CONCLUSION

A hybrid flow shop scheduling problem with pre affectation has been studied in this paper. This one has some specifications such us the system may contains lot of stages, each one may contain different parallel machine and the orders are pre assigned to the machines. In each stage, that orders that are not processed on any machine are assigned to a fictive one.

The objective is the minimization of the total tardiness. To achieve our objective, three methods have been applied on the problem. Two well known metaheuristics are applied such as à genetic algorithm (GA) and a particle swarm optimization (PSO).The third one is a newest approach, developed by us and presented in this paper which is a genetic algorithm under Fuzzy Logic Controller (FLCGA). The results obtained by the methods are discussed and show that the FLCGA is very efficient.

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MANAGING RETURNABLE PALLETS IN THE CONSUMER PACKAGED GOODS SUPPLY CHAIN:AN ANALYSIS OF THE ITALIAN INDUSTRY

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Abstract *— Returnable wooden pallets represent the most widespread tertiary unit load adopted in the Consumer Packaged Goods (CPG) industry for handling and shipping products along the supply chain. Pallet management represents a significant part of the total logistics spending of grocery retail companies and pallet management costs are borne by all the parties involved in the physical distribution process. These days, an ever-growing pressure on service level, concurrently with a reduction of the price of goods and services, drive companies in seeking higher efficiency in logistics and operations management and pallet management cost is increasingly becoming a relevant driver for achieving this objective. The present paper aims at analyzing the process for managing pallets along the whole CPG supply chain, in order to derive a cost model for assessing the overall unit cost related to pallet management in the CPG supply chain.*

Keywords — Consumer Packaged Goods, Physical Distribution, Supply Chain Management, Unit Loads

INTRODUCTION

Unit loads (ULs) represent a key factor in physical distribution processes, being integration elements between consignors and consignees and facilitating handling, storage and shipping [26]. Therefore, tertiary ULs (which consolidate boxes, trays, crates of packaged goods, i.e. primary and secondary ULs) make receiving, storage and shipping activities easier. Tertiary unit loads are consolidated by means of pallets, roll cages, dollies, slip sheets, etc., and most of them can be considered as returnable devices, being designed to be used in more than one single delivery. In this paper we decided to focus on palletized unit loads, being the most widespread tertiary unit load for shipping goods, with particular respect to the Consumer Packaged Goods (CPG) industry [4]-[8]-[16]. This industry is characterized by a complex supply chain, where at least six players are involved: manufacturers, retailers, logistics service providers (3PLs), the carriers operating for the 3PLs (which in Italy are typically sole proprietorship companies), the cooperative workforce in warehouses for the handling activities and, finally, the retail stores. It is thus clear that the management of the physical and information flows, along with the exchange process for goods between the players of the supply chain, turns to be a critical issue that needs to be addressed. The exchange of goods happens along with the shipment of pallets, that can be managed according to different strategies. As to the sector concerned, the main strategies are represented by pallet pooling and pallet exchange, being the latter the most widespread system for managing pallets in the Italian CPG industry (more than 80% of the overall shipped pallets, according to Efficient Consumer Response - ECR Italy) and for this reason being the actual focus of the present work. Pallet management represents a significant part of the total logistics spending of grocery retail companies [26] and pallet management costs are borne by all the parties involved in the physical distribution process [24]. Then, it is worthy to consider that these days an ever-growing pressure on service level [11], concurrently with a reduction of the price of goods and services [1]-[12] drive companies in seeking higher efficiency in logistics management. Given this background, a strategic approach to managing pallets is increasingly becoming a relevant driver for achieving higher efficiency and consequently there needs to develop specific managerial tools aimed at assisting logisticians in better understanding the cost implications of managing pallets along the supply chain. For doing this, and for achieving a close assessment of the costs of managing

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pallets, we relied on a sound costing technique, such as the activity-based costing (ABC), which, as it will be further explained, is largely deemed to represent a useful tool for logistics operations costing.

THEORETICAL BACKGROUND

A pallet can be defined as “a horizontal rigid platform characterized by a minimum height compatible with the handling activities performed by means of trans-pallet or forklift trucks or other suitable material handling equipment, used as a device for collecting, stacking, storing handling and transporting goods and loads” (EN ISO 445:2001 Norm). A wide range of different pallet types have been introduced in the market over the years, characterized by various sizes and materials. However, the need for a common size and material pallet pushed some industries towards the adoption of standardized unit loads. For instance, in the CPG industry, both retailers and manufacturers agreed on the use of a standardized pallet (i.e. Eur-Epal pallet, promoted by the European Pallet Association).

Various pallet management strategies can be adopted by the players operating in a specific industry. As to the sector concerned (CPG), two main strategies are adopted: pallet pooling and pallet exchange. The pallet exchange system, promoted by ECR and based in Italy only on Eur-Epal standard pallets, implies that the retailer is required to return to the product manufacturer the same amount of certified quality pallets at the time of delivery (immediate exchange). However, it often occurs that the exchange of pallets cannot be performed concurrently with the delivery of goods, due to some criticalities which may delay the physical exchange of Eur-Epal pallets. For instance, the retailer may not have enough unloaded pallets in stock to be returned to the product manufacturer. In other cases, the carriers may refuse to load empty pallets on their trucks since they have to perform other deliveries or, finally, because of disagreements on the quality standards of the returned empty pallets. All these elements create the so called “delayed exchange”, where a “pallet voucher” is issued by the retailer to the product manufacturer, implying a debt of empty pallets to be settled in the future (i.e. following deliveries). The debt can be settled by means of a subsequent return of empty pallets or by means of a payment. In the pallet pooling, the consignor (i.e. a product manufacturer) rents an amount of pallets from a pooling company, which supplies the required number of empty pallets to be loaded with goods and then shipped to one or more consignees (i.e. retailers). The consignor pays a fee for the number of rented pallets plus additional charges based on how long the pallet is in use and on the average distance between shipping and delivery points. The pooling company organizes and performs the collection of its returnable assets (i.e. rental pallets), to be successively rented to other consignors.

The costs of managing pallets in the CPG industry

The costs of managing pallets have been considered from different viewpoints in the scientific literature. Pallets have aroused interest in the scientific community in particular with regard to the costs related to their dimensional standardization. The widespread adoption of standard size pallets can generate significant savings in the physical distribution process [23]. Although over the years standard size pallets have gradually become common, differences between the standards adopted by diverse countries can be still found, making international trade more expensive, especially with inter-continental exchanges. With respect to the costs of exchanging pallets, when different sizes and standard pallets are used, it is necessary to re-palletize goods in the most suitable way before shipping them to a specific destination. Reference [23] proposes a model to assess the impact of re-palletization on the logistics management total cost, highlighting an increase (1$ per carton) where a re-palletization from one standard to another is required. Other perspectives address the estimation of pallets manufacturing cost. The most extensive work has been proposed by [20] who described the Pallet Costing System (PCS). The authors developed a model to assess the overall unit cost for producing wooden pallets. With regards to contributions aiming at calculating the total cost of pallet management, literature proves to be fairly poor, even if the relevance of determining this total cost has been acknowledged [3]. In this field, research is still in the early stages of investigation. The few present literature contributions are mainly concentrated on the impact of pallet purchasing, handling and distribution costs, rather than on overall management costs [27], especially when the exchange system is concerned. A paper by [13] is more specifically focused on the calculation of the overall pallet management cost. The article addresses the cost of managing pallets, providing some elements to support the choice between pooling or exchange systems. Reference [24] present a study on two alternative pallet management systems: pooling pallets and disposable pallets. The authors demonstrate that in a typical US CPG supply chain the average cost of pooling pallets is higher than the cost of disposable ones. However, pallet management costs from the manufacturer's point of view may be lower as far as the pooling system is concerned, depending on the number of pallet deliveries and collection cycles. Though, the paper proposed by [24] does not include any analysis on pallet exchange, which, so far, is a theme poorly investigated in the scientific literature: only a seminal paper presented by [17] studies the Pallet Exchange Program (PEP) in the US, with an attempt to determine the savings deriving from the adoption of this system. However, the advancements of this paper are basically built on the costs and the charges related to the inventory of companies' total pallets on hand, thus making difficult an accurate determination of the actual total pallet management costs and savings deriving from the exchange system. Even though the literature on pallets shows to be significantly poor with respect to the determination of the actual management cost, the costing of the logistics activities has been treated to a wider extent by the scientific community [10]-[14]-[15] and in the literature there are numerous examples of the use of the activity-based costing (ABC) in the logistics field (e.g. [21]-[22]). Some of these scientific contributions can be directly connected to the investigation area we are addressing, such as the adoption of ABC in the field of logistics and for determining the cost of managing returnable assets processes. In fact, ABC proves to be a widespread method for reverse logistics cost assessment. Especially, with regard to the issues this research is addressing, a model to calculate the costs related to reverse logistics management for beverage containers, based on ABC, has been proposed by [9]. Conclusively, we can affirm that the presented literature analysis supports the relevance and significance of managing pallets and it allows summarizing how the scientific community has dealt so far with the topic under study. From the analysis of the literature, we found the existing body of knowledge particularly wanting of a comprehensive examination of the pallet exchange system, along with a precise and exhaustive definition of the activities to be performed in a pallet management process, neither for a generic player of the supply chain, nor for the whole supply chain. Besides the formalization of a generic pallet management process, the literature proved to be wanting of tools for assessing the actual cost of the pallet management process.

RESEARCH METHODOLOGY

Given the lack of prior research on the considered subject, as previously described, and considering that pallet management in supply chains is an under-explored area, we decided to adopt a qualitative research methodology. In fact, this approach can be particularly appropriate during the early stages of investigation of a phenomenon [5]-[28]. In particular, we decided to exploit case study research with in-depth interviews: we chose a multiple-case approach, considered remarkably suitable in our research, for being able to provide rich insights about a partially studied context and indeed ensuring a higher degree of generalizability than a single case approach [6]-[18]-[28]. In order to ensure research reliability, an interview protocol was built and a formal structure to the interview was conferred. To perform the case studies, we developed a series of semi-structured interviews, with adapted and tailored questions to fit the main research aims. A pilot test was performed before the interviews with a panel of practitioners and experts in the logistics field. Multiple sources of evidence were used, besides interviews: reports, archival data, direct observations and on-field audits [19]-[28]. The direct observations and audits included on-field measurements of the areas allocated to managing pallets and of the time spent by human resources on the pallet management process (assessed by means of the Method Time Measurement, MTM [25]). With respect to company documents, we analyzed records related to the shipment and receiving of palletized goods and empty pallets, such as the pallet accounting sheets and all the invoices related to any activity connected to pallet management, the transport accounting sheets, the reports from the ERP system of each company (i.e. related to the shipment and receiving of goods), the contracts between product manufacturers, retailers and carriers, the material handling quality assurance and safety procedures. We found many difficulties in obtaining from companies cost information properly connected to the pallet management process and thus, in presence of a poor costing capability by companies, it was evident that a sound methodology for determining and assessing the cost of managing pallets was necessary. The ABC methodology guided us in the collection of the information related to the resources, their costs and the relevant drivers, while the investigation of the pallet management process performed by the various players operating in the CPG supply chain in the examined case studies allowed identifying the activities related to the management of empty pallets, which constitute the basis of our cost analysis based on ABC. In order to be able to compare the numerical values of the pallet management costs, all the cases were based on data as of year 2009.

FINDINGS

As mentioned in the introduction, the CPG supply chain is composed by numerous players and the physical flows and relationships between them can be described as represented in Figure 1. The CPG supply chain is characterized by a high degree of complexity, since many different ways can be exploited for organizing the physical flows between the various players. This hinders the definition of a unique reference model for adequately representing any possible supply chain configuration. For this reason, a deep analysis of the activities connected to the pallet round-trip along the CPG supply chain (from the production plant of CPG manufacturers down to the points of sale of retailers and back) was carried out with respect to two different supply chain configurations, which were intended to compare two polar operating contexts: depending on the number of echelons and layers involved in the distribution network, we analyzed a “simple” and a “complex” configuration. The considered process includes the physical operations for selecting, controlling and handling empty pallets incoming to the various sites, the transportation of palletized unit loads to the points of delivery, the administration activities related to the inbound/outbound flows of empty pallets and finally the collection of the exchanged empty pallets by means of backhauls.

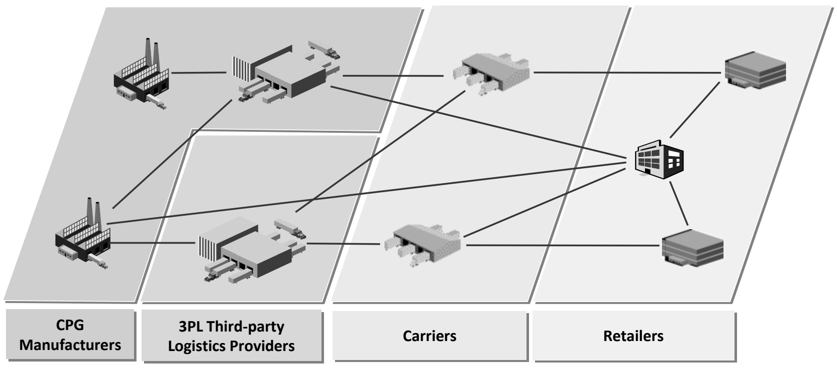

FIGURE 1.

The physical flows and the relationships between the players of the CPG supply chain

In particular, we investigated 21 companies operating in the Italian CPG supply chain, subdivided as follows: 3 retailers, 7 third-party logistics providers, 6 carriers and 5 CPG manufacturers, selected because of their structured know-how related to pallet management. In this way it was possible to determine an exhaustive depiction of the phenomenon under study, thanks to the found similarities and differences.

“Simple” supply chain configuration: in this configuration the manufacturer ships goods directly to the retailers’ distribution centers, by means of Full Truck Loads (FTL) shipments performed by carriers, which may go across their network’s transit points to deliver goods to the points of destination.

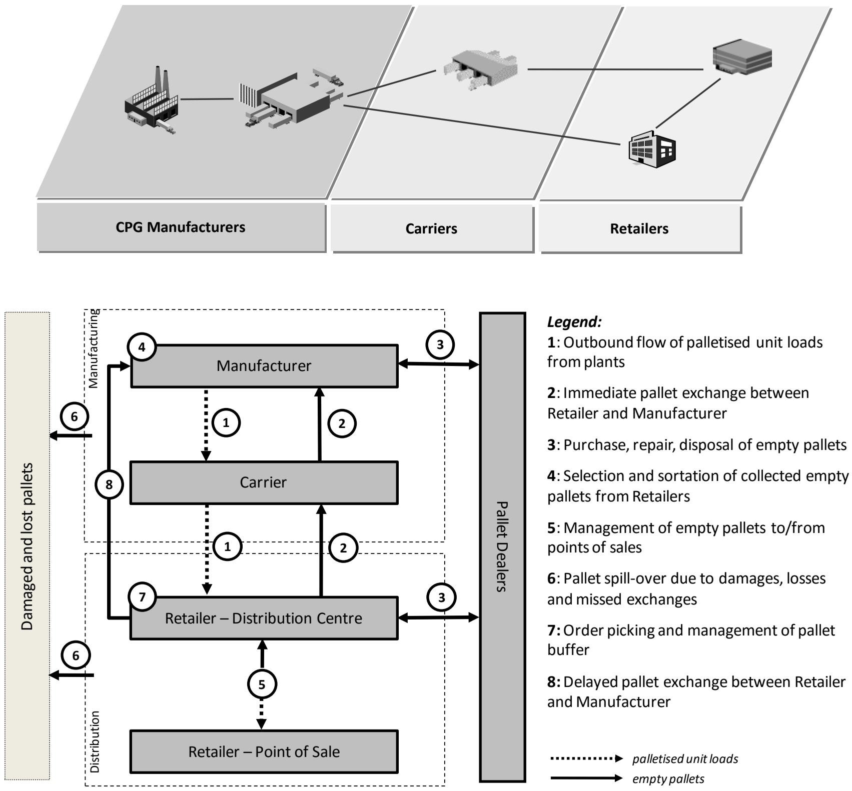

FIGURE 2.

The “simple” supply chain configuration and the related activities

The considered activities relate primarily to the management of empty pallets, such as control of the collected pallets returned from retailers (4), necessary to avoid plant downtimes and a lower quality level of circulating pallets, and the management of the pallet buffer at the retailers’ distribution centers (7). Other activities are connected to the palletized unit loads, such as their shipment within the distribution network (1). Pallet exchange is performed after the receiving of unit loads by retailers and it may be immediate (2) or delayed (8) with a specified frequency (e.g. monthly), which emerged to be the most commonly used. In fact, CPG manufacturers generally prefer to receive full loads of pallets suitable to feed the production lines, rather than receiving time after time an amount of empty pallets equal to the number of delivered unit loads. For various reasons (e.g. if the distance between manufacturers and retailers is great), the parties may agree to pay a fee instead of returning pallets. In some cases, the manufacturer gives the carrier the responsibility for collecting pallets at the point of delivery: in this scenario, still not widespread in the Italian CPG industry, it is used to agree on a franchise in order to consider a percentage of non-collectable pallets (e.g. with a franchise value equal to 5% the carrier will return 95 pallets out 100 received and shipped pallets). The manufacturer may be in credit with both retailers and carriers, if the latter are required to manage the collection of pallets. We considered also activities related to pallet life-cycle, which involve players such as pallet manufacturers, repairers and dealers (3). We then applied the ABC to each player to derive the cost of the activities and the pallet management unit costs. To allow the comparison and the sum of the these costs, the analysis has been performed with reference to the outbound flow from a manufacturer with a network simple configuration (unit cost equal to 1.15 euro/pallet), which delegates the primary transportation and distribution to a carrier, whose operating cost is equal to 0.5 euro/pallet. Considering as a retailer the best-in-class company resulting from [3] (unit cost equal to 0.78 euro/pallet), we derived a total pallet management unit cost for the CPG supply chain equal to 2.43 euro/pallet. Being based on the cost values of best-in-class companies, this figure represents the lower bound of the pallet management cost. However, as suggested by ECR Italy, less than 25% of flows in the CPG industry are organized according to the “simple” configuration.

Complex supply chain configuration: in this configuration the presence of a 3PL, operating a central warehouse and responsible for the management and transport, also by means of third-party carriers, of the unit load shipped to retailers, confers a relevant degree of complexity to the pallet management process.

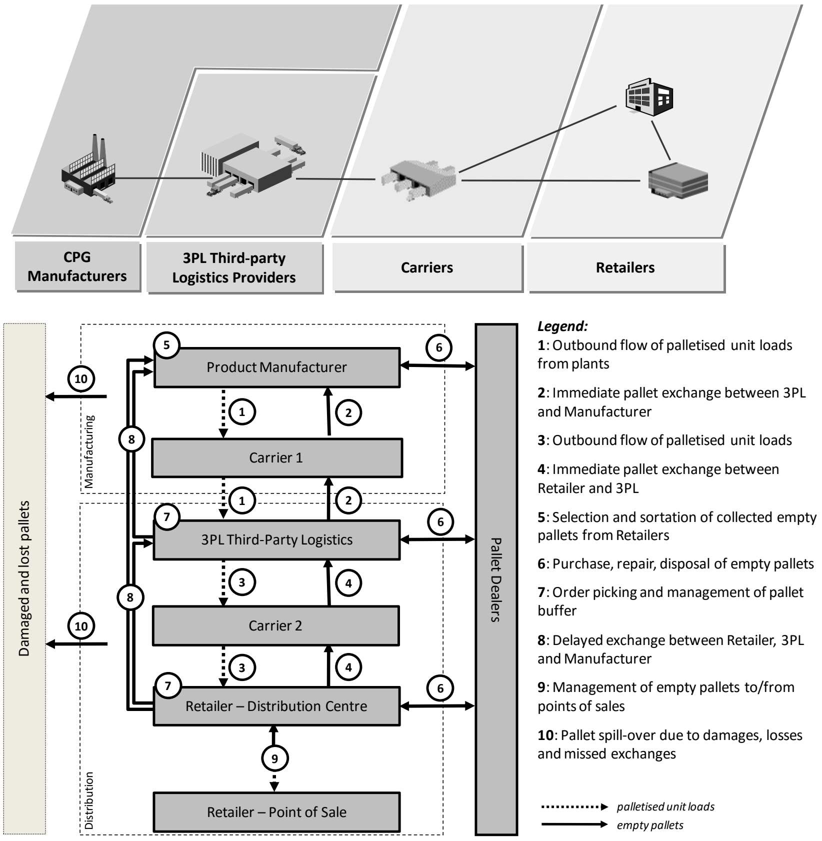

FIGURE 3.

The “complex” supply chain configuration and the related activities

The palletized unit loads shipped from the CPG manufacturer’s plant (1) are moved to the 3PL’s warehouse. After receiving the unit loads, the 3PL exchanges empty pallets (2) with the carrier, retrieving them from its pallet buffer. However, most frequently the delayed exchange is performed: the empty pallets will be later collected by the manufacturer by means of dedicated FTL backhauls. The collection of empty pallets from the 3PL and from the retailer represents the most critical process for the manufacturer, which has to use part of the collected pallets to feed its production lines (5). If the collected pallets are not suitable from a quality viewpoint, the manufacturer has to buy new ones, reselling non compliant pallets to a pallet dealer (6). The points of delivery may directly interact with the 3PL for the replenishments and such orders are processed through fulfillments performed by means of a picking executed using empty pallets retrieved from the pallet buffer (7). From the shipping area goods are then loaded on trucks and moved up to the points of delivery (3). Transportation can be performed directly by 3PLs (by means of owned vehicles) or by trucking companies. Pallet exchange (4) is performed at the retailers’ points of delivery, both at distribution centers and at points of sale. The exchange can be immediate or delayed. In the latter case, after the unloading of the palletized unit loads, the carrier is given a “pallet voucher”. The registration of the voucher is extremely important, since it identifies the subject which will bear the risk of non-recovery of the outstanding pallets. If the vouchers are addressed to the 3PL, this will responsible to organize and manage the collection of empty pallets. Conversely, the responsibility of the collection is attributed to the manufacturer (8). The main criticality for retailers is related to the control of the received pallets. Another source of complexity is represented by the difficulty of controlling pallets stored at numerous points of sale across the country (9) and to ensure the return flows to distribution centers, after recording and selecting pallets to be returned. When a new distribution centre or warehouse is open, retail companies often do not consider to invest in a new pallet buffer for the exchange: they perform distribution with the pallets they receive from manufacturers only. This generates significant imbalances (10) in terms of return of pallets, and this contributes to increase the number of issued pallet vouchers. To solve these problems, some retailers keep the inbound/outbound pallet accounting at points of sale, allocating to them the spending for the potential buffer restore. The pallet accounting between 3PLs and points of delivery is much more complex than the one performed between 3PLs and manufacturers, due to the relevant number and to the different types of points of delivery to keep accounted. Therefore, issues such as administration, restoring of the pallet buffer and the backhauls for collecting empty pallets assume a significant importance, especially from a CPG supply chain perspective. The total cost of pallet management in the “complex” configuration was determined by applying in this case as well the ABC to each player. We identified a CPG manufacturer having a distribution network with the presence of an outsourced central warehouse and with deliveries of small shipments particularly concentrated in some months of the year. The selected manufacturer is characterized by a cost of 2.50 euro/pallet, together with its 3PL (0.85 euro/pallet) and the carriers hired for the primary transportation (0.30 euro/pallet) and the secondary distribution (0.80 euro/pallet). The retailer has a two-echelon distribution network (primary and secondary distribution centers), further penalizing the resulting costs, which was determined equal to 1.12 euro/pallet [3]. The overall supply chain pallet management cost is thus equal to 5.57 euro/pallet. Having considered such a supply chain configuration, this figure represents the upper bound of the pallet management cost for the CPG supply chain.

Figure 4 summarizes the outcomes of the research in terms of pallet management unit costs.

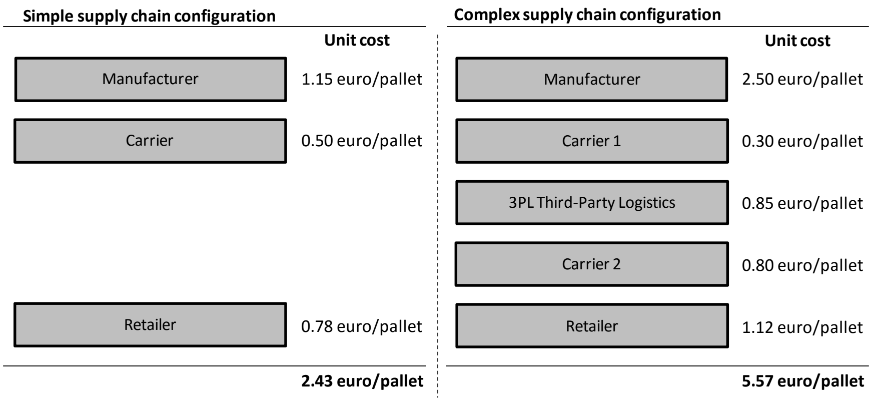

FIGURE 4.

The pallet management unit costs in the “simple” and in the “complex” supply chain configuration

DISCUSSIONS AND CONCLUSIONS

The CPG supply chain is complex and articulated and consequently we necessitated to scope our analysis to extreme scenarios, since it is very difficult to describe and compare every possible configuration of the supply chain. Complexities arise, due to the increase of the numbers of involved players. In the case of the “complex” configuration (the most widespread in the Italian CPG environment), not only the 3PLs are present, but also others players on whom the 3PLs, the manufacturers and/or the retailers rely for transportation and handling activities. Given these considerations, it is impossible to find a unique pallet management cost for the CPG supply chain: according to our research, we found a cost ranging from 2.43 euro/pallet to 5.57 euro/pallet. In particular, in the “complex” configuration, the presence of numerous players, along with the manifold echelons composing the distribution network, increase the complexity and the number of the related activities, of the material handling movements, of the control activities and they all increase the risks of loss, damage and/or subtraction of empty pallets, thus making the overall pallet management cost grow. Other considerations indicate that while manufacturers purchase new pallets for restoring the pallet buffer, often relying on pallet repairers and dealers, and thus trying to keep efficient the pallet exchange closed loop, 3PLs and retailers (which generally are not the owners of the circulating pallets) are generally unable to ensure a proper pallet exchange system. Thus, they get charged for the missing pallets or have to buy new ones to restore the losses, by means of the delayed exchange. These remedies seem to be aimed at temporarily fixing the pitfalls of 3PLs' and retailers' inefficiencies rather than being finalized at creating collaborative approaches and solutions for making really efficient the closed loop of the pallet exchange system. As a further consequence of this operating way, the respective cost structures are very different for each player in the supply chain, hardly comparable and in some cases quantifiable. Another remark is centered around the collection of empty pallets: backhaul costs depend not only on the position of each player in the distribution network, but also on factors such as the capillarity of the network itself (which, if high, allows the optimization of the collection of empty pallets within the forward-shipping activity) and on factors such as the capability of companies to trace pallets throughout the various sites of the network. All these elements lead to very specific management approaches and to significant deviations of the costs. We found relevant differences also in the contractual agreements between the parties, especially as regards the inbound and outbound franchises and the terms for the collection of empty pallets. In particular, the contractual aspects can be a critical driver for the policy chosen by the firms with respect to the overall management of the pallets, since they determine the boundaries of the responsibility of each player. In fact, our research showed that some of the identified costs are tightly dependent on the pallet management process performed within each site and consequently their value can be optimized only through a change in the operations. Thus, for reducing the value of the considered costs, companies should re-engineer the pallet management operations within their site, in order to make them more cost-effective (e.g. the number of dedicated human resources depends, *coeteris paribus* and keeping constant the pallet flows, on the design of the physical activities and process; the number of damaged pallets depends on the care the operating workforce uses for handling and storing them throughout the warehouse, along with the layout of the floor spaces and the linearity of the handling flows). On the contrary, other costs depend on the contractual agreements as well as on the resources absorbed by the pallet tracking activity (both staff and IT systems). Companies can reduce the value of these cost items by redesigning the contractual agreements and by re-allocating the resources to the related activities and re-defining the inbound and outbound franchise values. In any case, similar considerations apply exclusively to the investigated area of interest, i.e. the activities and processes typical of the EUR-EPAL pallet exchange system. It would therefore be of great interest to develop a wider analysis of pallet management costs by comparing the exchange system with the pooling system which, as known, is the most widespread in the rest of Europe.

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CHOOSING THE APPROPRIATE COLLECTION CENTER PLACE FOR A REVERSE LOGISTICS SYSTEM

Betül ÖZKAN [1], Hüseyin BAŞLIGİL[2]

Abstract *— Companies should provide high quality products at low price for their customers because of the increasing global competition. An effective supply chain management is a must have for companies. Nowadays reverse logistics becomes more important because natural resources begin to run out and there are environmental concerns. Collection center is one of the most important part in a reverse logistics system. In this paper we will choose the most appropriate collection center place for a reverse logistics system. We have three alternative places to open a new collection center for the company. First of all, we determine our criterias. Then we applied different multi criteria decision making techniques on our problem. These techniques are AHP and TOPSIS. Then we compared the results of these two different techniques. And finally we decide on the new collection center place for the company.*

Keywords — AHP, collection center, reverse logistics, TOPSIS

INTRODUCTION

Reverse logistics becomes more important for companies in recent years. Resources run out, people have more environmental concerns, customer demands are more special and companies are trying to reduce the production costs. These factors cause that more companies use reverse logistics.

There are many definitions for reverse logistics in the literature. One of the first reverse logistics definitions was made by Stock (1992). According to this definition, the term reverse logistics often used to the role of logistics in recycling, waste disposal and management of hazardous materials; a broader perspective includes all issues relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal [1]. Another definition is Fleischmann's (2001) definition. According to this, reverse logistics is the process of planning, implementing and controlling the efficient, effective inbound flow and storage of secondary goods and related information opposite to the traditional supply chain directions for the purpose of recovering value and proper disposal [1]. CSCMP (Council of Supply Chain Management Professionals) defines reverse logistics as a special part of logistics that focuses on the movement and management of a product and resource after the sale and delivery to the customer [2].

Collection centers are an important echelon in the reverse logistics systems. Generally used or defective products are left to the collection center firstly. Then, from collection centers the products are transported to the centers where the products can be repaired/remanufactured/recycled or disposed.

PROBLEM DEFINITION

In our reverse logistics system, customers bring returned products to the collection centers. Then from collection centers returned products are transported to the production centers. In the production center, there are two types of operation. New products are produced and the returned products are remanufactured in the production centers. Then both new products and remanufactured products are sent to the distribution centers. And from distribution centers these two types of products are transported to the customers.

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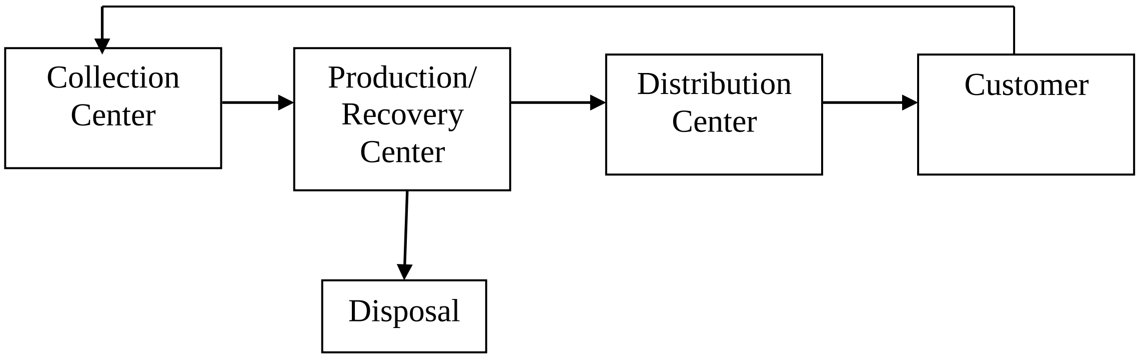

FIGURE 1
Reverse logistics System

In this study we chose a new collection center place. We used two different multi criteria decision making techniques AHP and TOPSIS. We have three alternative places: Collection Center A, Collection Center B and Collection Center C.

Criterias

We have 5 main criterias for choosing a collection center place. These are distance to the production and recovery center, land cost, installation cost, ease of access for customers and capacity.
Distance to the production center: Carrying returned products to production centers is very important in a reverse logistics system. When the distance between collection center and production center increase, transportation cost and transportation time will be increased.
Land cost: The cost of the collection center place should be evaluated before determining on the alternatives.
Installation cost: The machines and equipment have an installation cost. If this cost is low, it will be better for a collection center.
Ease of Access for customers: It is very important that customers can bring returned products easily to collection centers.
Capacity: The capacity of collection center is an important criteria. The capacity of the collection center should be equal or more than the returned products.

The datas for three alternative collection centers are given in Table 1.

TABLE 1
The datas for alternatives

	Distance to the production center	Land cost	Installation cost	Ease of access for customers	Capacity
Collection Center A	30	500000	1500000	3	300
Collection Center B	25	600000	1000000	1	200
Collection Center C	35	550000	2000000	2	30

SOLUTION OF THE PROBLEM

AHP

The Analytical Hierarchy Process (AHP) is a decision-aiding method developed by Saaty. It aims at quantifying relative priorities for a given set of alternatives on a ratio scale, based on the judgment of the decision-maker, and stresses the importance of the intuitive judgments of a decision-maker as well as the consistency of the comparison of alternatives in the decision-making process [3].

First of all, we created a comparison matrix for the main criteris. Then we calculated the weights of main criterias. To compare the criterias and alternatives, we used Saaty's 1-9 pairwise comparison scale. Then, we calculated the importance weights of alternatives for each criteria. Then we calculated consistency. Consistency ratio should be less than 0.1. And finally we determined the total points of alternatives.

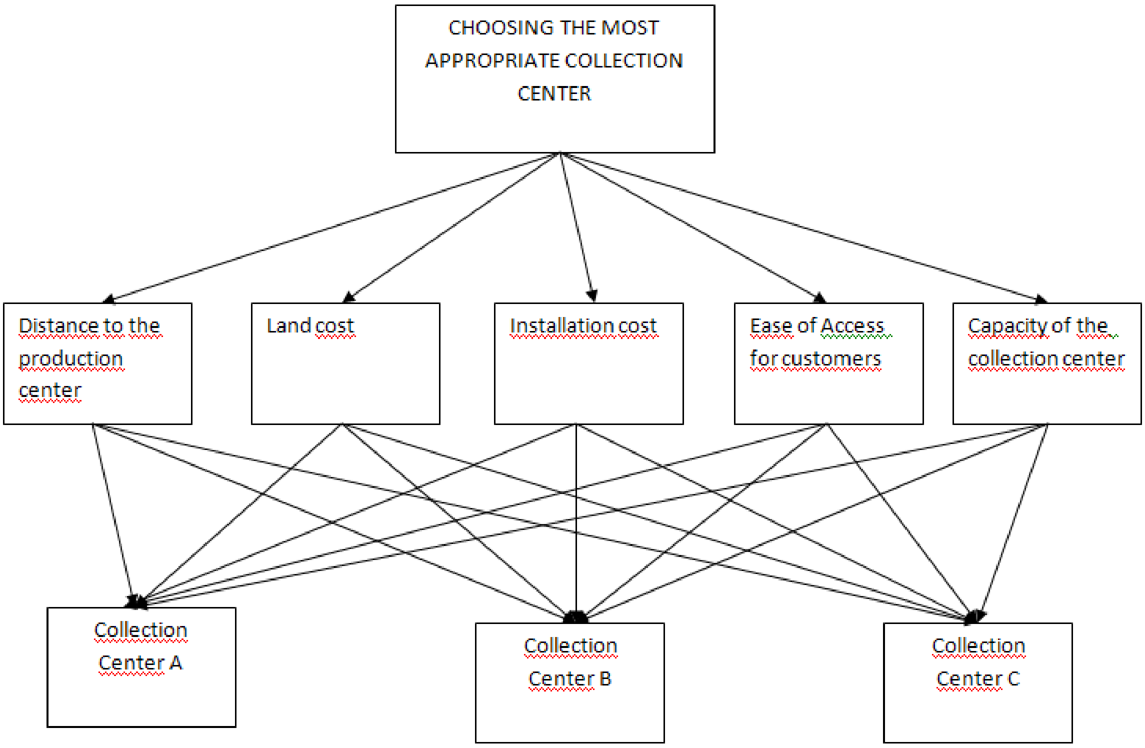

FIGURE 2
Hierarchical structure of the problem

TABLE2
Pairwise comparison scale [4]

Scale of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally
3	Moderate importance	One element is slightly favoured over another
5	Strong importance	One element is strongly favoured over another
7	Very strong importance	An element is very strongly favoured over another
9	Extreme importance	One element is most favoured over another
2,4,6,8	The intermediate values	Adjacent to the two scales

TABLE 3
Pairwise comparison matrix of main criterias

	Distance to the production center	Land cost	Installation cost	Ease of Access for customers	Capacity	Weight
Distance to the production center	1	5	3	3	0.33	**0.26095**
Land cost	0.33	1	2	0.33	0.2	**0.083189**
Installation cost	0.33	0.5	1	0.33	0.2	**0.062007**
Ease of Access for customers	0.5	3	3	1	0.33	**0.161765**
Capacity	3	5	5	3	1	**0.43209**
Sum	5.16	14.5	14	7.66	2.06	

To determine the importance weights for the alternatives, we converted the given datas to 1-9 scale.

TABLE 4
Pairwise comparison matrix for distance to the production center

Distance to the production center	Collection center A	Collection center B	Collection center C	Weight
Collection center A	1	0,33	3	**0,25103166**
Collection center B	3	1	6	**0,65331735**
Collection center C	0,33	0,166	1	**0,09565099**
Sum	4,33	1,499	10	

Consistency rate is 0.013.

TABLE 5
Pairwise comparison matrix for land cost

Land cost	Collection center A	Collection center B	Collection center C	Weight
Collection center A	1	5.00	3	**0.63399699**
Collection center B	0.2	1	0.33	**0.10601418**
Collection center C	0.33	3	1	**0.25998883**
Sum	1.53	9	4.33	

Consistency rate is 0.025

TABLE 6
Pairwise comparison matrix for installation cost

Installation cost	Collection center A	Collection center B	Collection center C	Weight
Collection center A	1	0,33	3	**0,25051171**
Collection center B	3	1	6	**0,65376328**
Collection center C	0,33	0,166	1	**0,09572501**
Sum	4,33	1,496	10	

Consistency rate is 0.015.

TABLE 7
Pairwise comparison matrix for ease of access for customers

Ease of Access for customers	Collection center A	Collection center B	Collection center C	Weight
Collection center A	1	8,00	4	**0,7015207**
Collection center B	0,125	1	0,25	**0,07181707**
Collection center C	0,25	4	1	**0,22666223**
Sum	1,375	13	5,25	

Consistency rate is 0.04.

TABLE 8
Pairwise comparison matrix for capacity

Capacity	Collection center A	Collection center B	Collection center C	
Collection center A	1	2,00	7	**0,61520232**
Collection center B	0,5	1	3	**0,29244965**
Collection center C	0,143	0,33	1	**0,09234803**
Sum	1,643	3,33	11	

Consistency rate is 0.003.

TABLE 9
Final points of alternatives

Collection Center A	0,513085474
Collection Center B	0,357822031
Collection Center C	0,129092495

According to AHP, Collection Center A has more point and it is the most appropriate collection center.

TOPSIS

Our second method is TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). TOPSIS is found in 1981 by Hwang and Yoon. This methodology is based on the principle that the solution alternative has the smallest distance from the positive-ideal solution and the furthest distance from the negative-ideal solution [5].

We use for the criteria weights, the weights that we found in AHP. In our problem *distance to the production center ,installation cost and land cost* criterias are negative criterias and *ease of access and capacity* criterias are positive criterias. So in our calculation we used positive criterias divided by one. (For example Collection Center A has 3 points for ease of access for customers. We used 1/3). So we calculated the positive criterias, as they are negative. And for that reason, the collection center that has minimum point is the best alternative.

TOPSIS has some steps [6, 7]:

- The decision matrix is established.
- Decision matrix is normalized.

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{j=1}^{J} w_{ij}^2}}, \quad j = 1, 2, 3, \ldots, J, \quad i = 1, 2, 3, \ldots, n \qquad (1)$$

- Weighted normalized decision matrix is constructed.

$$v_{ij} = w_i * r_{ij}, \quad j = 1, 2, 3, \ldots, J, \ i = 1, 2, 3, \ldots, n \qquad (2)$$

- Positive and negative ideal solutions are determined.

$$A^* = \{v_1^*, v_2^*, \ldots, v_n^*\} \quad \text{maximum values} \tag{3}$$

$$A^- = \{v_1^-, v_2^-, \ldots, v_n^-\} \quad \text{minimum values} \tag{4}$$

- The distance of each alternative determined.

$$d_i^* = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^*)^2}, \quad j = 1, 2, \ldots, J \tag{5}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}, \quad i = 1, 2, \ldots, J \tag{6}$$

- The relative closeness to ideal reference point is calculated.

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-}, \qquad i = 1, 2, \ldots, J \tag{7}$$

- The ranking of alternative is determined.

TABLE 10
Decision matrix

	Distance to the production center	**Land cost**	**Installation cost**	**Ease of access for customers**	**Capacity**
	26.10%	8.32%	6.20%	16.18%	43.21%
Collection Center A	30	500000	1500000	0.333	0.0033
Collection Center B	25	600000	1000000	1	0.005
Collection Center C	35	550000	2000000	0.5	0.033
	52.44	955248.66	2692582.40	1.17	0.03

TABLE 11
Normalized decision matrix

	Distance to the production center	**Land cost**	**Installation cost**	**Ease of access for customers**	**Capacity**
	26.10%	8.32%	6.20%	16.18%	43.21%
Collection Center A	0.149	0.044	0.035	0.046	0.043
Collection Center B	0.124	0.052	0.023	0.139	0.064
Collection Center C	0.174	0.048	0.046	0.069	0.425
	0.45	0.14	0.10	0.25	0.53

TABLE 12
Weighted normalized decision matrix

	Distance to the production center	**Land cost**	**Installation cost**	**Ease of access for customers**	**Capacity**
	26,10%	8,32%	6,20%	16,18%	43,21%
Collection Center A	0,149	0,044	0,035	0,046	0,043
Collection Center B	0,124	0,052	0,023	0,139	0,064
Collection Center C	0,174	0,048	0,046	0,069	0,425
	0,45	0,14	0,10	0,25	0,53

TABLE 13
Positive and negative ideal solution

	Distance to the production center	**Land cost**	**Installation cost**	**Ease of access for customers**	**Capacity**
	26,10%	8,32%	6,20%	16,18%	43,21%
Collection Center A	0,15	0,04	0,03	**0,05**	**0,04**
Collection Center B	**0,12**	**0,05**	**0,02**	**0,14**	0,06
Collection Center C	**0,17**	0,05	**0,05**	0,07	**0,43**

TABLE 14
Positive distance calculation

	Distance to the production center	**Land cost**	**Installation cost**	**Ease of access for customers**	**Capacity**	
	26,10%	8,32%	6,20%	16,18%	43,21%	**Sum**
Collection Center A	0,0006	0,0001	0,0001	0,0086	0,1464	0,395
Collection Center B	0,0025	0,0000	0,0005	0,0000	0,1301	0,365
Collection Center C	0,0000	0,0000	0,0000	0,0048	0,0000	0,069

TABLE 15
Negative distance calculation

	Distance to the production center	**Land cost**	**Installation cost**	**Ease of access for customers**	**Capacity**	
	26.10%	8.32%	6.20%	16.18%	43.21%	**Sum**
Collection Center A	0.0006	0.0000	0.0001	0.0000	0.0000	0.027
Collection Center B	0.0000	0.0001	0.0000	0.0086	0.0005	0.095
Collection Center C	0.0025	0.0001	0.0005	0.0005	0.1464	0.387

TABLE 16
Final points of alternatives

Collection Center A	**0,065**
Collection Center B	0,207
Collection Center C	0,848

According to TOPSIS result Collection Center A is the best alternative.

CONCLUSION

In this study we determined the best collection center place for a reverse logistics system. We have 5 main criterias. And to determine the best alternative we use two different multi-criteria decision making techniques: AHP and TOPSIS. According to these two techniques **Collection Center A** is the best alternative. Collection center B is the second and Collection Center C is the worst alternative.

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A NONLINEAR REVERSE LOGISTICS MODEL WITH PRICING AND COLLECTION STRATEGY

Ayşe Cilacı Tombuş[1], Necati Aras[2]

Abstract *— The importance of reverse logistics (RL) has increased in the recent years. There are no worldwide estimates of the economic scope of reuse activities, but the number of firms engaged in this sector is growing rapidly in response to the opportunities to create additional wealth, and in response to the growth in extended producer responsibility legislation in several countries. Unfortunately, even with this significant development for the RL market in recent years, a sufficient number of analytical models do not exist to assist in RL strategic decisions. So, we have focused on this issue and designed a nonlinear reverse logistics network including the collection and pricing strategy. Then we have solved the problem and reported the results by using Cplex and Golden Section Search.*

Keywords — Facility Location, Golden Section Search, Cplex, Nonlinear Mixed Integer Programming, Reverse Logistics

INTRODUCTION

The importance of reverse logistics (RL) has increased in the past decade. There are no worldwide estimates of the economic scope of reuse activities, but the number of firms engaged in this sector is growing rapidly in response to the opportunities for creating additional wealth and the growth in extended producer responsibility legislation in several countries. Take-back obligations, customer pressure, and economic motivation stimulate a number of companies to explore options for take-back and recovery of their products [1]-[2].

European Union (EU) has two directives in effect to deal with the fast increasing waste stream of electrical and electronic equipment and complements: The first one is recycling of electrical and electronical home devices (2002/96/EC WEEE)[3] . The second one is about the limitation of the use of some hazardous materials (2002/95/EC RoHS).

It is expected that new planned legal regulations in Turkey for European Union will enforce Turkish producers to recover and recycle at least a predetermined fraction of the products sold. Recovering and recycling activities involve collection of used products, inspection/separation to determine the condition of the return (i.e., whether it is recoverable or not), reprocessing the return (which may include reuse, recycling, remanufacturing or repair), disposal of returns which are found to be unrecoverable due to economic and/or technological reasons, and redistribution of recovered products [3].

Unfortunately, even with these legal regulations for the RL market in recent years, a sufficient number of analytical models do not exist to assist in RL strategic decisions. So, we have focused on this issue and designed a nonlinear reverse logistics network including the collection and pricing strategy. Then we have solved the problem by an approach which makes use of Cplex and Golden Section Search.

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[3] WEEE, http://ec.europa.eu/environment/waste/weee/index en.htm

OVERVIEW OF THE LITERATURE

In this section, we review the previous efforts on the design of reverse logistics networks. Fleischmann et al. [4] make a review of product recovery network design. Most of the existing models in the reverse logistics context put emphasis on the modeling aspect of the problem and use commercial software packages to solve the resulting Mixed Integer Linear Programming Problems (MILPs) mainly because of the increased complexity of the models.

Lu and Bostel [5] use a similar model to ours with manufacturing, remanufacturing and intermediate centers, but they do not consider acquisition prices for collecting used products. Furthermore, they have an uncapacitated model.

Marin and Pelegrin [6] analyze an MILP facility location model considering forward and backward flows. They assume that the number of returns is proportional to demand for each customer and the remanufacturing capacity of a plant is proportional to its manufacturing capacity.

Aras and Aksen [7] investigate a mixed-integer nonlinear facility location-allocation multi-type return model under drop-off strategy to determine both the optimal locations of the collection centers and the optimal incentive values of each return type. Customer motivation for return is the financial incentive offered by the company for the returned item. The distance between customer and the nearest collection center also affects the returns.

Aras et al. [8] develop a mixed-integer nonlinear facility location-allocation model to find both the optimal locations of a predetermined number of collection centers and the optimal incentive values for different return types under a pick-up strategy.

Salema et al. [9] propose an MILP formulation for the design of a reverse logistics network based on a warehouse location-allocation model where both forward and reverse flows are considered simultaneously. They first define a single product model with unlimited capacity and subsequently extend it to a multi-product capacitated recovery network model, where capacity limitations and a multi-product system is considered. In the work developed by Salema et al. [10], a multi-product model is proposed with capacity constraints, uncertain demand, and return rates.

Salema et al. [11] develop a strategic location-allocation model for the simultaneous design of forward and reverse supply chains. Forward and reverse networks consist of two echelon structures, creating a link between factories and customers through warehouses or disassembly centers. Strategic decisions such as network design are accounted for together with tactical decisions, namely, production, storage and distribution planning. The integration between strategic and tactical decisions is achieved by developing a two-time scale, with a fully interconnected structure. This scale involves a macro time related to the strategic decisions, and a micro time related with the tactical decisions. An MILP formulation is obtained.

Min et al. [12] solve only a reverse logistics network for product returns. Their model includes discounted transportation costs for large volumes. Returned products must be collected in reverse consolidation points in order to benefit from discounts. There is trade-off between inventory carrying costs of the consolidation points and freight rate discounts.

Ko and Evans [13] solve also forward logistics network as in our problem. Their capacity of facilities may be expanded to different levels gradually, which makes the non-linear components of the model.

Üster et al. [14] study a multi-product, single-source, closed-loop supply chain network design problem. The following studies include a more comprehensive review. Rubio et al. [15] build up a database with the articles on reverse logistics published in the most relevant journals within the period 1995-2005. Demirel and Gökçen [16] review and classify the studies about RL network design problems for product recovery and analyze their main characteristics.

THE BASIC MODEL

In this section, we develop and analyze a mixed-integer nonlinear programming (MINLP) model which helps to simultaneously determine the number and locations of distribution centers (DCs), inspection centers

(ICs) and remanufacturing facilities (RFs) in production/distribution systems so as to minimize the total cost. DCs receive the products from the plants and ship them to the customer zones, while inspection of the returned products is performed at ICs. Depending on the condition of the returns, they are either shipped back to the RFs or disposed of.

We consider a single product. The number and location of plants with limited capacity are given.Initially, all plants produce new products and we have to determine which of them should be equipped with remanufacturing capability. This decision incurs fixed costs. We want to locate DCs and ICs among potential sites. Opening DCs and ICs incurs also fixed costs. We note that they have unlimited capacity.

The number, locations and demand of customer zones are given. All demand should be satisfied by production or remanufacturing At each customer zone, a fraction of the local demand is returned. The number of returns at customer zone *k* is a fraction of demand *k*. The collected amount is proportional to acquisition price and inversely proportional to competitor's acquisition price. There is only one competitor. The collected amount also depends on the unit cost savings *b* from a return. It can be defined as the difference between the manufacturing and remanufacturing cost per unit. Unit manufacturing and remanufacturing costs do not vary with plant location, and unit remanufacturing cost is lower than the unit manufacturing cost. Only some of the returns delivered to an IC are found to be remanufacturable after inspection.

Flows of goods have been shown in Figure 1:

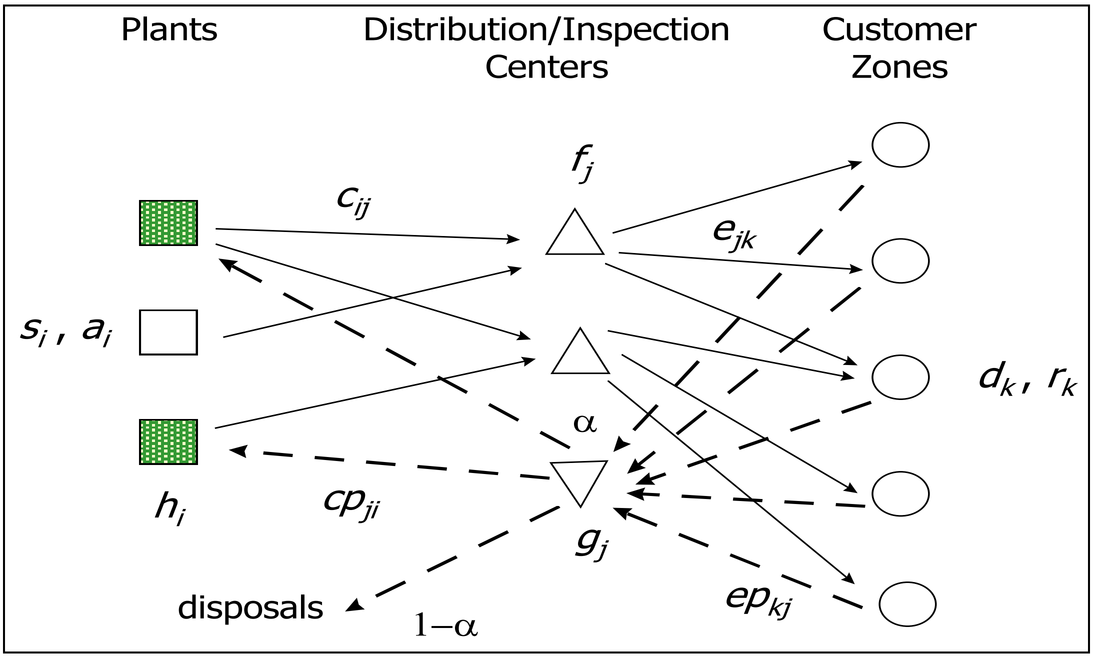

FIGURE. 1
Flows of goods

Using the index set *i* for plants and RFs, *j* for DCs and ICs and *k* for customer zones, we define the following parameters and variables:

Parameters:

f_j : fixed cost of opening a distribution center at site *j*

g_j : fixed cost of opening an inspection center at site *j*

h_i : fixed cost of opening a remanufacturing facility at plant *i*

c_{ij} : cost of shipping one unit from plant *i* to distribution center *j*

e_{jk} : cost of shipping one unit from inspection center j to customer zone k

cp_{ji} :cost of shipping one unit from inspection center j to plant i

ep_{kj} :cost of shipping one unit from customer zone k to inspection center j

d_k : demand at customer zone k

r_k : return at customer zone k

α : proportion of returns found to be remanufacturable after inspection

τ : return ratio

s_i : manufacturing capacity of plant i

a_i : capacity of remanufacturing facility at site i

l : acquisition price of the competitor

b : unit cost savings

Variables:

$$Y_j = \begin{cases} 1 & \text{if a DC is located at site } j \\ 0 & \text{otherwise} \end{cases} \qquad \textbf{(3.1)}$$

$$T_j = \begin{cases} 1 & \text{if an IC is located at site } j \\ 0 & \text{otherwise} \end{cases} \qquad (3.2)$$

$$H_i = \begin{cases} 1 & \text{if an RF is located at site } i \\ 0 & \text{otherwise} \end{cases} \qquad (3.3)$$

X_{jk} :amount shipped from DC j to customer zone k

W_{kj} :amount shipped from customer zone k to IC j

U_{ij} :amount shipped from plant i to DC j

V_{ji} :amount shipped from IC j to remanufacturing facility i

L : used product acquisition price

R_k: total collected amount at customer zone k

Then , the product recovery network design problem can be formulated as the following MINLP.

$$
\begin{aligned}
\text{P:} \quad z &= \min \sum_j f_j Y_j + \sum_j g_j T_j + \sum_i \sum_j c_{ij} U_{ij} + \sum_j \sum_k e_{jk} X_{jk} + \sum_j \sum_i cp_{ji} V_{ji} \\
&\quad + \sum_k \sum_j ep_{kj} W_{kj} + \sum_i h_i H_i + \sum_k (L-b) R_k
\end{aligned}
$$

s.t.

$$
\begin{aligned}
\sum_j X_{jk} &= d_k && \text{for } \forall k && (3.4) \\
\sum_j W_{kj} &= R_k && \text{for } \forall k && (3.5)
\end{aligned}
$$

$$
\begin{aligned}
\sum_k X_{jk} &= \sum_i U_{ij} && \text{for } \forall j && (3.6) \\
\alpha \sum_k W_{kj} &= \sum_i V_{ji} && \text{for } \forall j && (3.7) \\
\sum_j U_{ij} - \sum_j V_{ji} &\leq s_i && \text{for } \forall i && (3.8) \\
\sum_j V_{ji} &\leq \sum_j U_{ij} && \text{for } \forall i && (3.9) \\
\sum_j V_{ji} &\leq a_i H_i && \text{for } \forall i && (3.10) \\
X_{jk} &\leq d_k Y_j && \text{for } \forall j,k && (3.11) \\
W_{kj} &\leq \tau d_k T_j && \text{for } \forall j,k && (3.12) \\
R_k &= \tau d_k \frac{L}{L+l} && \text{for } \forall k && (3.13) \\
X_{jk}, W_{kj}, U_{ij}, V_{ji}, L, R_k &\geq 0 && \text{for } \forall i,j,k && (3.14) \\
Y_j, T_j, H_i &\in (0,1) && \text{for } \forall i,j && (3.15)
\end{aligned}
$$

SOLUTION METHODOLOGY AND RESULTS

We observe that when the acquisition price is fixed, the remaining problem becomes an MILP that can be solved by GAMS/Cplex solver. To find the best value of the acquisition price, the following two methods have been compared:

(i) For each Golden Section (GS) search iteration (which has been applied recursively) where the acquisition price value *L* is fixed, the remaining MILP is solved by the commercial Cplex solver (GS + C),

(iii) For each integer *L* value fixed in the search interval, the remaining MILP is solved by the commercial Cplex solver (ES + C).

Two different data sets with two different unit cost savings and two fixed cost values are generated. Table

1 summarizes the instances used for the experiments.

INSTANCES	DATASET	UNIT COST SAVINGS	FIXED COST
1	1	20	5000-7500-10000
2	1	20	10000-15000-20000
3	1	40	5000-7500-10000
4	1	40	10000-15000-20000
5	2	20	5000-7500-10000
6	2	20	10000-15000-20000
7	2	40	5000-7500-10000
8	2	40	10000-15000-20000

TABLE. 1

Scenarios for Experiments

The search interval has been set as $[l/2, \max\{1.5l, b\}]$ for *L*. In both data sets, the problem size is (*x*; *y*; *z*)=(5-10-20) where *x* shows the number of plants and potential RFs, *y* shows the number of potential DCs and/or ICs, and *z* shows the customer zones. We have selected the following parameters: $\tau = 0.7$, $\gamma = 0.7$,$l = 10$

The values assigned to the unit cost savings are 20 and 40. By assigning two distinct values to f_j (5000 and 10000), g_j (7500 and 15000) and h_i (10000 and 20000), we obtain two different fixed cost instances where each instance is shown as a triplet (f_j-g_j-h_i). These preliminary tests have been run on AMD Athlon (tm) 64X2 Dual Core Processor 4600+ 2.41 Ghz and 3.93 GB of RAM. All two methods have been coded within the GAMS v22.2 suite and solved by Cplex solver called from within GAMS.

We present the results in Table 2. Depending on the results, we conclude that the best method in terms of efficiency and accuracy is applying GS search with Cplex. The reason why GS search with Cplex yields slightly better solutions than Exhaustive Search is that the latter is limited by unit increments. So, we choose to apply GS search to find *L* and solve the remaining MILP with different algorithms.

	Total Cost		*L*		Time (sec)	
Instances	**GS + C**	**ES + C**	**GS + C**	**ES + C**	**GS + C**	**ES + C**
1	28.610	28.610	7,07	7	4	45
2	61.110	61.110	7,07	7	5	44
3	19.068	19.070	12,18	12	4	47
4	51.568	51.570	12,18	12	4	45
5	28.532	28.533	6,99	7	6	55
6	61.032	61.033	6,99	7	6	57
7	18.589	18.589	12,09	12	6	55
8	51.089	51.089	12,09	12	6	52
Averages	39.950	39.950	10	10	5	50

TABLE. 2

Results

Before assessing the performance of the different methods for larger problem instances, we perform additional tests using Exhaustive Search in the problem size (5-10-20) by enlarging the search interval of *L* to (0,100) and trying unit cost savings values in the interval [0,150] by increments of 10 to explore the nature of the total cost function. To ensure that a good solution is found, GS search is applied in an iterative manner.

Our model is a highly nonconvex MINLP, and commercial solvers have a great deal of difficulty in handling such models. We have also tried other commercial solvers such as SBB, OQNLP, and DICOPT and the results were not satisfactory.

When the fixed cost triple is (5000-7500-10000), it is not cost effective to collect used products if their unit cost savings is below 80. When the fixed cost are twice as large, it is profitable to collect used products only if their unit cost savings is above 140. We used the following capacity formula:

$$a_i = \left\lfloor \frac{\alpha\tau\sum_k 1.5 d_k}{n} \right\rfloor$$

$$s_i = \left\lfloor \frac{1.8\sum_k d_k - n a_i}{n} \right\rfloor$$

CONCLUSIONS

In this study, we have developed a nonlinear reverse logistics model. The solution method is based on the observation that when the acquisition price is set to a given value, the remaining problem becomes an MILP. To be able find the best acquisition price Golden Section Search has been applied in an iterative manner. MILP has been solved by using CPLEX solver. When the problem size increases, it is expected that CPLEX performance in terms of time goes worse, so we are planning to investigate alternative exact solution methods such as Lagrangean Relaxation and Benders Decomposition in the future.

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PERCEIVED VALUE ADDED LOGISTICS THROUGH THE SUPPLY CHAIN

Turhan BİLGİLİ[1]

Abstract *- Logistics has played a key role in the development of new perspectives of business. It provides the framework within which information substitutes for inventory, activities are co-ordinated, and the sequence of production activities can be optimised over the complete supply chain. Contemporarily, the thrust of technology and of product innovation is towards the tailoring of individual designs and solutions for each consumer; a value added process for the logistics function is to find ever more innovative ways of allowing the marketplace and the level of choice it demands while maintaining distribution cost and efficiency at affordable levels. This research paper will aid logistics enterprises in understanding what the value added logistics would be in supply chain through the evaluation of logistics services classified in three geographic categories specifically global, regional and local LSPs. It also examines the importance of logistics applications and offering prioritization into the perceived value by the customers. The research is intended to employ a considerable selection as well as several choices for logistics dealers to facilitate current operations and supply chain efficiency.*

Key words- Supply Chain (SC), Information and Communications Technologies (ICT), Value Added Logistics (VAL), Logistics Service Provider (LSP).

INTRODUCTION

Logistics involves a broad spectrum of activities that mainly covers planning, coordinating, sourcing, implementation and control of flows of goods, services and information from the point of origin to the point of consumption. Similarly, logistics operations cover three types of flows: physical flows, information flows and financial flows. Conventionally, it features most significantly in transportation, warehousing and cargo forwarding activities. Nevertheless, the landscape of the industry has gradually evolved towards greater emphasis on high Value Added Logistics (VAL), essentially an integrative profile that incorporates processes designed to efficiently support and facilitate different elements in the supply chain.

There exist various research areas which are related to the concept, e.g. research streams focusing on value-based purchasing typically on health care [1] and value-based management where the literature contains many unsettled issues, particularly alternative performance measurement theories [2].

Yet, there has been any report today which highlights the importance of logistics to an economy since it describes the typical operations of supply, production, distribution and replenishment processes, and emphasizes the possibility of outsourcing a number of these operations to local enterprises with the appropriate experience to perform them. Logistics firms choosing to be in the forefront of today's market must systematically expand and successfully implement competitive strategies. According to recent developments and global financial crisis felt by every corner of our world, more and more logistics firms have to decide on that integrated logistics and the value driven by that integration process would bring that corporate offering more opportunity to convey value to the customer than any other business process [3].

The emergence of VAL is closely related to the growing importance of supply chain management under globalisation. Global market expansion and liberalisation have extended the supply chain to cover more and more regions, as manifested by increased international procurement and marketing activities as well as offshore trade. These developments require more effective supply chain management that has to be built upon an integrative set of specialised logistics services [4].

Undeniably, for many organizations, changes in logistics have provided the catalyst for major enhancements to their business. Leading industrial organizations have recognized that there is a positive 'value added' role that logistics can offer the specialism needed, rather than the traditional view that the

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various functions within logistics are merely a cost burden that must be minimized regardless of any other implications. Thus, the role and importance of logistics has, once again, been recognized as a key enabler for business improvement and come under the category “value added logistics” [5]. Of course, those activities must perform any (ad-hoc) actions which require extra manpower or resources since logistics is an important activity making extensive use of the human and material resources that affect an economy.

In spite of the fact that contemporary logistics means collaborative working between buyers and suppliers, joint product development, common systems and shared information (to be fully synchronized), the fundamental goal of planning and applying logistics systems is also to gain and sustain comparative advantage. On the other side, globalisation has also led to intensified competition in the international market that boosts the demand for VAL to cope with the challenge. By enabling effective logistics operations, VAL can lower the costs substantially.

Five caveats should be noted at the commencement. First, the study was conducted from a European perspective although companies and 3PL service providers on three continents were included in the study. Second, the study focused primarily on the EU trade; while many firms of the other trade blocks (enterprises located regionally in the geography of NAFTA, ASEA, EFTA and BSEC) interviewed also contributed from logistics and some other but relative sectors, since inquiries pertaining to logistics dynamics emphasize the global economy. Third, the study is focused on top 5 enterprises in logistics industry which are nation-wide and announcing highest profit margins in 2009; including NVOCCs (non vessel operating common carriers). Fourth, intermodality has been observed primarily and liner alliances operating on the surface modes were considered by and large but neglecting air transport operations. Fifth, staff at least 2 year experience who involved in operational level in logistics activities were addressed for the questionnaire.

This study examines the effect of experimental applications that may affect logistics success in the supply chain operations. The results of the questionnaire, which was designed to bring out how experiments are treated in logistics industry, revealed three groups of role players; global, regional and local LSPs. In the second part of the study, whether these groups differ significantly with regard to logistics achievement is investigated. The results revealed that there is a correlation amongst current logistics operations and supply chain efficiency. Furthermore, there is significant difference in the importance of logistics applications and offering prioritization into the perceived value by the customers.

LITERATURE SURVEY

Over the last quarter, there has been increasing interest in supply chain management as a potential source of competitiveness and value added services in logistics. Nevertheless, there has been hardly witnessed to the studies in support of logistics enterprises in understanding what the value added logistic would be in supply chain through the evaluation of logistics services.

An initial review of the literature identified few papers aimed in VAL, as logistics services interacting are relatively new and somehow identical whereas the literature on value based management deals particularly alternative performance measurement theories [6].

Moreover, because of VAL can uplift the efficiency and flexibility in delivering different types of goods to different destinations with unique requirements in terms of quantity, quality and variety, researches are expected to observe the timeliness in goods delivery and replenishment which are regarded as “sine qua non” to shorten service cycles. Another issue that helps to the success of VAL is the successful implementation of customer satisfaction programmes which has been the ability to capture customer perceptions in a cost effective and timely manner.

The examples of early studies on VAL were focused on systematic approaches on enterprise level coinciding material management processes. For instance, Fawcett and Fawcett presents a paradigm of the firm that provides both a rationale and an initial point for the integration of the firm's value-added materials management activities suggesting a structure, the essence of which is that customer value is added by the functional areas only when consistency exists among decisions made in decision areas [7]. Some cases questioning the value in logistics services were focused on the value offering point in the customers’ demand chain within quality perspective [8].

With the beginning of new era, there have been observed an increasing trend in researches and articles binding logistics as a process that creates value but fall short of exploring the competitiveness that VAL serves [9]. Another example for bilateral studies would be the relationships among technology use and acceptance, and perceptions of quality and satisfaction with logistics services investigating on industrial customers with logistics service quality perceptions and satisfaction levels [10].

Similarly, value driven by logistics activities in supply chains was quoted by Stavrulaki and Davis but more often on integrated perspective of how products and processes should be aligned with strategic decisions to enhance competitive advantage [11]. From the other point of view, organizational effectiveness and efficiency in SC were discussed uniquely but those are aside from value-based approaches [12].

Competitiveness in logistics operations were also argued with the insights of logistics capabilities on firm performance by both customer and information dimensions capabilities, but that helped to highlight relationships to performance solemnly [13].

While there are many ongoing research efforts on various aspects and areas of VAL by LSPs, so far little attention has been given to the performance evaluation, and hence, to the measures and metrics of supply chains. However, logistics value had been defined conceptually to serve the researchers on understanding the terms value and value-added processes when they gained popular usage at the outset of last decade, while they are neither clearly defined nor accurately measured [14] and [15].

Design/methodology/approach

The problem was derived as to find a meaningful difference between logistics and value added services while sub-problem was defined as;

1. Logistics is;

   a. A synchronized operational service (Group 1),

   b. A customer oriented overhaul (Group 2),

   c. Just a requirement based replenishment (Group 3).

2. Is there any difference between LSPs which are providing harmonized activities on demand and LSPs which are providing conventional services?

In this study, qualitative research has been integrated on the basis of a literature review. Data for the qualitative research were collected through logistics departments and/or LSPs by a structured questionnaire that employs a formative Likert 5-scale cluster. To test and find the value added processes in logistics, an online survey was prepared using WebSurveyor and an introductory e-mail with a link to the survey was sent to a sample of members of logistics organizations classified in three geographic categories specifically global, regional and local area. Measurement items are adapted from existing scales found in SPSS literature. Academic colleagues and logistics practitioners reviewed the items for face validity and readability. The scales are evaluated for reliability, convergent validity, and discriminant validity using data collected in a mail survey of logistics service providers and customers.

Unfortunately, while the population of logistics industry has been out-of-reach since its complexity and divergence, only 160 respondents were attained from a sample cluster of 580 where overall response rate is 28%. Out of such a sample, 14 correspondents (35%) per each of 4 LSPs on global platform; 11 correspondents (34,37%) per each of 5 LSPs on regional platform and 7 correspondents (30,63%) per each of 7 LSPs on local platform were involved in the survey.

Clustering

The clustering was realized into three groups due to respondents' core activities in logistics; namely transportation, warehousing and other logistics operations.

Data Collection Tools

A questionnaire form followed by a test in MS office format was utilized to collect qualitative data.

a. Questionnaire Form: The form has been designed and developed to stereotype what the value is and personal envisage on what comes to be an added value to logistics operations. Seven basic logistics services were guided in order to curtail analytic discrepancy and enable consistency, and prioritization of those services was also asked.

b. Logistics Performance Test (LPT): Prior to logistics performance test, core logistics activities were scored under 50 test questions and 30 questions out of those 50 were selected after a reliability testing in an LSP which has a global brand in Turkey. In conclusion, the reliability of LPT was calculated by Kuder-Richardson (KR21) formula and the result was achieved as 0,84.

Findings

The data captured from the questionnaires were evaluated and prior to analyzing results the hierarchy of sub-problems was considered. On the initial stage of the study, results of LPTs due to three geographic groups of role players were obtained and laid on Table 1.

TABLE 1
LPTs' mean

Groups	n	%	$\bar{x}$	SD
Group 1	14x4	35	21,36	6,06
Group 2	11x5	34,37	14,46	5,12
Group 3	7x7	30,63	12,72	5,38
Total	160	100	15,77	6,16

According to Table 1 the lowest average belongs to Group 3 whereas the highest average has been hold by Group 1. In spite of the fact that Group 1 has a 35%, the rest of the sample has a cumulative rate of 65% ignoring value added processes in logistics activities. The reason of such an outcome is that there hasn't been any customer oriented and integrated operations introduced into operational practices to punctuate the significance of optimized logistics solutions. Besides, the sample sizes of each group (56, 55 and 49) driven after LPTs has a balanced impact that the infrastructure of logistics activities are well confined.

A one way variance analysis has been bespoke per the following sub-problem in quest of the meaningful difference and the results were displayed on Table 2.

TABLE 2
The meaning of difference amongst groups

Source of variance	Sum of squares	Degree of freedom	Average of squares	F
Intergroup	1503,88	2	751,94	25,96*
Intra group	4546,01	157	28,95	
Total	6049,90	159		

*$p<0.05$

As regard to Table 2, the values imply the importance weighed confirming that the difference is meaningful between LSPs which are providing harmonized activities on demand. On the second stage of the research the source of difference amongst groups has been analyzed and Scheffe test was applied for the consistency index based on difference of mean. The results indicating conceptual understanding and applied methods to add value into services have been set on Table 3 with a 95% confidence interval.

TABLE 3
Scheffe Test Results in VAL in Logistics Operations

Groups		Difference of Mean	Standard Error	P	95% Confidence Interval	
					Lower Limit	Upper Limit
Group 1	Group 2	6,90*	1,04	0,00	4,32	9,47
	Group 3	8,63*	1,45	0,00	5,03	12,23
Group 2	Group 1	-6,90*	1,04	0,00	-9,47	-4,32
	Group 3	1,73	1,26	0,39	-1,39	4,85
Group 3	Group 1	-8,63*	1,45	0,00	-12,23	-5,03
	Group 2	-1,73	1,26	0,39	-4,85	1,39

*p< 0,01

According to Scheffe test results above, the difference of mean for Group 1 is exceedingly higher than the rest two. And this also exemplify there is no meaningful dissimilarity between Group 2 and 3. Thus, such a result of a persistent failure to manage the firm as a cohesive value-added system is again on the stage.

CONCLUSION

The complexity of the interactions amongst the logistics firms’ value-added services underlies the challenge of managing the firm as a value-added system fully synchronized and integrated technology, customer management and contemporary approaches on demand. However, both regional and local firms have the ability to add value into logistics services but that does not arise typically from any single functional expertise or from the ownership of a unique methodology since the efforts to build a competitive advantage is guided by a globalizing economy which reiterates the fact that logistics as usual within and among the firm’s value-added functions is not a viable approach to competition.

The research findings reveal that any capability alone cannot be considered a distinctive factor directly relating firm performance as adding value. Logistics capabilities must be used to facilitate the creation of other specific, difficult to imitate capabilities. In that sense, the concept of VAL can be obsessed that buyers should hold providers of logistics accountable for both cost and quality of care, hence, the impact of logistics differentiation is not manifested through a particular application such as consolidation in warehousing or kitting a product before handling; rather, synchronized efforts must be leveraged through sharing and connectivity across logistics departments and the supply chain. The results also help to explain why many firms fail to improve performance in VAL after expending considerable resources to adopt emerging techniques while other firms succeed. In addition, the results support operational performance which may be extended to a discrete assessment of cost performance to furnish future researches to investigate whether logistics functions have an impact on the interrelationships identified in LSPs’ core businesses.

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COLD SUPPLY CHAIN MANAGEMENT FOR PERISHABLE FOODS TRANSPORTATION: A REVIEW AND PERSPECTIVES

Turan Paksoy [1], Eren Özceylan [2]

Abstract — *In order to get maximum profit from supply chains, enterprises need to manage their resources and concern for the environment with the need to have more growth. This is more significant in the case of perishable food transportation, as environment pollution and climate change do threaten agriculture productivity. Because of the precisions of perishable foods such as produce, meat, fish, milk and more, transportation presents many opportunities along the supply chain that can lead to contamination or spoilage. So it is very important that providing remarkable cold supply chain management for environmental sensitive to ensure the quality and efficiency of the product. Cold supply chain management deals with from the point of harvest or processing until it reaches the consumer—including pre-cooling, freezing, storing, delivering, distributing and retailing. This study will focus cold supply chain management for perishable foods transportation. Especially, this paper reviews the importance of cold supply chain from the perspectives of performance factors such as transportation modes, refrigerating systems, supporting technologies, risk assessment factors, and temperature monitoring etc., on designing to networks for cold chain transportation.*

Keywords — *Cold supply chain, food transportation, perishable foods, and refrigerated storage.*

INTRODUCTION

In order to govern globalization, countries need to reconcile natural resource management and concern for the environment with the need to have more growth and employment. This is particularly important in the case of food supply chain management, as environment pollution and climate change do threaten agriculture productivity [1].

For many products, a decision about supply chain strategy involves a choice between responsiveness and efficiency. The appropriate choice depends on how the product changes in value over the time interval between production and delivery to the customer [2]. At this point, perishable foods are become more important than the other products (non-perishable). So, production and logistics facilities in the supply chain of perishable goods are situated between the origin and the supply market or in a part of the latter. Any changes in time-distance or temperature in the chain could increase the costs or cause the net present value of the activities and their added value in the supply chain to be perturbed [3].

Equipments and processes used to keep perishable products in a conditioned environment are referred to as a ‘‘cold chain”. The cold chain starts at farm level (harvest methods, pre-cooling) and continues through to the first handling, processing, distribution and finally to the consumer level (cooling practices and behaviour) [4]. Most food products are perishable and their shelf life can be greatly affected by temperature conditions in the supply chain: time/temperature control becomes a critical issue in fresh food logistics, and the efficient and effective tracking of cold chain conditions is one of the main points to be addressed [5].

This paper wishes to take attention into cold supply chain management and give information for readers and researchers. This study will focus cold supply chain management for perishable foods transportation. It reveals that the consumers do not have adequate awareness about refrigeration practices or consider them selves responsible for maintaining cold chain and food safety.

LITERATURE REVIEWS

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Due to the increasing food safety regulations and consumers' awareness regarding food consumption, the study of the food chain or agri-food chain recently has capture more attention in the areas of food science and engineering, and supply chain management.

Oliva and Revetria [6] study different technologies like RFID or TTI can help to keep the quality of food under control because of this problem is particularly important for meat products, where the cold chain management plays a strategic role for the quality of the product arriving to the consumers' home. Montanari [5] indicated the optimal configuration of a cold chain in terms of technology and management when RIFD is employed for tracking products through the cold chain. To this purpose, firstly boundary conditions and food requirements are identified, secondly, depending on the technology, two cold chain management systems are proposed, and thirdly a feasibility analysis is carried out to assess the economic, tactical and strategic implications of the models proposed. Finally, a case study based on fruit products is presented. Görçün and Saygılı [3] focus on food logistics and transportations on the light of international rules and regulations related with transportation and stocking of food products as international standards, equipments. Especially refrigerating systems are analyzed as cryogenic refrigerating systems, mechanic refrigerating systems and ice. Ruteri and Xu [7]' study, SCM in the food industry sector was studied in a qualitative survey covered 23 food processing firms in Tanzania, with the purposes of identifying the existing supply chain operation, knowledge of SCM concept and challenges facing the sector. The findings of the study suggest that a lot of efforts need to be addressed to ensure that food processors benefit from SCM concept. The understanding of SCM concept among the processors seems to be low, thus, hindering them from taping up the advantages that SCM concept offer. Kundakçı and Ergönül [8] mention refrigeration facilities in fishery products industry, refrigeration, refrigerated storage and frozen storage of fishery products in their study. Vacuum packaging in fishery industry, processing methods of processed fishery products like surumi, fish sausage, fish salami and fish burger and their refrigerated and frozen storage methods were clarified. Blackburn and Scudder [2] examine supply chain design strategies for a specific type of perishable product-fresh produce, using melons and sweet corn as examples. Using the product's *marginal value of time*, the rate at which the product loses value over time in the supply chain, they show that the appropriate model to minimize lost value in the supply chain is a hybrid of a responsive model from postharvest to cooling, followed by an efficient model in the remainder of the chain. Rong et al. [9] integrate food quality in decision-making on production and distribution in a food supply chain. They provide a methodology to model food quality degradation in such a way that it can be integrated in a mixed-integer linear programming model used for production and distribution planning. The resulting model is applied in a case study, and can be used to design and operate food distribution systems, using both food quality and cost criteria. Ahumada and Villalobos [10] review the main contributions in the field of production and distribution planning for agri-foods based on agricultural crops. They focus particularly on those models that have been successfully implemented. The models are classified according to relevant features, such as the optimization approaches used, the type of crops modelled and the scope of the plans, among many others. Through their analysis of the current state of the research, they diagnose some of the future requirements for modelling the supply chain of agri-foods. Joshi et al. [4] attempted to study the awareness, behaviour and practices among Indian consumers, regarding maintenance of cold chain from retailer's place to home and at homes within the framework of food safety. A sample of 524 consumers is taken in total. The study is conducted at 12 retail stores and through household visits in three state capitals in India. The study reveals that the consumers do not have adequate awareness about refrigeration practices or consider them selves responsible for maintaining cold chain and food safety. In Kuo and Chen [11]' study, a logistics service model based on the advancement of the Multi-Temperature Joint Distribution System (Fig. 1), namely MTJD, is being proposed for the food cold chain. The proposed service model facilitates innovation in logistics services and gives the logistics sector a competitive advantage in the area of thermal protection for perishable shipments and temperature sensitive products. Smaller shipments and timely deliveries offer unique challenges when operating a cold chain. A case study is performed by using the regulative cycle. MTJD provides a new scheme for continuously temperature controlled logistics, which can jointly deliver and store multi-temperature goods.

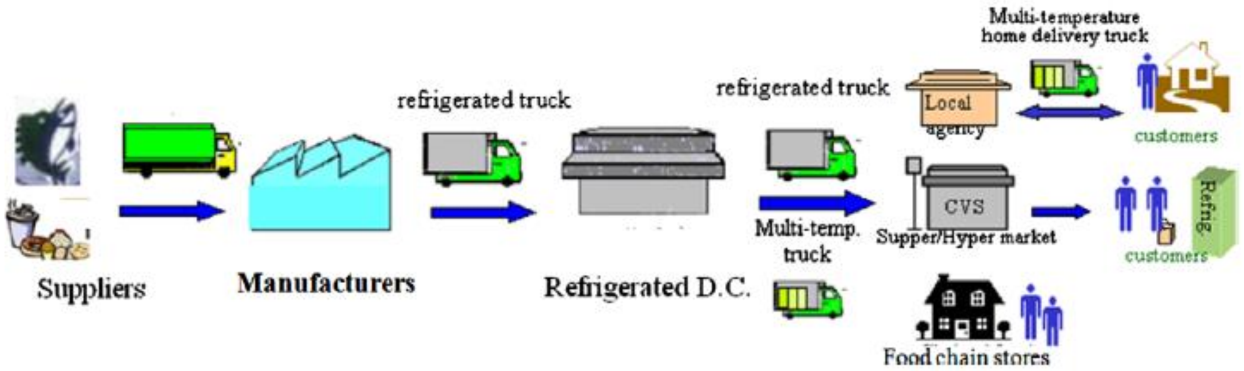

FIGURE 1
An Example of MTJD [11]

FOOD and COLD SUPPLY CHAIN

Better management of supply inputs and timely delivery of products and services at the lowest possible cost are effective practices for achieving sustainable business success. Supply chain management integrates suppliers, manufacturers, distributors, and customers to meet final consumer needs and expectations efficiently and effectively [12].

The term *food chain* (Fig. 2) refers to the total supply process from agricultural production, harvest or slaughter, through primary production and/or manufacturing, to storage and distribution, to retail sale or use in catering and by consumers [11].

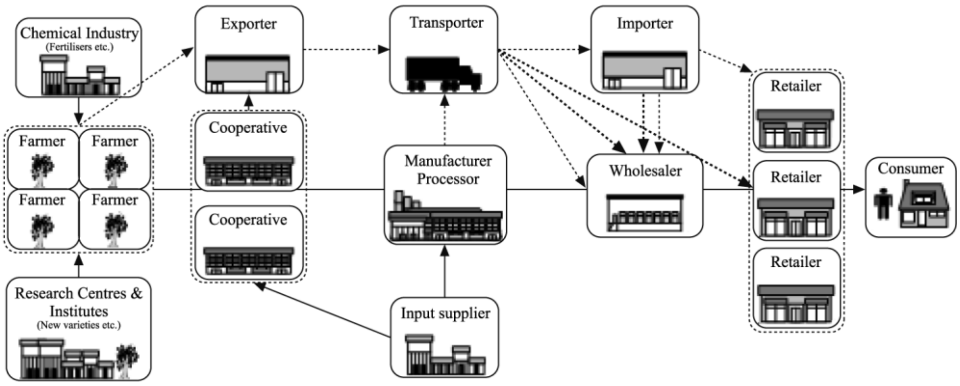

FIGURE 2
Food Supply Chain [13]

The agri-food supply chain possesses several characteristics such as shelf life constraints for raw materials and perishability of products, long production throughput time, seasonality in production, necessity of conditioned transportation and storage, safety concerns, and so on. Due to the increasing food safety regulations and consumers' awareness regarding food safety, the study of the food chain or agri-food chain recently has capture more attention in the areas of food science and engineering, and supply chain management [11].

Consumer awareness of food safety and government food safety regulations are the major driving forces behind cold chain development. Cold chain issues have continued to be seriously addressed in the food industry and academia in recent years. In temperature sensitive and perishable products logistics, a special type of supply chain management has been established, named cold chain management [11]. In the last decade, the incidence of food borne disease has increased in Europe, despite the introduction of Practice and Hazard Analysis of Critical Control Point (HACCP) and the proliferation of food safety regulations. The increasing international competition in food manufacture and trade, the stricter consumer demands and the social changes, combined to the recent food borne outbreaks stress the need for more effective food quality and assurance systems [6].

The global market of refrigerated products and prepared meals is increasing rapidly due to the main drivers of globalization [14]:

- decreasing tariffs (WTO, GATT),
- permanent improvement of transportation efficiency (the emergence of air travel, induced traffic on the new highways, faster ocean crossings, etc.),
- development of communication and information technology,
- and development of cold chains techniques.

The food industry is the leading manufacturing sector in Europe, in terms of turn over, value added, employment and number of companies. Its turn over was 836 billion Euros in 2005 and it employed nearly four million people. Although food industry has a major impact on our lives and economy, it is largely made up of small companies. Of the 283000 food companies in Europe, over 99% are SMEs (Small and Medium Enterprises). These SMEs generate almost half of the industry's food and drink turnover and employ over 61% of the workforce [1]. These SMEs may outsource their food logistics to 3PLs in order to focus on their foodservice specialty and to reduce the logistics cost. The focus on logistics has shifted from manufacturer-oriented to consumer-oriented. The transportation cost is increasing because the number of deliveries to customers is greater than ever, while the shipment size and the delivery time continue to shrink. Therefore, it is necessary to develop cost effective and mass-customized logistics services in the food chain [11].

The International Institute of Refrigeration estimate that, in theory, if developing countries could acquire the same level of refrigerated equipment as that in industrialized countries, over 200 million tonnes of perishable foods would be preserved, this being roughly 14% of the current consumption in these countries (Table 1) [15].

TABLE 1
Refrigeration Requirements and Losses due to Lack of Refrigeration [15]

	World Population	**Developed Countries**	**Developing Countries**
Population in 2009 (billion in habitants)	6.83	1.23	5.60
Refrigerated storage capacity (m3/1000 inhabitants)	52	200	19
Number of domestic refrigerators (/1000 inhabitants)	172	627	70
Food losses (all products) (%)	25	10	28
Losses of fruit and vegetables (%)	35	15	40
Loss of perishable foods through a lack of refrigeration (%)	20	9	23

Oliva and Revertria [6] define the key issues for cold chain in the following points:

• *Cold chain integrity:* that implies maintain and use the correct temperature.

• *Know the supply chain:* that implies the analysis of the characteristics of the product flow through the supply chain from producer to consumer and identifies / understands the impact of actions (planned and unplanned) on product temperature.

• *Food safety:* that implies maintain perishable product under the correct temperature conditions during marketing, ensuring food safety as well as the routine temperature measurement, meeting of time bound temperature criteria.

• *Temperature monitoring:* that relies on the checking of supply chain performance, on the identification of problem areas in the supply chain, on quality management assurance and on the adoption of an insurance against claim, in order to protect value chain assets. As proposed by 3PLs, there are five major categories in the temperature control and monitoring for the food supply chain. They include hot food (above 60 ºC constantly), fresh food (18 ºC constantly), cold food (0 ºC to +7 ºC), chilled food (-2 ºC to +2 ºC), frozen food (below -18 ºC), and deeply frozen food (below -30 ºC) [11].

• *Product specification and handling:* based on knowledge in precise terms what customers want, on the translation of such requirements into product and handling specifications guarantee proper Customer Service

Level, on the development management and handling procedures to match the specifications and check for compliance.

These key issues also could be seen in the Figure 3.

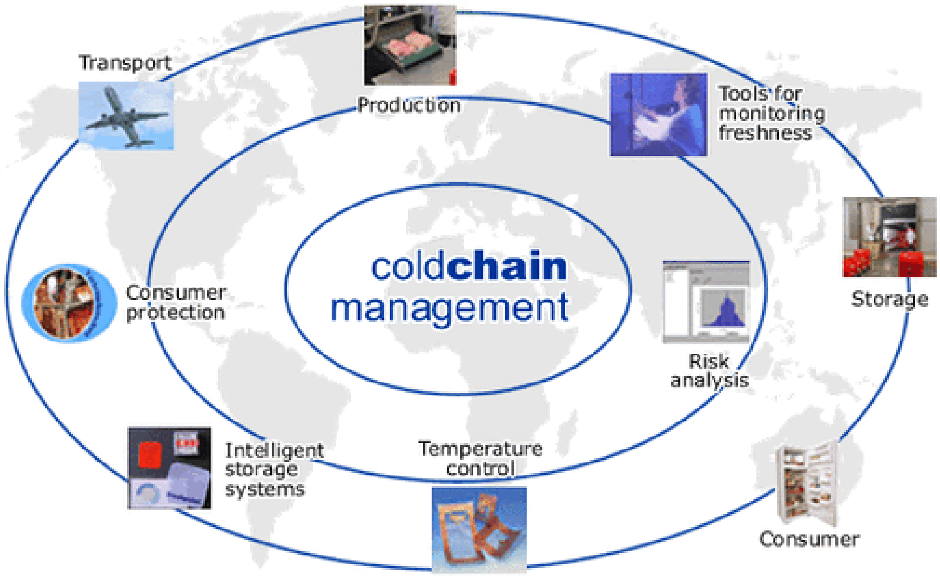

FIGURE 3
Cold Chain Management [16]

The next section outlines six key factors that play an influential role in the evolution and development of modern food supply chains [17].

Quality: Quality is the degree of congruence between customers' expectations and their realisation. In wealthier societies in general, consumers want quality and lower prices. Nevertheless, there are difficulties and challenges. For example, regional producers of mutton and lamb may be remote from their customers and, due to a reduction in the number of meat processing facilities and the distances, over which the meat is transported, they are also separated from consumers. They include quality assurance schemes, production and manufacturing to retailers' protocols and the application of quality management systems and standards such as HACCP and ISO series.

Technology: The food supply chain includes a technological dimension. These include accurate weighing, refrigeration, controlled atmospheric bacterial growth inhibition, pasteurisation, micro-element pollutant detection, bar coding, electronic recognition of packaging, the use of stabilisers, artificial insemination, embryo transplantation, precision seeding, environmentally and welfare friendly animal housing, and organic crop and animal production systems.

Logistics: Various researchers have argued that logistics is a key business process that provides increased customer satisfaction. It is useful to note that whilst logistics concerns primarily the processes of a single firm, supply chain management also encompasses the external environment of an organisation and subsequently includes the external flows of materials, information and revenue between various businesses.

Information technology: Information technology applications support the movement of products and product information dissemination in the food chain. For example, the identification of products with bar codes using optical (electronic) methods such as electronic point of sales (EPoS) (scanning) technology is employed widely to identify product locations in retail warehouses and stores and to record product movement onto and off vehicles. An example of electronic transmission of information using standard protocols is electronic data interchange (EDI) based on a specific standard to co-ordinate various members of the supply chain [18].

The regulatory framework: The food supply chain is affected by the socio-political environment; the text will therefore refer to the regulatory framework defined by national and international law. This regulatory framework reflects increased consumer concerns about food safety, labelling and product traceability.

Consumers: Consumers drive the supply chain; 'demand chain' would therefore be a more accurate description when the primary driving force in terms of type, volume, quality and value of food supplied is considered. Economic analysis is applied to obtain a better understanding of consumer behaviour and achieve extra insight into the strategic direction of change in food consumption. Price elasticity of demand measures the change in demand for goods when there is a change in price; cross price elasticity measures the change in demand for particular goods when the price of other goods changes-consumers will substitute one type of food for another. With respect to various consumers and channels, the distribution and delivery services can primarily be categorized into four divisions, cold logistics, ambient temperature logistics, express and home delivery and scheduled shuttle transportation. They are described as follows [19]:

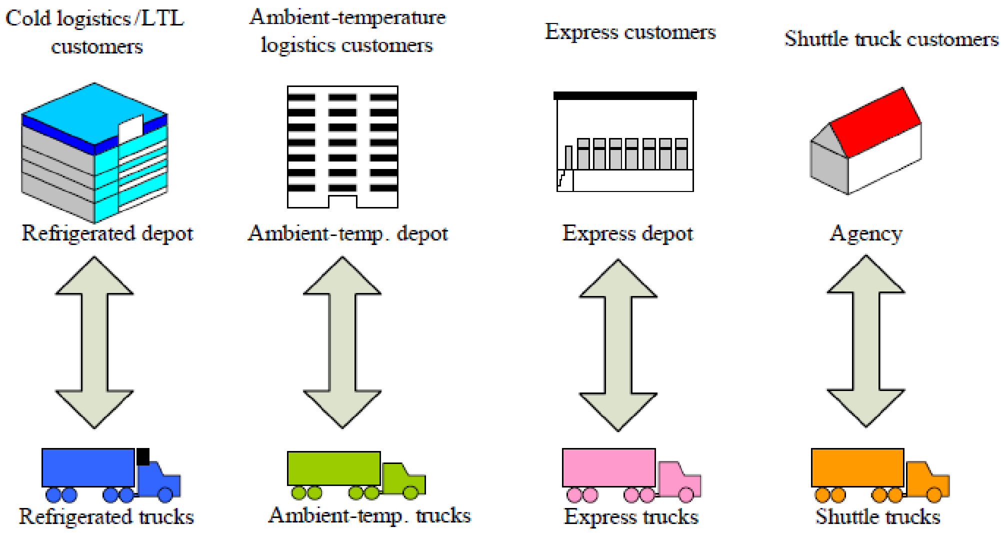

FIGURE 4
Four Divisions of Food Logistic Services [19]

CONCLUSION

The design of the supply chain, and in particular of the distribution phase, for fresh-food products, such as fresh and fresh-cut produce, fruit or meat, cannot be achieved without considering the perishable nature and the variability of the products entering the chain [20].

In this paper a general framework for describing a food and cold supply chain, a small literature and key issues to improve the performances of the network preserving the quality of the product are presented. After the introduction section, a small literature is given to clarify the subject. Then the food and cold supply chain is emphasized with key issues which affect the chain.

Further research could focus on developing optimization models and the application of the model in a wide range of food industries, and the development of more detailed industry-specific models.

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INTEGER - LINEAR PROGRAMMING USED IN SUPPLY CHAIN MANAGEMENT OF A CATERING FIRM

Fatih Tatlılıoğlu[1], Murat Baskak[2], Gülgün Kayakutlu[3]

Abstract *— Catering services have a complicated supply chain network that includes processes like purchasing raw materials, inventory management, production planning and distribution planning. In this complexity, important decisions are taken to eliminate uncertainties. Development of mathematical models will play crucial roles to support decisions which will sort out problem. This study aims to minimize the distribution costs of a catering firm; hence an integer linear programming model is developed. Application of the model is implemented for a catering firm which operates in Esenboğa Airport. Achievements of this study show remarkable reductions in total distribution costs by using a mathematical model that integrates all effective factors.*

Keywords — Supply Chain Management, Logistics, Catering Services, Integer - Linear Programming

INTRODUCTION

Air transportation is a dynamic sector which has to self-renew and adapt to change in technological developments. It plays a crucial role in global market economy and global effectiveness. Currently, the number of people traveling by plane is rapidly increasing; civil aviation and passenger transport activities are to be improved rapidly. Similar to global tendencies, prices have been reduced and the number of passengers has increased in Turkey. Furthermore, many new airlines entered the market and quality is improved to have competitive advantages in addition to the reduced prices. It is observed that the aviation sector in Turkey tends to grow and the industry began to flourish.

Rapidly developments on aviation sector and large increases in the number of passengers have led improvements in catering services between the years 2002 to 2010 in Turkey. Catering has become a competitive advantage factor among the airlines. The implementation of Supply Chain Management has become inevitable for catering firms who want to reduce costs while improving the quality and the speed of the services.

To adopt the agility and economic conditions, companies continuously take short or long term decisions. For a small business, these decisions are influenced by inventory and pricing policies and for the large enterprises, more factors as to production, investment, financing, storage, prices, employment, competition and transport policies have a role. They all have the common objective of reducing the uncertainty and hence, using concrete data to create mathematical models to analyze problems has an important role in decisions [1].

When today's conditions are evaluated, minimization of transportation costs has shown many benefits; it provides cost and time-based competitive advantage in the distribution mobility or flexibility in developing price policy and healthy logistical and financial plans [1].

In this study, three different types of product transportation problem were investigated using the Integer Linear Programming model from one catering company that operates in Esenboğa Airport.

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This study is so organized to present the literature survey and integer linear programming approach in the following three sections and then an integer linear programming model is established.

CATERING SERVICES AND FLIGHT CATERING

In Caterer Profile, catering is defined as "the art of presentation of food & beverage for a large group in places where preparation and distribution of meals or serving food was not considered when built.

Flight catering is probably one of the most complex operational systems because a large scale flight catering production unit may employ over 800 staff to produce as many as 25.000 meals per day during peak periods. A large international airline company may have hundreds of takeoffs and landings everyday from just their main hub. These facts make flight catering dissimilar to any other sector of the catering industry. While the way food is served on trays to airline passengers bears some resemblance to service styles in restaurants and cafeterias, the way food is prepared and cooked increasingly resembles a food manufacturing plant rather than a catering kitchen. The way food and equipment is stored resembles a freight warehouse and the way meal and equipment are transported and supplied has a close affinity to military-style logistics and distribution systems. Figure 1 represents only an outline of the process flow in flight catering, since such operations are highly complex and have a number of alternative configurations [2].

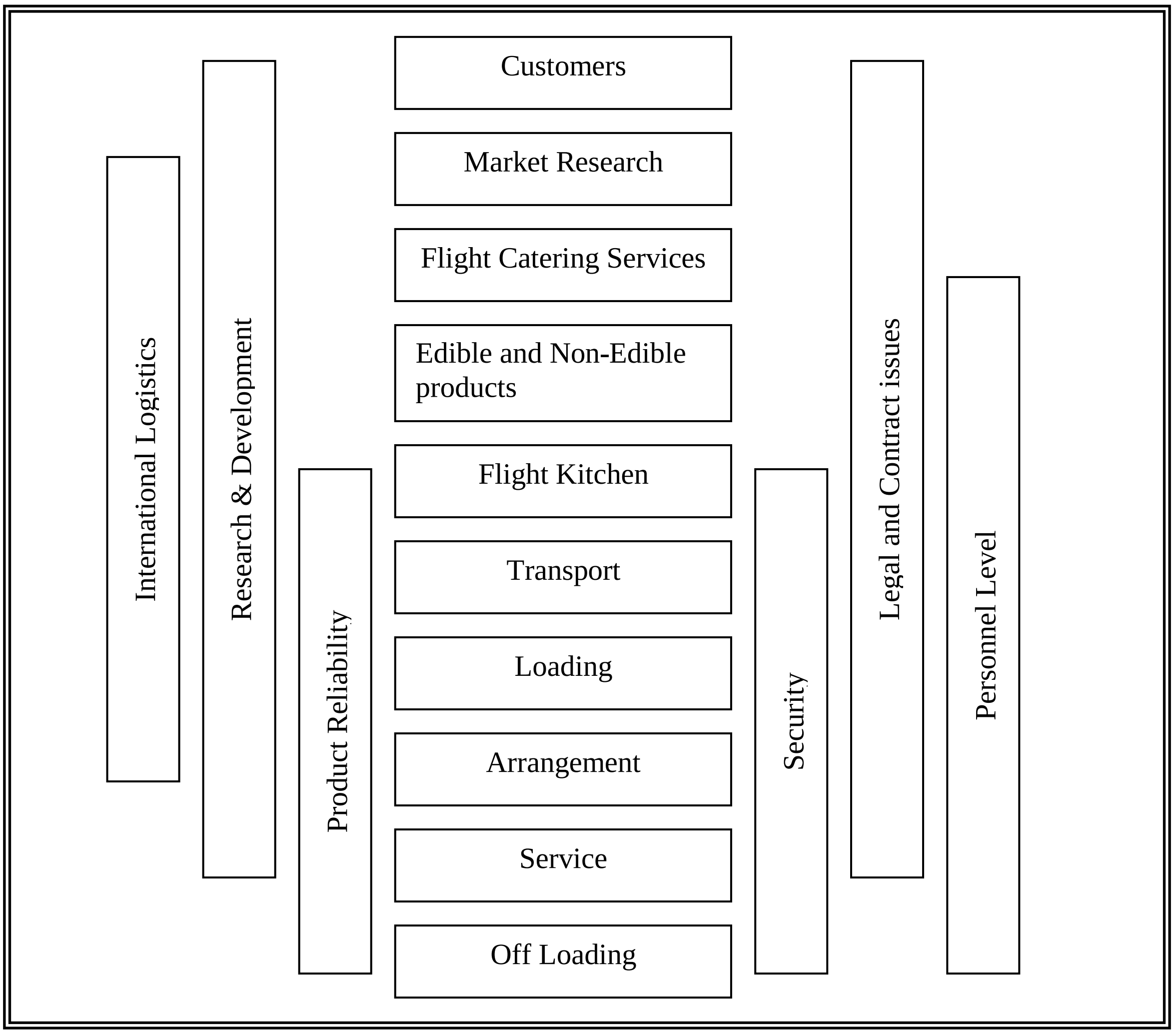

FIGURE 1
Process Flow in Flight Catering [2].

Flight catering starts with the information on the number of passengers and their needs. Such information is available from both market research and actual passenger behavior. On the basis of this, airlines sometimes develop their products and service specification with the consulting of caterers. Such specifications determine exactly what food, drink and equipment items are to be carried on each route for each class of passengers. At the heart of the flight catering system is the flight production unit, which is part warehouse, part food manufacturing plant, part kitchen and part assembly belt. In response to forecasts of passenger numbers on any given flight, the production unit follows a series of complex steps to produce trayed meals and non-food items ready for transportation to the aircraft. Transportation is usually carried out by using specialist high-loader trucks that enable trolleys to be rolled on and off aircrafts. Once loaded, trolleys and other items need to be stowed on board to ensure the microbial safety of edible items and security and safety of the crew, passengers and aircraft. At the designated time during the flight, the cabin crew carry out the service of meals, snacks and other items. On arrival to the destination, each aircraft is then stripped of all equipment and trolleys, which are returned to the production units for cleaning and re-use [2].

Airline catering operations are related with 80% logistics and 20% cooking. When we think of the requirements for equipments installed on the aircraft, the list confirms this ratio. Related to this logistics all materials are mutually supplied to both arrival and departure airports.

Logistics related to catering operations are affected by a variety of factors. Such as; changes in the aviation industry, business demands, aircraft schedule, cabin configuration, technology and airport facilities.

Sustainability and profitability of an airline company is based on the strength of competitive advantages and on the supply chain the company belongs.

Supply chain that airlines need to be established is shaped by in long-term managerial strategies, in medium-term tactical and in short-term daily operational decisions [3]. Services offered to passengers in aircrafts are highlighted by increasing competition in aviation.

Transportation costs vary with the increase in the amount of stock. For example, transportation costs for purchases below the carrying capacity divided less amounts so the unit cost of transportation is increasing. Also, in a cramped warehouse, vehicles will not work in normal capacity so losses and cost increases are aroused. Transportation costs in connection with catering equipment should be taken into consideration are as follows:

- Transportation cost between the stations
- Distribution costs from main hub
- Transport costs in warehouse
- Transportation costs from the kitchen to the service
- Transportation costs from service to aircraft and from aircraft to service

LOGISTICS OPERATIONS AT AIRPORTS

Flight and route planning: in the widest sense, it can be expressed as determining the flight plans and aircraft routes. It also covers; where the plane will fly to, where the transfer will be made, if necessary, where receiving fuel, maintenance, etc. services and exercises on minimizing the cost with optimum flight plans.

Ground handling: it can be defined as all services providing to aircrafts and passengers from arrival of an airplane to the departure on airports according to the standards set by International Aviation Rules and Civil Aviation Regulation.

In Airport Ground Handling Regulation (SHY-22), types of airport ground handling services are grouped as follows [4]:

- Representation
- Passenger Traffic
- Load Control and Communications
- Ramp
- Aircraft Line Maintenance

- Flight Operations
- Transportation
- **Catering services**
- Supervision and Administration
- Aircraft Special Security Services and Control

Air cargo services: Today, depending on the International Civil Aviation Organization (ICAO) and International Air Transport Association (IATA) rules, firstly taken into consideration of country and carrier limitations; packaging, labeling, proper preparation of documents and transportation with an air vehicle of goods (mail and luggage are excluded) are defined as "Freight Transportation" [5].

INTEGER LINEAR PROGRAMMING

Linear programming is a technique and a decision making tool that determines how to use limited resources most effectively [6]. In other words, it is the analysis of problems in which a linear function of a number of variables to be maximized (or minimized) when those variables are subject to a number of restraints in the form of linear inequalities [7].

Decision values used in linear programming are sometimes unavoidably integer in real-life problems. In this sense, integer linear programming is an extension of linear programming that all or a portion of the decision variables must take integer values [8].

However, if the problem has both some integer variables and other variables that met the divisibility assumption as fractional values, this kind of problem is called mixed linear programming problem [9].

In linear programming models, integer programming is faced with in the following ways:

Completely integer programming: all decision variables in the model must take integer values.

Mixed integer programming: some of the decision variables in the model should be zero or greater than zero, the rest should be integer.

0-1 integer programming: all decision variables in the model are either zero or one [10].

In the literature, integer linear programming is applied to many business problems. One of these application areas is the supply chain. Purpose of models established on this respect for long-term is providing the strategic allocation of resources for effective decision support including supplier selection, and/or arrange capacity of producers and distributors as well as distribution of these capacities to the products and others. The problem in the models is to decide the variety, capacity, location and the number of the manufacturers and stores to minimize total cost or maximize the profit [11].

APPLICATION

General Information About the Catering Firm: Do&Co was established as a restaurant in central Vienna in 1981. Today, it works in three main groups: restaurant/lounge/hotel/bar management; catering of international organizations and airline catering in Europe and North America.

The British Museum and Lufthansa First Class Lounge Catering Services, Hotel Vienne, operations of Hofzuckerbacker Demel in Vienna and Salzburg, Formula 1, Paddok Club and UEFA Champions League’s catering organizations; Lauda Air, Emirates, British Airways are references of the Do&Co.

Do&Co and Turkish Airlines established Turkish Do&Co (THY Do&Co İkrâm Hizmetleri A.Ş.) as a partner in 2006. Since 2007, Turkish Do & Co is operating nine gourmet kitchens all over Turkey: Istanbul (Atatürk and Sabiha Gökcen), Ankara, Antalya, Izmir, Bodrum, Trabzon, Dalaman and Adana. Over 60 national and international airlines are catered from these locations.

ISO 9001 quality management system and food safety system established according to the principles of HACCP are applied in Turkish Do&Co.

Turkish Do&Co Supply Chain Management consists of complex operations such as; supplied food, beverage and equipment more than 60 national and international airlines, in accordance with each customer's unique requirements and specifications, service and delivery should be made in the right place, time and amount. Preparation process lasts 24 hours period and includes operations such as; removal of equipments and garbage used in catering services, washing of reused materials, separation of all the airline's own specific material and storage until the next use and stock keeping.

The supply chain process flow of Turkish Do&Co:

1. STEP

- DELIVERY TO TURKISH DO&CO

For Turkish Do&Co the first step of the chain is raw materials delivery to Turkish Do&Co's nine production kitchen by suppliers. The product that comes with cold chain will be delivered by controlling degrees according to status of the product. The materials are registered on the documents, and in dispatch department materials are logged into the system via Rota program according to the dispatch note (amount).

2. STEP

- STORAGE IN COLD ROOMS

Turkish Do&Co stores received materials in their cold rooms in each production point ready for use.

3. STEP

- PRODUCTION

Chain continues with using stored raw materials and transforming into a finished product. Deadline of the products is very important for an airline catering company. Besides, each catering request that is not fulfilled can cause plane delays and so can cause great losses. In Turkish Do&Co, products are prepared in three types of kitchen; hot, cold, and the bakery.

4. STEP

- STORAGE IN COLD ROOMS

After the production, foods are re-stored in a cold room as part of the cold chain. Hot meals served in flight can be shock frozen after being cooked. The cold sandwiches that contain fresh vegetables, meat or dairy products must protect in cold chain.

5. STEP

- TRANSPORTATIO N PLANNING

Dispatch is a planning step of the chain locating the finished products by company and flight, to which companies and to which flights are determined. Delivery is planned together with the Rota to follow and accordingly, catering is prepared to be shipped to the aircraft with trolley (Handling).

6. STEP

- LOADING TO VEHICLES

Prepared trolleys are loaded to specially equipped vehicles (High Loading) for delivery and are sent to apron. Apron is the area where aircrafts are parked at the airport. Each parking place has a number.

7. STEP

- LOADING TO PLANES

When vehicles arrive to the specified aircraft, catering staff place the delivered goods (newspaper, bread, trolley, etc...) to the planned location. The location for the goods varies according to aircraft type and the preferences of the airline. Catering service is only responsible of placing the materials.

8. STEP

- OFF - LOADING FROM PLANES

When the aircraft makes its flight and return to the main station, materials are evacuated from the aircraft in a similar system (Off Loading).

9. STEP

- DELIVERY TO TURKISH DO&CO

Remaining materials of the aircraft are delivered to Turkish Do&Co's stores.

10. STEP

- WASHING AND SEPERATION

Equipments from the aircraft are sent to the washing unit to be washed and/or disposed. Returned materials are disrupted except the untouched drinks and packaged goods because the cold chain is broken. The returned equipments are separated by owner and prepared for re-use.

Investigation of Turkish Do&Co's Distribution Operations with the Integer Linear Programming Model:

Integer Linear Programming (ILP) Model can be created as described below for minimization of the distribution costs of a flight catering firm.

i) Assumptions in the model:

- Production costs were not taken into account in the model.
- Aircrafts are assumed to request the same amount of products.
- Distance between the bridges is not taken into consideration so travel time of reaching the first plane is performed at the same time. Service time varies depending on the type of loading.
- Airplanes take of at planned time and land to the airport at least one hour before departure.
- Only the planes approaching the bellows demand catering services.
- A High Loader can make three types of loading; (i) serves one aircraft and returns, (ii) serves two aircrafts and returns, (iii) serves three aircrafts and returns.
- Company has 5 high loaders which have the same features.
- Service time for the first, second and third types of loading are respectively 29, 47 and 65 minutes.
- Amount of loading for the first, second and third types of loading are respectively 7, 14 and 21 trolleys.

- Fuel cost of high loaders is 80 Kr/km, distance between apron and business is 3 km, distance between the two aircrafts served in apron is 800 meters. In these circumstances for first, second and third types of loading fuel costs are respectively 4,8, 5,44 and 6 TL.
- Service is provided to 13 aircrafts in 40-minute intense period.
- The first aircraft must be served at least one hour before its departure.
- In this context, catering services are provided within 65 minutes between 7:50 to 8:55 a.m. for 13 aircrafts landed between the hours of 8:50 to 9:30 a.m..

ii) Definition of decision variables and parameters

Decision variables:

X_{ij} : numbers of traveling for the ith vehicle performing the jth type of loading

Parameters:

d_{ij} : cost of delivery for the ith vehicle performing the jth type of loading

a_{ij} : service time for the ith vehicle performing the jth type of loading

f_{ij} : amount of loading for the ith vehicle performing the jth type of loading (trolley)

b_i = maximum service time for the ith vehicle

h_k = total amount of loading carried in aircrafts

t_k = total number of aircrafts to be served

i = 1, 2, 3, 4, 5 (n: number of vehicles)

j = 1, 2, 3 (m: loading type)

iii) Formulation of the objective function

$$Zmin = \sum_{i=1}^{n} \sum_{j=1}^{m} dij\ Xij \quad \textbf{(1)}$$

$Zmin = 4{,}8X_{11} + 5{,}44\ X_{12} + 6\ X_{13} + 4{,}8X_{21} + 5{,}44\ X_{22} + 6\ X_{23} + 4{,}8X_{31} + 5{,}44\ X_{32} + 6X_{33} + 4{,}8X_{41} + 5{,}44\ X_{42} + 6\ X_{43} + 4{,}8X_{51} + 5{,}44\ X_{52} + 6X_{53}$

iv) Constraint equations

Time constraints:

$$\sum_{j=1}^{m} aij\ Xij \leq bi \quad \textbf{(2)}$$

$29X_{11} + 47X_{12} + 65\ X_{13} \leq 65$

$29X_{21} + 47\ X_{22} + 65X_{23} \leq 65$

$29X_{31} + 47\ X_{32} + 65X_{33} \leq 65$

$29X_{41} + 47\ X_{42} + 65X_{43} \leq 65$

$29X_{51} + 47\ X_{52} + 65X_{53} \leq 65$

Load constraints:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} fij\ Xij = hk \quad \textbf{(3)}$$

$7X_{11} + 14X_{12} + 21X_{13} + 7X_{21} + 14X_{22} + 21X_{23} + 7X_{31} + 14X_{32} + 21X_{33} + 7X_{41} + 14X_{42} + 21X_{43} + 7X_{51} + 14X_{52} + 21X_{53} = 91$

This constraint shows the amount of load and does not have any effect on the solution

Number of aircraft constraints:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} j * Xij = tk \qquad (4)$$

$1X_{11} + 2X_{12} + 3X_{13} + 1X_{21} + 2X_{22} + 3X_{23} + 1X_{31} + 2X_{32} + 3X_{33} + 1X_{41} + 2X_{42} + 3X_{43} + 1X_{51} + 2X_{52} + 3X_{53} = 13$

Positive (not to be negative) condition:

$X_{ij,} \geq 0$ and integer

v) Solution

The following results are achieved by solving mixed integer program using WinQSB software. $Z = 28{,}80$ *TL*

$X_{11}=1 \quad X_{23}=1 \quad X_{33}=1 \quad X_{43}=1 \quad X_{53}=1$

$X_{12}, X_{13}, X_{21}, X_{22}, X_{31}, X_{32}, X_{41}, X_{42}, X_{51}, X_{52} = 0$

Current delivery plan and cost is shown below for the purpose of clarifying the differences. $Z = 28{,}88$ *TL*

$X_{13}=1 \quad X_{23}=1 \quad X_{33}=1 \quad X_{42}=1 \quad X_{52}=1$

$X_{11}, X_{12}, X_{21}, X_{22}, X_{31}, X_{32}, X_{41}, X_{43}, X_{51}, X_{53} = 0$

Integer-Linear Programming Model Proposed is an alternative for Do&Co plans and results in a slightly reduced total costs. And in optimal solution, all aircrafts are served and 4 high loaders have no slack time, they use their 65 minutes but one high loader use 29 minutes so there is 36 minutes slack time.

CONCLUSION

The company must create an optimum distribution plan to be able to get their operations in time, because one of the most intense time periods are examined in the model. Currently, company does not work at an optimum point since the proposed model seems to give better results. In case of a review of long-term period, ILP model's advantages will be more clearly understood. Model may be recommended for future studies for using different evaluating criteria such as minimizing the total service time.

The results achieved in this study show the economic aspect of the problem reviewed. It is clearly observed that savings can be made by implementing an Integer Linear Programming model for minimizing the distribution costs. Moreover, this model can be improved to include other costs in a more complex analysis.

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IMPACT OF INNOVATION ON THE CUSTOMER-SUPPLIER RELATIONSHIP WITHIN THE SUPPLY CHAIN

Fatine Elharouni[1], Rachid Benmoussa[2], Abdellah Ait Ouahman [3]

Abstract — *The ever-increasing requirements of customers; competitiveness and internationalisation of markets, rising energy costs and production...Increasingly, factors require the enterprise to engage in approaches to innovation and collaboration. This paper discusses how the introduction of innovation especially product innovation can change the existing supplier relationship within the supply chain. The application of purchasing portfolio analysis conducted specifically to the conclusion that the introduction of an innovation leads to more cooperation in business relationships that already exist.*

Keywords — *Innovation, supplier relations, purchasing portfolio, portfolio business relationship*

INTRODUCTION

The turbulence of the environment and the increasing pace of technology renewal require the company to increase innovation and efficiency to maintain a competitive advantage. The company is refocusing on its core business and increases its purchases. This augmentation shows that the supplier relationship is an essential factor for a product with high quality. That innovation involves a change of supplier relations that may be something obvious, but how innovation can change the relationship with a supplier which is already established?

WHAT INNOVATION DO WE SPEAK ABOUT?

A firm is said to have a sustained competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors and when these other firms are unable to duplicate the benefits of the strategy.[1] and this function is completely filled with innovation.

In the literature, we see a variety of views on the types of innovation depending on the point of view or the discipline of the author. Among the numerous attempts, we will retain the model [2] that propose the concept of "transilience" to represent the different possibilities theoretically available to the company: Niche Innovation, Architectural Innovation, Current Innovation, breakthrough Innovation (figure 1)

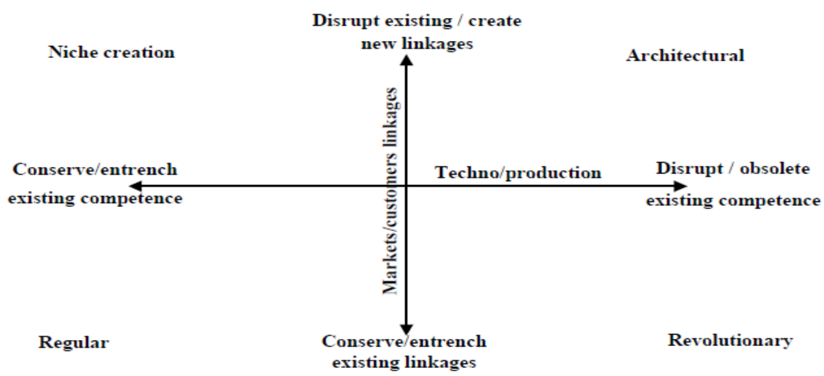

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FİGURE1.
Transilience map

In this work we start by the assumption that innovation which we are address does not destroy the business relationship and it is observed also in the firm or in its supplier.

THE PORTFOLIO OF PURCHASE AND ITS IMPLICATIONS

Purchases by their position at the interface of the customer / supplier relationship require more efficiency and effectiveness. Beyond the traditional methods of procurement management, which increases neither the profit nor the company's competitive position (all competitors receive the same discounts of the total cost of use). An adaptation of the Model (Figure 2) proposed by Kraljic [3] segment the purchase in different section (to answer the question of the logic followed for the supplier relationship) as:

- The importance that the organization gives them because purchases are not equal, this inequality can arise from different factors:
    - Strategic nature of the purchase;
    - The nature and extent of benefits that the procurement manager can expect;
    - Its high level of technicality;
    - The level of effort to manage the purchase...
- The report that it may lead vis-à-vis the supplier markets [4]

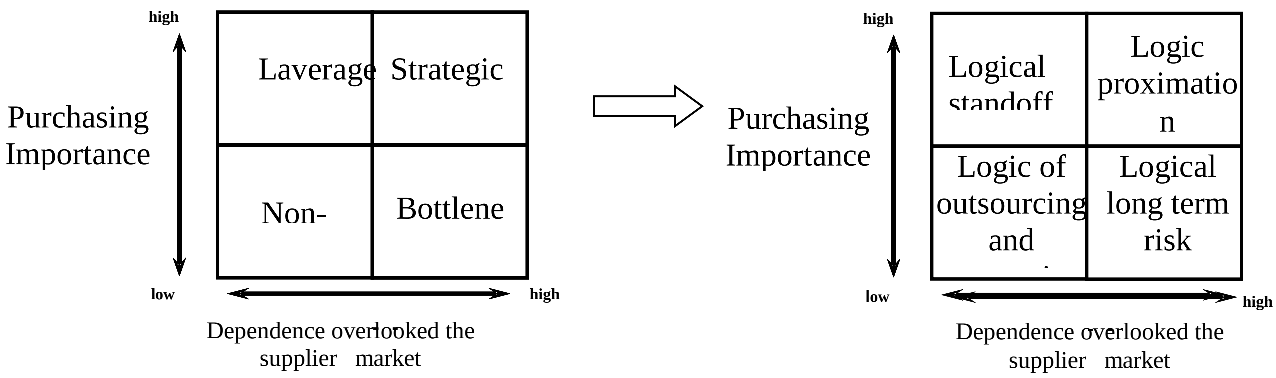


FIGURE. 2
The portfolio purchases and The portfolio purchases

The figure 2 identifies the main lines of action of purchasing managers by product segments. Thus, for non-critical purchases, the procurement manager should promote practices that minimize his intervention.

For leverage Items, we should focus on practices that facilitate the balance of power or at least give the company more advantage to the large supply on the market. For purchases bottleneck, the manager's action should be long term to reduce its dependence.

Finally, for strategic purchases, the manager should encourage practices to seek gains on the total cost parameters other than price. Given the diversity of shopping, it is natural that the procurement manager has at his disposal a variety of techniques (in this paper we are not interested to these techniques) to maximize profits in the short or long term and that in light of the circumstances. Thus, according to the family purchases (those identified in the portfolio), some techniques are better suited, and the portfolio is used to define the avenues available for purchases of Class [5].

This analysis provides the decision tree (everything leads the other) as follows (Figure 5):

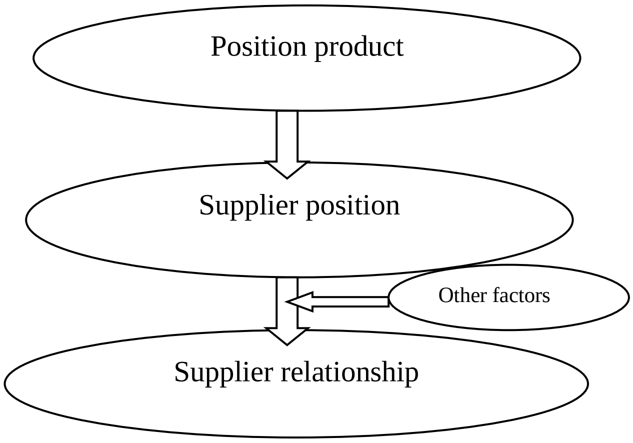


FIGURE 3
Scheme decision supplier relationship

MORE INNOVATION MORE COLLABORATION

To analyze supplier relationship and the process of technological innovation involves the question of the mode of interaction that occurs between the two.

Innovation by its transformative nature (increased need to purchase or change in the characteristics of the product ...) implies a shift of purchases from the company wallet matrix which encourages purchase from the buyer change provider behavior (since there is inevitably a movement on the business portfolio matrix), with a supplier with which a relationship is already established.

The movement of purchases have two scenarios depending on whether business innovation or innovation at the supplier (Figure 4).

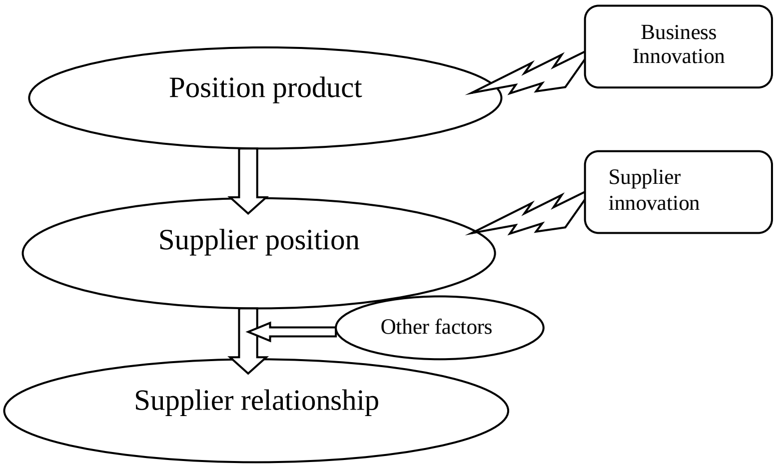


FIGURE 4
Scheme decision supplier relationship and innovation introduction

+ Innovation at the company increases the importance of the subject product innovation (at least at the output of innovation as it provides the firm a competitive advantage). The conditions are not the same and any link to purchase this innovation is very important for the company. The changement is in one sense and touches only non-critical purchases and bottleneck (Figure 5).

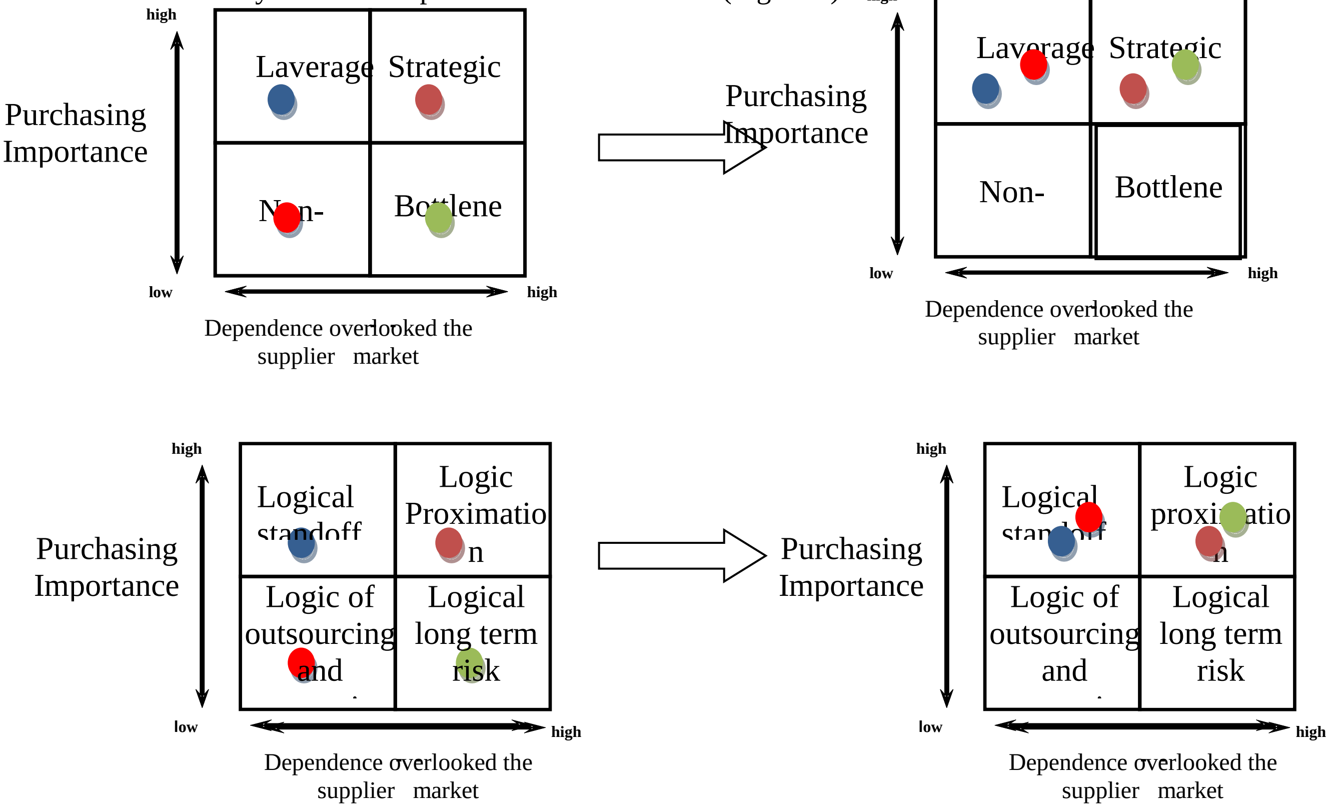
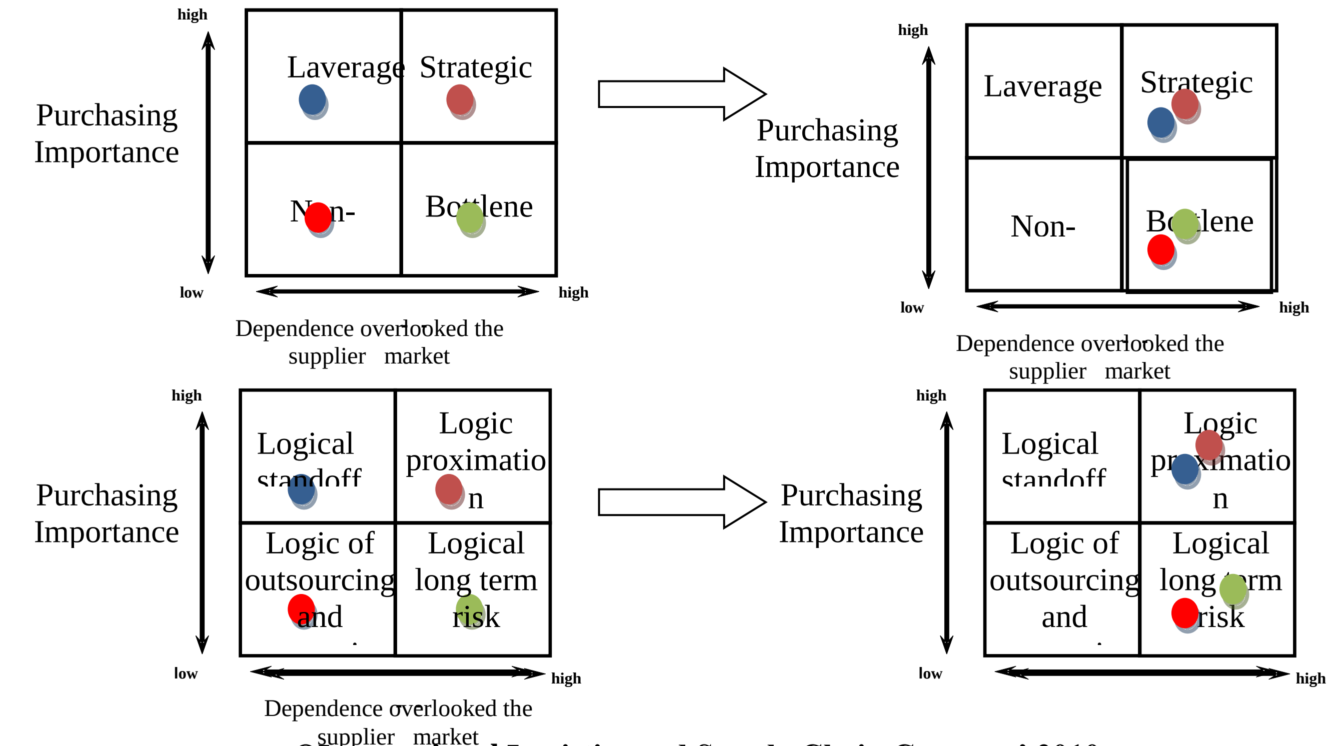


FIGURE. 5
Example of introducing innovation in the company and its involvement

+ Innovation at the supplier (gives it a competitive advantage) increases the dependence of the company vis-à-vis the latter. The image of the market changes and tends to the situation of monopoly or oligopoly. Change is in one sense and touches leverage and non-critical supplies (Figure 4).



Dependence overlooked the
supplier market

FIGURE 6
Example of introducing innovation in the providers and their involvement

We note that in an environment of innovation the concept of non-critical product tends to disappear. Therefore, the logic of outsourcing and contract is not interesting, and if there is a changement of position, it is for increasing its intensity. This reinforces the idea: innovation involves more collaboration with the supplier.

Indeed, in the evolution of the current context, marked by the establishment of closer relations between the different partners, supply tends increasingly to become involved in the innovation process, which mean that is not only to establish contacts with other partners but also to play a more active and interactive process of innovation, to boost relations in the process.

The scenarios are increasing, the Purchaser may for example ask a provider to offer more advanced components and assist in their design, a situation that is visible in the automotive industry where suppliers must offer modules that cross components from different suppliers.

Or also to support the competitiveness of some existing suppliers through information exchange, personnel and perhaps even money so that the supplier improves the quality of his product, service delivery, reduces his cycle time, or reduces the size of his production batches, etc..

For certain sensitive purchases, it is crucial to have sources of supply of high caliber. What is certain is that the positioning exercise purchases must be repeated periodically, it allows monitoring the market and suppliers to take proactive measures and thus keep pace with the innovation process.

CONCLUSION

In this paper, we could see the relationship between innovation and supplier relationship in the sense that the introduction of an innovation by the firm or its supplier changes the relationship toward more cooperation. However, the company that has waived to master all the technology linked to production will need the expertise of its buyers to involve more providers because a large share of new ideas and competitiveness-innovation will come from them. The relationship is then as cause and effect for better innovation, we need more collaboration.

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THE EFFECTS OF 2009 ECONOMIC CRISIS ON TURKISH SEAPORTS

Soner Esmer[1], Ersel Zafer Oral[2]

Abstract — *Logistics industry is one of the mostly affected sectors by economic and financial developments. The downward and upward movements of this industry seem to have been dependent upon the developments in the world trade in general and foreign trade in particular. In parallel with such trade developments, logistics industry displays an upward development and expansion as the world trade develops and foreign trade increases, and it records a downward movement together with contraction during the periods of contraction and crisis encountered in economy.*

The main purpose of this research is to analyze the effects of the 2009 financial crisis on the Turkish ports. To do this, the relevant data for 2000 to 2009 are evaluated. And also a questionnaire was developed to find the effects of the crises concerning both the individual regions as well as the each cargo type are separately scrutinized.

Keywords — *Economic Crises, Economic Contraction, Foreign Trade Expansion, Logistics, Seaport.*

INTRODUCTION

There is an increasing interest in the changing role of ports as a result of globalization of production and distribution. Traditionally ports were only providing shelter and berthing space, temporary storage and the provision of superstructure and infrastructure for cargo operation and movement within port. Contemporary ports have a new role to fulfill in the era of globalization [1]. Much of the literature advocating the future of ports as logistics centers highlights their nodal role in the changing patterns of maritime and intermodal transport [2]. Ports which are one of the noticeable rings of the international supply chain can be defined as a terminal and an area within which ships are loaded and/or unloaded with cargo and includes the usual places where ships wait for their turn or are ordered or obliged to wait for their turn no matter the distance from that area. It has interface with other forms of transport and in so doing provides connecting services.

Like other industries, port sector have been affected by 2009 global economic crises. However, the impact of the crisis at the Turkish port cannot be determined clearly. Different port managers have different views on effects of the crises.

2009 GLOBAL ECONOMICS CRISIS AND ITS EFFECT TO TURKISH PORTS

The economic crises, which actually had flashed certain warning signals that unfortunately had been ignored, had a clear and severe effect almost all over the world in 2009. According to the United Nations Economic Commission, the world is facing the worst crisis since the 1930s, which has been characterized by huge losses of both financial and non-financial wealth, most notably in developed countries, but in emerging economies as well [3].

As a reflected consequence of this though economic crises, the transport industry suffered from certain loss of cargoes, which resulted in a highly contracted area of business in this industry, making certain players with no competitive power leave the fighting ground. A clear example of such great loss has been experienced in shipping, the greatest player of the foreign trade play ground, where the number of ships voyages has displayed a dramatic fall. Such loss and sharp fall has caused ports to suspend their investments, lower their tariffs, and start taking certain measures to decrease their costs.

The year 2008 marked a major turning point in the history of the world economy and trade. Growth in the world economy slowed abruptly in the last part of 2008, in developing economies and countries with economies in transition has turned out to be less resilient than expected.

The global economic downturn and reduced trade, growth in international seaborne trade decelerated in 2008, expanding by 3.6 per cent as compared with 4.5 per cent in 2007. The volume of international seaborne

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trade in decline in demand for consumption goods, as well as a fall in industrial production in major economies and reduced energy demand, the deceleration in seaborne volumes affected all shipping sectors [4].

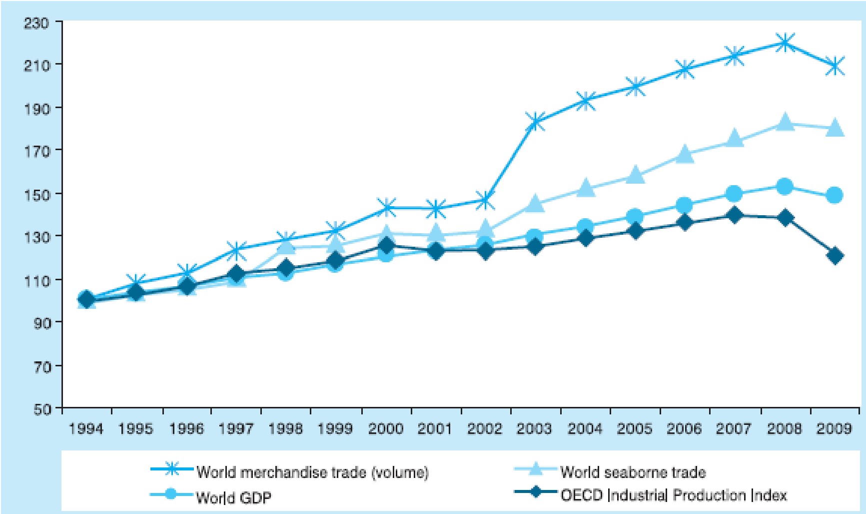

FIGURE 1
Indices for world economic growth (GDP), OECD Industrial Production Index and world seaborne trade (volume), 1994–2009 *(1994 = 100)* Source: [4].

Highlighting the strong interdependence between industrial production, economic growth, global trade and maritime transport services, Figure 1 illustrates how these variables are moving in tandem, including falling in unison in 2008 and 2009. A contraction in industrial production reduces output and trade, and by extension, reduces demand for maritime transport services and depresses global seaborne trade [4].

Turkey's foreign trade has direct impact on the crisis. In 2008, exports and import increased 23% and 18 % respectively. Compared to the previous year, export decreased by 22% while imports decreased 30.3% in 2009 [5]. These figures were directly effect to cargoes handled at Turkish ports.

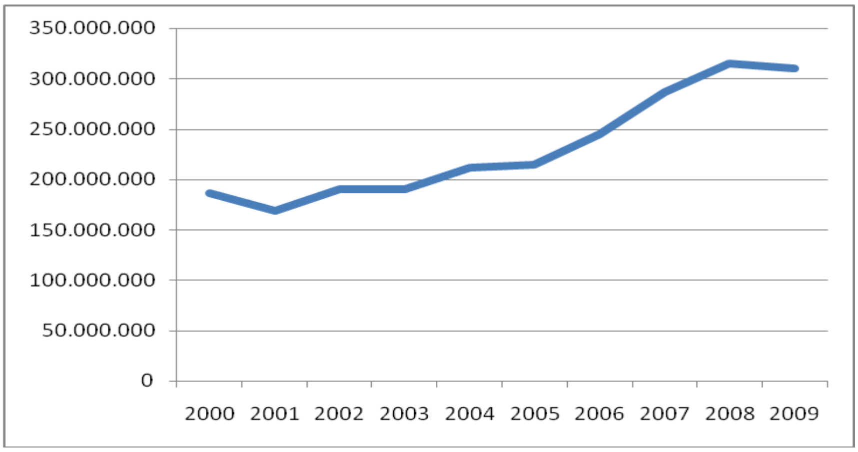

FIGURE 2
Annual Total Cargo Handling Figures in Turkish Port (ton). Source: [6].

Total cargo handled in ports of Turkey between 2007 and 2008 increased at a rate of 9.8%. However, as shown in Figure 2, approximately a 2% contraction had been occurred between 2008 and 2009.

METHODOLOGY

In the study, a questionnaire designed for assessment the effects of global economic crisis to the Turkish port sector. Nominal and interval scale is used in questions. Questionnaires were sent to 47 private port operators in Turkey and the rate of response was % 66 (30 ports). All survey respondents are senior port managers. To analysis the collected data, central tendency measures are used. In addition, response rate of questionnaire statements and reliability rate of questionnaire are calculated. Calculated reliability is 73.8% and from this perspective, reliable results were obtained from the survey.

SURVEY RESULTS

- **Predictions Relating to Global Economic Crisis**

Effects of the global financial crisis had been felt mainly in 2009. However, economic uncertainty continues in the first quarter of 2010. In this point, the idea of ""uncertainty" is remarkable. Because the port managers especially emphasizes that economic uncertainty is continues. Perceptions of the crisis had been overcome remained very low rates (Table 1.).

TABLE 1
Predictions Relating to Global Economic Crisis.

Predictions	Response Rate (%)
Economic uncertainty continues.	75
Economic crisis continues.	20
Economic crisis has been overcome.	5

- **The Most Effected Cargo Type From Global Economic Crises**

The first three load types which have mostly affected by global economic crisis in 2009 are general cargo, container and dry bulk cargo. On the other hand, cargoes the least affected from the economic crisis are domestic car transport, liquid cargo and automotive foreign trade (Table 2.).

TABLE 2
The Cargo Types Affected by Global Economic Crisis.

Affected	Less affected
1. General cargo	1. Domestic car transport
2. Container	2. Liquid cargo
3. Dry bulk cargo	3. Automotive trade

- **When the crisis will end?**

Around 50 % of the port directors are considering that the negative impact of the crisis on the ports will be overcome within two years. In addition to this, % 45 of the manager is considering that the effects of the crisis going to end in 3-4 years. And the remaining managers thinking that the negative effects of the crisis will take more than 5 years.

TABLE 3

Opinions of the Port Representative for the Crisis to be Overcome

Predictions about the global economic crisis	%
Crisis will be overcome within 0 – 2 years.	50
Crisis will be overcome within 3 – 4 years.	45
Crisis will be end in more than 5 years.	5

Evaluate the answers given in relation to the years when the economic crisis will be overcome until the year 2014 constituted 95% of the total responses. Around 50 % of the managers are also considered that the effects of the crisis will be overcome until the year 2012 (Table 3.).

- **Effects of Global Economic Crisis to the Turkish Ports**

Statements in the questionnaire directed at managers and expecting to be given a number from 1 to 5 (interval scale). Then the value for each expression of the average (arithmetic mean) was taken. The results obtained are examined particularly for 4 and above average reaching consensus can be noted in the statement.

As shown in Table 4, in time of crisis " the number of ships has decreased " and "profit margins have decreased in the ports" to suggest the answer closest to the average value reached 5. Then the highest average of the “competition has increased” and “Investment has been postponed” for expressions is obtained.

TABLE 4

Effects of Global Economic Crisis to the Turkish Ports

Statements	Means	Standard Dev.
The number of ships has decreased	4.5652	0,5897
Profit margins have decreased in the ports	4.5652	0,6623
Competition has increased	4.3913	0,8913
Investment has been postponed.	4.2608	1,0538

The findings for the crisis are in relationship with each other. Such that the decrease in the number of calling ship to the port directly affect port revenues and reduced profitability. And the other hand, with increasing competition, competitors who do not want to lose market share delayed investment in the crisis period.

CONCLUSIONS

The 2009 economic crises had a clear and severe effect almost all over the world. One of the sectors most affected by the economic crisis is the transport sector. Therefore, the sector most affected by global economic crisis has become maritime sectors. The decrease in sea transport also decreased the freight traffic of seaports. In this study, the impact of the crisis of Turkish ports and Turkish port sector are examined and it is understood that they are not very optimistic about the crisis. 95% of ports participating in the study stated that the crisis continues and around 50 % of participating reported the crisis would last longer than two years. However, despite the crisis in Turkey, seaports were able to survive. There has been no change of major bankruptcies and hands. Briefly, Turkish port was able to survive in spite of the affected by the crisis.

On the other hand, because of loss and fall has caused by the crisis, ports to suspend their investments, lower their tariffs, and start taking certain measures to decrease their costs. According to research results the impact of the global crisis will end in 2014

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A NEW MODEL FOR THE ON-LINE VEHICLE SCHEDULING PROBLEM WITH DRIVERS' WORKING HOURS

Arslan Taşkın[1], Mehmet Tanyaş[2], Murat Baskak[3]

Abstract — *In this paper, a new variant of the vehicle routing and scheduling problem is studied. Vehicle Routing Problem was first introduced by Dantzig and Ramser in 1959 in the paper "Truck Dispatching Problem". The basic problem was developed with the new varients during the last few decades. Based on the needs of the operations of a logistics company, we introduced a new problem in which the working hours of drivers and the possibility of using outsources are considered. The different capacities and properties of the vehicles are also considered since there are various demands of the customers according to their loading capabilities depending on the loading platforms in their depots. The model is an mixed integer program which aims to find the schedule with the least cost. The cost of each alternative is determined by the distance traveled, time spent and the cost of the outsourced operations with the penalty values depending on the delays of each service.*

Keywords — Vehicle routing and scheduling problem, drivers' working hours, mixed integer program

INTRODUCTION

In this paper on-line vehicle routing and scheduling problem with driver's working hours (OVSPDWH) is defined and considered. The origin of the problem is the vehicle routing problem (VRP) which has been studied since the paper "Truck Dispatching Problem" by Dantzig and Ramser [4] with a wide range of considerations. The main concern is finding the optimal route with a minimum cost while serving all the customers.

Some of the general constraints which are implemented to VRP and which will be implemented to the OVSPDWH are the capacity constraints, the constraints according to the number of origins and destinations, the time windows constraints, the demands of the customers about the properties of the vehicles, routes or drivers and the drivers' working hours constraints.

The Capacitated Vehicle Routing Problem (CVRP) is the problem where a heterogeneous fleet of vehicles is considered while finding the optimal route. The capacities of the vehicles may be different and the demands of each customer varies opposite to the incapacitated VRP where the capacities and the demands are ignored and every customer order represents a point where at least one vehicle has to stop by. A. Hoff et al. [7] described the three different aspects of the concept "capacity"; physical dimensions, compatibility constraints and costs of a heterogeneous fleet of vehicles. In the survey by Toth and Vigo [11], the models for the CVRP are studied widely. Tütüncü [5] solved the CVRP for a fleet with a fixed number of vehicles.

The number of origins and the destinations is another parameter that determines the modeling approach. The problem under consideration could be one-to-one where each order comes with one origin and one destination, one-to-many-to-one where the origin of the orders are a single depot while the destinations are multiple and the way back the origin of the orders are multiple while the destination is the single depot, many-to-many where there could be many origins and destinations for a single order. The model in this paper can be classified as a one-to-one vehicle scheduling problem where the origin is a single depot and the destination is the customer's depot. Similarly during the way back, the origin is the customer's depot and the destination is the single depot. Since the orders are received on-line which means the orders come during the real time, the scheduler needs to consider the received orders already and the possible order receivings. The operations of

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the logistic company being worked with, takes longer times to complete which makes the decision making while scheduling the vehicles at the depot and at the destination region becomes independent. The decision making at the depot does not affect the scheduling performance at the destination region because the on-line orders are received very dynamically and the long period between the start and end of an operation makes it impossible for realistic predictions. In this paper the scheduling at the destination region will be considered. In the survey by Berbeglia et al. [6] a classification is built according to the origin and destination numbers.

The time windows constraints can be classified as soft or hard depending on the allowance of serving besides time windows. If serving a customer before or after the time period is not allowed then the model must not schedule a vehicle. On the other hand the delays below a threshold value may be acceptable and the penalty costs can be implemented to the model with the penalty functions. Belfiore et al. [9] used hard time windows while modeling a real-life vehicle routing problem. Li et al. [8] challenged with time windows where the travel and service times assumed to be stochastic. Kallehauge [3] studied the different formulations for the vehicle routing problem with time windows (VRPTW). Ibaraki et al. [10] and Qureshi et al. [1] considered soft time windows while offering different penalty functions for different cases.

Even though the VRP has been studied widely, the drivers' working hours is not taken into consideration in most of the studies. The policies of the governments restrict the amount of time the driver can drive during a day, a week and two adjacent weeks. International freight companies must consider the working hours since the amount of the time which is needed by the vehicles generally extends the maximum time the driver could drive in one day. In Li et al. [8] the working hours considered by limiting the driving hours with a threshold value. Also Goel [2] suggested a model considering the European Union's restrictions in his book "Fleet Telematics".

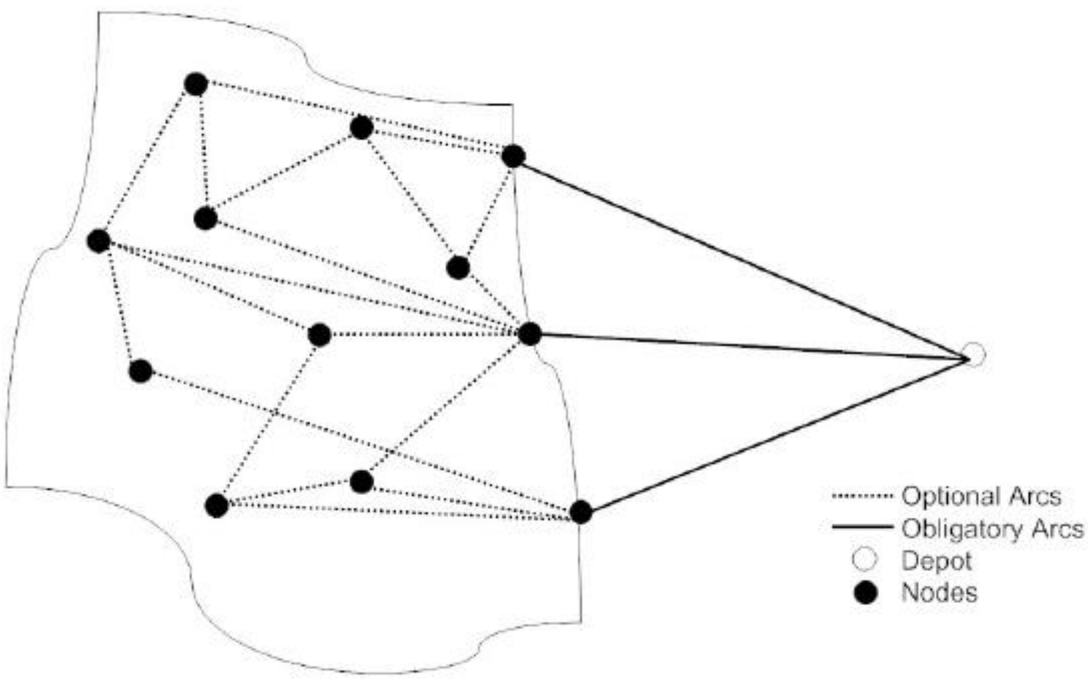

FIGURE. 1
Optional and Obligatory Arcs and Nodes.

The problem being considered in this paper is a vehicle scheduling problem which focuses on the decision making on a geographically bounded region. It is assumed that the route out of a known region which vehicles use does not differ from one activity to another. There is one depot where delivery activities start. The delivery nodes where delivery customers locate and the pickup nodes where pickup customers locate are in this bounded region (Figure 1). The cost of the activities strictly depends on the time spent and the distance traveled in this region which varies by the scheduling decisions. After the vehicles leave the region the route they use are the same so that the cost of the activities outside the region does not change with different scheduling alternatives. In real life applications the bounded region may be thought as a country or a set of countries in which the vehicles need legal permission to drive in. The vehicle may have permission to enter some of the countries in the route and not for the others, so it has to search for an appropriate route. While leaving the country where pickup and delivery activities completed, the permissions may affect the choice of the border gate. This choice determines the distance covered so the cost of the activity. The border gate is going to be referred as a reference location where the vehicle has to pass through. In the international freight operations, the custom operations of carried goods must be completed after the loading at the origin and before the unloading at the destination if there are no other agreements between the related governments. The custom operations may be completed at the customer depot or some other place and with each order it will specify another location to pass through.

This paper is organized as follows. In section 2 the problem is defined and the model is built for the OVSPDWH. In section 3 the model is tested with the GAMS program while section 4 is the conclusion.

PROBLEM DEFINITION AND FORMULATION

The OVSPDWH can be defined and formulated as the following graph theoretic problem. Let $G=(V,A)$ be a complete graph where $V=N_1\cup N_2\cup C_1\cup C_2$ is the vertex set and A is the arc set. $N_1=\{n_{11},n_{12},\cdots,n_{1m}\}$ corresponds to nodes where vehicles are or will be free to serve new customers, $N_2=\{n_{21},n_{22},\cdots,n_{2m}\}$ are the nodes where vehicles need to pass through while entering or leaving the region and $C_1=\{c_{11},c_{12},\cdots,c_{1n}\}$ corresponds to the nodes where the pickup customers located and $C_2=\{c_{21},c_{22},\cdots,c_{2n}\}$ corresponds to the nodes where the custom operations of the related customers will be completed. For any vehicle i node n_{2i} will be a reference point where the route after this node will not change depending on the customers.

In the OVSPDWH, when the vehicle i is scheduled to serve to customer j, the cost of the vehicle will be calculated as the sum of the cost of distance it traveled until the reference node n_{3i} and the cost of time vehicle has to spend to serve the planned customer and reach to the reference node n_{3i}. The distance d_{ij} that vehicle i has to travel when scheduled to serve customer j is expressed as follows:

$$d_{ij}=d_{(n_{1i},c_{1j})}+d_{(c_{1j},c_{2j})}+d_{(c_{2j},n_{2i})} \qquad (1)$$

where each arc $(n_{1i},c_{1j}),(c_{1j},c_{2j}),(c_{2j},n_{2i})\in A$, $i=1,2,\cdots m$, $j=1,2,\cdots n$. $d_{(e,f)}$, $(e,f)\in A$ is the length of the arc (e,f). q_j denotes the demand of the jth customer. The capacity of the ith vehicle is Q_i. A vehicle may serve to a pickup customer unless the demand of the customer will not exceed the vehicle capacity.

If we define $h(t)$ as:

$$h(t) = \textit{the amount of time a vehicle needs to operate t time units of jobs,}$$
$$\textit{considering driver's working hours restrictions} \qquad (2)$$

and assume that the vehicle travels with a constant velocity v, then the time t_{ij} that vehicle i has until the reference node when scheduled to serve customer j is expressed as follows:

$$t_{ij} = t_{(n_{1i},c_{1j})} + t_{c_{1j}} + t_{(c_{1j},c_{2j})} + t_{c_{2j}} + h\left(\frac{d_{(c_{2j},n_{2i})}}{v}\right) \qquad (3)$$

where $t_{(e,f)}$, $(e,f) \in A$ is the duration between the time vehicle is ready to leave node e and the time when it has to be at node f. $t_{c_{1j}}$ and $t_{c_{2j}}$ are the service durations, $i = 1,2,\cdots m$; $j = 1,2,\cdots n$.

If the unit distance cost is shown by α and unit time cost is shown by β, then the cost co_{ij1} of the vehicle i which is scheduled to serve customer j is calculated by the following formula:

$$co_{ij1} = d_{ij} \cdot \alpha + t_{ij} \cdot \beta \qquad (4)$$

If the service starts with a delay at customer j, the penalty cost co_{ij2} is added to the total cost. For each customer, different penalty functions should be used according to the allowance of the early or late arrivals. The penalty function of each customer is denoted by $f_j(h_{ij} - t_{(n_{1i},c_{1j})})$, $j = 1,2,\cdots,n$. h_{ij} is the duration vehicle i needs, to start service at customer j:

$$h_{ij} = h\left(\frac{d_{(n_{1i},c_{1j})}}{v}\right) \qquad (5)$$

Then the penalty cost co_{ij2} is:

$$co_{ij2} = x_{ij} \cdot f_j(h_{ij} - t_{(n_{1i},c_{1j})}) \qquad (6)$$

The probability of using a outsource vehicle for the customer j is shown by pr_j which is 1 if there is an outsource vehicle that can be used or 0 otherwise. Whenever $m < n$, the outsource vehicles may guarantee to serve all the customers. The cost of the outsource vehicles co_{j3} is the amount paid to rent the vehicle.

After the scheduling, there may be some vehicles unscheduled. These unscheduled vehicles will create another cost co_{i4}. If the scheduling period is t_{sp}, the start time of the next scheduling activity is τ_{sp}, the time when vehicle i is ready to serve new customers is τ_i (Figure 2) then $(\tau_{sp} - \tau_i) \cdot \beta$ will be the cost of keeping the vehicle without any action until the next scheduling time. There is still a possibility of unscheduling the vehicle after the next scheduling activity so there will be more to add to this cost. If the possibility of finding a pickup customer until the next scheduling time at node n_{1i} is p_i, then the cost of the unscheduled vehicle will be as follows:

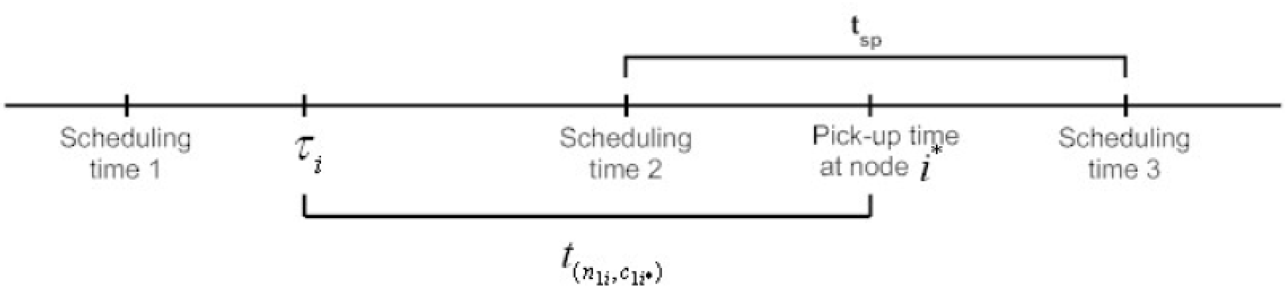

FIGURE. 2
Timeline for the schedule.

$$co_{i4} = (\tau_{sp} - \tau_i)\cdot\beta + \left(1 - \prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot(E[d_{ii^*}]\cdot\alpha + E[t_{ii^*} - (\tau_{sp}-\tau_i)]\cdot\beta) +$$

$$\left(\prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot(t_{sp}\cdot\beta + \left(1 - \prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot(E[d_{ii^*}]\cdot\alpha +$$

$$E[(t_{ii^*}+t_{sp}) - (\tau_{sp}-\tau_i+t_{sp})]\cdot\beta) + \left(\prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)(\cdots)) \quad (7)$$

$E[x]$ is the expected value of the random variable x. $\sigma-neighborhood$ of a vehicle node is the neighborhood in where there are potential customers that it makes sense to send the vehicle instead of waiting for the next scheduling period. This neighborhood includes the nodes within the distance $d_{(n_{1i},c_{1\iota})}$ where:

$$co_{i4} \geq (d_{i\iota}\cdot\alpha + t_{i\iota}\cdot\beta) \quad (8)$$

Since c_{1i^*} is not a deterministically known node within the $\sigma-neighborhood$ of n_{1i}, d_{ii^*} and t_{ii^*} are random variables.

If A is defined as follows:

$$A = t_{sp}\cdot\beta + \left(1 - \prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot(E[d_{ii^*}]\cdot\alpha +$$

$$E[(t_{ii^*}+t_{sp}) - (\tau_{sp}-\tau_i+t_{sp})]\cdot\beta) + \left(\prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot(\cdots) \quad (9)$$

Then

$$A = t_{sp}\cdot\beta + \left(1 - \prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot(E[d_{ii^*}]\cdot\alpha +$$

$$E[(t_{ii^*}+t_{sp}) - (\tau_{sp}-\tau_i+t_{sp})]\cdot\beta) + \left(\prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot A \quad (10)$$

And finally

$$A = \frac{t_{sp}\cdot\beta + (1 - \prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*))\cdot(E[d_{ii^*}]\cdot\alpha + E[(t_{ii^*}) - (\tau_{sp}-\tau_i)]\cdot\beta)}{1 - \prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)} \quad (11)$$

We find co_{i4} as:

$$co_{i4} = (\tau_{sp} - \tau_i)\cdot\beta + \left(1 - \prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot(E[d_{ii^*}]\cdot\alpha + E[t_{ii^*} - (\tau_{sp} - \tau_i)]\cdot\beta) +$$

$$\left(\prod_{n_{1i^*}\in\sigma-neigh.}(1-p_i^*)\right)\cdot A \qquad (12)$$

When scheduling the vehicles the properties of the vehicles and the demands of the customers according to these properties must coincide. For example depending on the customer's depot some properties of the vehicle may not be appropriate for the service. There may be some equipments needed or the driver may need to have some extra capabilities (i.e. ADR license to carry hazardous materials) to serve a certain customer. The properties of the vehicles will be expressed with v_i^k and the demands of customers regarding to the properties with γ_j^k $(k = 1,2,\cdots,\kappa)$. The property demands must be taken into account when building a schedule.

The RTVSP model which aims to find the minimum cost while serving all the customers is as follows:

$$min\sum_{j=1}^{n}\sum_{i=1}^{m}x_{ij}(co_{ij1} + co_{ij2}) + \sum_{j=1}^{n}y_j co_{j3} + \sum_{i=1}^{m}((1 - \sum_{j=1}^{n}x_{ij})co_{i4}) \qquad (13)$$

$$s.t.\sum_{i=1}^{m}x_{ij} + y_j = 1 \qquad j = 1,2,\cdots,n \qquad (14)$$

$$\sum_{j=1}^{n}x_{ij} \le 1 \qquad i = 1,2,\cdots,m \qquad (15)$$

$$\sum_{j=1}^{n}(x_{ij}q_j) \le Q_i \qquad i = 1,2,\cdots,m \qquad (16)$$

$$\sum_{j=1}^{n}\gamma_j^k = \sum_{j=1}^{n}\sum_{i=1}^{m}x_{ij}v_i^k\gamma_j^k + \sum_{j=1}^{n}y_j\gamma_j^k \qquad k = 1,2,\cdots,\kappa \qquad (17)$$

$$y_j \le p_j \qquad j = 1,2,\cdots,n \qquad (18)$$

$$x_{ij}, y_{ij} \in \{0,1\} \qquad (19)$$

In this model (14) indicates that every customer must be visited by one and only one vehicle whether with a vehicle in the fleet or with an outsource vehicle. Equation (15) is the constraint that does not allow any vehicle to be scheduled for more than one customer. Equation (16) is the capacity constraint. The demanded capacity of the scheduled customer for a vehicle cannot exceed the capacity of that vehicle. Equation (17) is the constraint that prevents the inappropriate matches according to the properties demanded and properties supplied. Equation (18) is the constraint that does not allow an outsource vehicle match with a customer, if there is no possibility of finding an outsource vehicle.

COMPUTATIONAL RESULTS

The model is tested with The General Algebraic Modeling System (GAMS). GAMS is a high level language that allows users to solve complex models.

The results are generated with a Intel Core 2 Duo 1.83 GHz and 2.00 GB memory computer.

The problems consist of randomly selected customer nodes and their custom nodes in a given graph. The custom nodes are generated to be the same node as the customers' nodes with a 0.5 probability. There assumed to be four different vehicle types according to their capacities. The demands of the customers also vary that may not fit to every vehicle in the fleet.

There assumed to be 5 different properties associated with the vehicles and the properties of every vehicle and the demands of the customers according to the properties of the vehicles are also generated randomly.

The loading hours generated from a discrete interval of hours of the day and the time instance that each vehicle will be ready to serve a new customer is generated from a continuous interval.

For the working hours limitations a simple rule is created. In the model every driver can drive 9 hours and must complete 11 hours of rest period without interruption. All drivers assumed to be completed their rest period at the time when they are ready to serve to a new customer.

The probability to find a outsource vehicle for a customer node is a binary variable while the probability to find a customer in the vehicle node and its neighborhood nodes is randomly generated from the interval$[0,1]$. If the probability to find a outsource vehicle for a customer node is 1, then is assumed that all the capacity and vehicle property constraints are satisfied by the outsource vehicle. For each node n_{1i} in the region an unscheduling cost $co_{i4}(\tau_i)$ is calculated before running the model.

TABLE 1
Model test results

m	n	# of scheduled vehicles in fleet	# of scheduled outsource vehicles	Solution time (in seconds)
20	15	12	3	0.001
20	20	16	4	0.001
20	25	17	8	0.001
50	40	37	3	0.015
50	50	44	6	0.016
50	60	50	10	0.016
80	60	54	6	0.016
80	80	70	10	0.031
80	100	80	20	0.047

The costs per unit distance covered and unit time spent, α and β are determined by the logistics company's accounting specialists. The average velocity of the vehicle and the outsource vehicle's cost are assumed to be constant and also determined by the specialists of the company.

With all the assumptions and the calculations mentioned above, for m vehicles and n customers, the results are summarized in Table 1.

CONCLUSION

A new variant of Vehicle Scheduling Problem is defined in this work. A model is developed to solve the OVSPDWH and the high level language GAMS is used to model the problem and generate a solution.

A real life application is solved by generating problems with randomly generated data. The specialists of the freight operations provided data where needed. The solutions are received in remarkable durations. The logistics company started a project to implement the model to the information technologies and vehicle tracking system.

Since the real life operations include more stochastic information, a further study can be made to focus on and deal with this stochastic information. The velocity of the vehicles can be generated as a stochastic data considering the rush hours of the roads. The calculations of probabilities of finding an outsource vehicle and a customer in given node can be extended to a more reliable base to generate schedules for longer planning horizons. For the orders a new acceptance system may be included in the model where rejectable orders may be tackled with the unrejectable orders. Partial vehicle loadings also can be implemented on the model to allow a vehicle to serve multiple customers at a time. The service durations can be expressed with stochastic variables for each customer.

With the current work the scheduling performance of a logistics company is increased even though more reliable results will be clear in a longer period. The interested researchers are encouraged to develop the model in this paper.

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FLIGHT CYCLE SIMULATION FOR EFFECTIVE USE OF CAPABILITIES AND SOURCES OF AIRFORCE BASE.

Bahtiyar EREN[1], Asst.Prof.Dr.Altan ÖZKİL[2]

Abstract *— The mission of an Air Force of any country may be defined as to deliver sovereign options for the defense of its country and its global interests. They are responsible not only for destroying a target anywhere in the world but also delivering humanitarian assistance to where and when it is needed. There is one reality that all these may happen in any where and at any time. This really forces Air Forces to be ready to accomplish flight operation missions given by headquarters for twenty-four hours a day. This requires a continuing training. The flight units train themselves and carry out different missions in different quantity not only by using their resources and capabilities but also resources and capabilities of different flight units from different Air Force Basis. In this study, the flight cycle of flight units was analyzed by a simulation mode developed in ARENA. Revised input data set were used because of security reasons. The efficiency of flight cycle was determined by using several measures of performance. The replication and deletion method was used in output analysis and 95 % confidence intervals for each measures of performance were estimated.*

Keywords — Efficiency of Air Force Bases, Flight Cycle, Discrete Event Simulation, The Occupancy Rate of Flight Exercise Areas, Runway Usage

INTRODUCTION

Uncertainties in today's security environment and changes based on those uncertainties make the armed forces be operationally ready so as to deter all kinds of threats from the beginning of peace times. In order to maintain the inland security and carry out the either national or international missions given by appropriate authority, the armed forces train all the time. Logistics comes into play while carrying out the missions as well. Training activities requires the combination of several resources such as man, material, time and place. When there is a lack of resources, the effective use of available resources becomes prominent issue. The high cost of procurement and sustaining resources in any Air Force makes the issue of effective use of available resources even more critical.

In this context, there are many studies about military especially in aviation. The studies carried out extensively cover the experimentation of validation of military deployment plans and the identification of drawbacks in both logistics support and planning phase of deployment plans including air-transportation [1]. The other study uses both the simulation and optimization techniques in order to minimize the waiting time of passengers during the "check-in" and to determine the optimum amount of flight catering to be procured so as to have a minimum excess in the end of the flight. Thus, the processes of "check-in" and "catering" are improved via simulation [2]. Due to the high number of flights that takes place in commercial airports rather than military ones, it is concluded that the simulation and simulators are very useful for training the personnel who work in control tower, optimizing the usage of runway and apron [3]. With the intent of simulating the Air Traffic Management that has a major role in the use of airports in a fast and real way, it is stated that National Aeronautics and Space Administration (NASA), Federal Aviation Association (FAA) and other US public and private corporations use simulation as a vital tool [4]. It is observed that the effective usage of resources related to flight activies is generally limited to commercial flight and airports. Therefore, in this study, the simulation is focused on flight cycle that composed of military aircraft take-off, flight to the exercise area, exercise, flight back to base and landing as well as the effective use resources such as runway, exercise area etc.

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PROBLEM DEFINITION

This study covers the flight cycle of war fighter aircrafts that stationed or deployed to the one of the busiest Turkish Air Forces bases that is analyzed in a simulation environment. The flight cycle, in this study, begins with the "ready to take-off" aircraft in the runway, take-off, flight to the dedicated airfield either for training or for exercise purpose, accomplish the stated mission in the flight plan, back flight to the base and ends with landing.

This study ends up with the assessing the usage of flight resources such as runway and airfield area. Each air force base has its own series of airfield. The same airfield can be used for both exercise and training purposes. The flight cycle that is basically composed of five stages (take-off, flight to the airfield, and carry out the mission, back flight and landing) is very complex in reality. When the aircraft type, mission type, the variability of take-off and landing time during the day and the duration of flight are considered, the simulation method is chosen as an appropriate approach.

INPUT ANALYSIS

Assumptions

Either a single aircraft or more aircraft are assigned in the flight plan so as to carry out the mission. The time required for estimating the runway usage depends on the number of aircraft in the flight plan. There are some controls such as engine control takes place in the runway before take-off, similarly, the runway cannot be used until the aircraft in the final approach lands and clear the runway. The average runway usage in minutes is shown in Table-1 with respect to the number of aircraft in the flight plan. For example the flight plan with three aircraft allocate the runway as a total of 6 minutes, that's, two and half minutes for take-off preparation, two minutes for take-off and one and half minutes for landing.

A/C Number	Take-off Preparation	Final Approach	Landing Time	Total Runway Usage
1 x A/C	1.50	1.00	0.50	3.00
2 x A/C	2.00	1.50	1.00	4.50
3 x A/C	2.50	2.00	1.50	6.00
4 x A/C	3.00	2.00	2.00	7.00
5 & More A/C	4.00	2.00	3.00	9.00

Table 1 **The Average Runway Usages (In Minutes)**

In order to carry out the mission written in the flight plan, some aircraft (A/C) that takes off from the base fly back to the same base, others fly to the main (original) or other bases. One of the parameters that make the problem even complex is the duration of flight, which is subject to change whether it is done during the peace time training or exercise periods. It is naturally assumed that the duration of flights that take place during the exercise periods is longer and the frequency of take-off and landing is very much higher. The flight in exercise periods uses airfield at most possible available whereas the flights in training use the airfield fully, partially or none. The flights that not use the airfield may follow low/high altitude navigation profile for training purposes. The flights in training are similar to the ones in exercise periods in such a way that some flights head to the airfield directly others head to the airfield following a navigation mission.

The analysis takes care of the flights according to the flight plan that requires whether airfield usage is stated or not. If airfield is stated, then runway and airfield usage are analyzed together, otherwise; only runway usage is analyzed. The airbase which analyzed in this study has 14 different airfields. The take-off time and flights to the airfield vary because of the distances from the base. Take-off, airfield usage and landing have different probabilistic characteristics.

Data and Analysis

The simulation study is based on past 112 days of flight data that took place in one only Air Force Base, which is coded as Base-1. Within this period of time, 2860 mission, which is the input data for flight cycle, is completed. An illustrated input data is shown in Tablo-2. "The sequence number" is the ordinal number of mission completed, "Date" defines the exact time that flight is done (for example; the flight that is done in 1st of Sept, 2008 is coded as 20080901), "take-off" and "landing base" are the name of the base. If either take-off or landing base is "other", it means that flight data is considered as outbound or inbound to the "Base-1". The take-off and landing time, the squadron's original base name, A/C type and quantity are straight forward. As mentioned before, there are 14 different airfield dedicated to Base-1. Airfield number, which begins with the number 1, shows which airfield, is allocated in the flight plan. In the "Airfield Number" column below Table-2, P1 and P2 stands for the navigation profile utilized in the flight plan. When you examine the Table-2, it is clear that Base-1 is open for flight 11 hours 45 minutes, which the difference between first take-off time, 08:15, and last landing time, 19:00.

Sequence Number	**Date (Year Month Day)**	**Take-Off Base**	**Landing Base**	**Take-off Time**	**Landing Time**	**Squadron**	**A/C Type & Quantity**	**Airfield Number**
1	20080901	Base -1	Base -1	08:15	09:15	Base -1	2XF-16	1A, P1
2	20080901	Base -1	Other	08:30	09:10	Base -1	4XF-4E	1A-B-C
3	20080901	Other	Base -1	08:40	09:30	Base -1	3XF-16	1A
4	20080901	Base -1	Base -1	08:20	09:05	Other	3XF-16	1A-B
5	20080901	Base -1	Other	08:25	09:07	Other	4XF-4E	1E, P2
6	20080901	Other	Base -1	18:15	19:00	Other	2XF-16	1E-F-G

Table 2 **A Generic Example of Data Set**

The duration of outbound and inbound flights to the airfield is determined with the help of squadron personnel. In the current training policy, the pilot can follow navigation profile either from departure to training area or recovery (flight back to Base-1 from training area). In this study, it is assumed that the navigation profile takes 15 minutes deterministically regardless of airfield number. In addition to that the navigation profile is carried out only in outbound flights. The flight in sequence number one in Table 2 above states that two F-16 aircraft of Base-1, takes-off at 08:15 and lands at 09:15 to the Base-1. But when analyzed the flight duration in depth with the assumptions made in this model, following the take off, two F-16 do the 15-minute navigation profile, which is P1, before reaching at the training area 1A, carry out the mission in the field and lands after a predetermined recovery time. In other words, event though the flight seems to take 60 minutes, combat training portion of it is just 30 minutes. Six mission flights with 18 A/C is shown in Table-2, two of the flights takes-off and lands back to Base-1, two of them either takes-off or lands Base-1 only.

Input analysis is conducted in order to determine the input probability distributions. First, descriptive statistics is recorded regarding to input data. Second, informal tests are conducted for statistics. Lastly, the formal tests are applied to determine the probability distributions of input data. The results of input distribution such as interarrival times of takes-off and landing, training and exercise times are listed in Table-3.

Variable	Distribution	Std. Error	Degrees of Freedom	Ki Square Value	p-value	Confidence Degree	Evaluation
Interarrival times of takes-off	-0.001 + WEIB(18.2, 0.613)	0.005	21	143	<0,005	%95	Appropriate Distribution
Interarrival times of landing	-0.001 + 551 * BETA(0, 0)	0.002	7	14,4	<0.0459	%97,5	Appropriate Distribution
Training Area 1B (in Peace)	-0.001 + EXPO(75.7)	0.005	3	7,33	0.0656	%97,5	Appropriate Distribution
Training Area 1B (in Exercise)	-0.001 + EXPO(27.7)	0.006590	0	0,414	<0,005	%95	Appropriate Distribution

Table 3 An Input Probability Distribution

MODELING

Assumptions

Within the scope of this study, only one of the Turkish Air Force bases, coded as Base-1, is analyzed and logistics support issues such as maintenance facilities and parking area available in the Base-1 are excluded. It is assumed that any departure from Base-1 may end up with landing Base-1 or the other bases as part of the mission. By the same token, any departure from the other bases may end up with landing Base-1. Each Air Force Base has its own series of training areas which have predetermined height, width and depth. It is assumed that Base-1 has 14 different training areas. Regarding the mission, the A/C may either occupy only one training area such as 1A or a combination of training areas such as 1A, 1B and 1C. The search and rescue flights are ignored in the model due to the fact that they do not use up runway and training area resources.

Conceptual Model

System elements of flight cycle simulation model like events, entities, attributes, variables are defined as follows.

Events

Events are the ones which change the state instantaneously. Events in this study can be listed as follows. The take-off preparation in the runway, the runway usage during take-off, departure to the other bases, take-off during exercise and training periods, the non-usage of training areas (missions such as air-to-ground, reconnaissance, cap etc.), departure to the training area w/o low/high altitude profile flight, recovery, the landing of A/C that take off from the other bases.

Entities

Entities are the ones which are dynamic and flow through the system. Entities in this study are fundemantally the A/C.

Attributes

Attributes are the ones which differentiate the entities from each other. Attributes in this study are squadron names, Base names, take off base, landing base, training area, A/C type and the number of A/C in the flight.

Variables

Variables, core part of the simulation, are the ones which are defined by user or predefined system characteristics. Variables are used for explaining the events in the system. Daily flight program is used as an input. Based on daily basis, the variables used in the model are as follows. The probability of taking-off and landing to Base-1, the probability of taking-off from Base-1 and landing to the other bases and vice-versa, the number of A/C that are landing Base-1, the probability of mission groups that have one, two, three, four, five and more A/C, the probability of take-offs that are carried out in either training or exercise periods, the probability of departure to training area in either training or exercise periods, the probability of departure to training area w/o low/high altitude profile, the probability of departure for each of the 14 training areas in either training or exercise periods.

Measures of Performance

The measures of performance for the study are the number of A/C that take-off or landing, runway usage and usage of the each training areas.

Logical Model

The logical model is depicted in Figure-1 as below. The steps in the logical model are summarized.

- The A/C performs flight and engine controls in the runway before take-off.
- The take-off base can be either Base-1 or the other bases.
- If the take-off is from the other bases, then the usage of runway in Base-1 is only observed during the landing. Following the landing, the entity leaves the system.
- If the take-off and landing are only to Base-1, then the usage of runway in Base-1 is observed during both take off and landing.
- If the take-off is from Base-1 and landing is to the other bases, then the usage of runway in Base-1 is only observed during take off.
- Take-off can be in either training or exercise periods. In either case, the departure to the training area can be w/o low/high altitude profile. During the exercise periods the operational tempo is higher than training periods.
- It is determined how long the flight will take in the case of not using training area. After the completion of the flight, the A/C will land Base-1, occupy the runway resource, and the entity will be disposed.
- If the departure plan does not require low/high profile, then the how long the flight to training area take will be determined by expert opinion. The usage of training area is determined by the distribution found in input analysis. Following the recovery, the usage of Base-1 runway is recorded, and the entity will be disposed.
- If the departure plan requires low/high profile, then the runway usage is recorded, and then the deterministic duration time of profile flight, the usage of training area determined by the distribution found in input analysis, recovery, the usage of Base-1 runway are recorded, and the entity will be disposed.

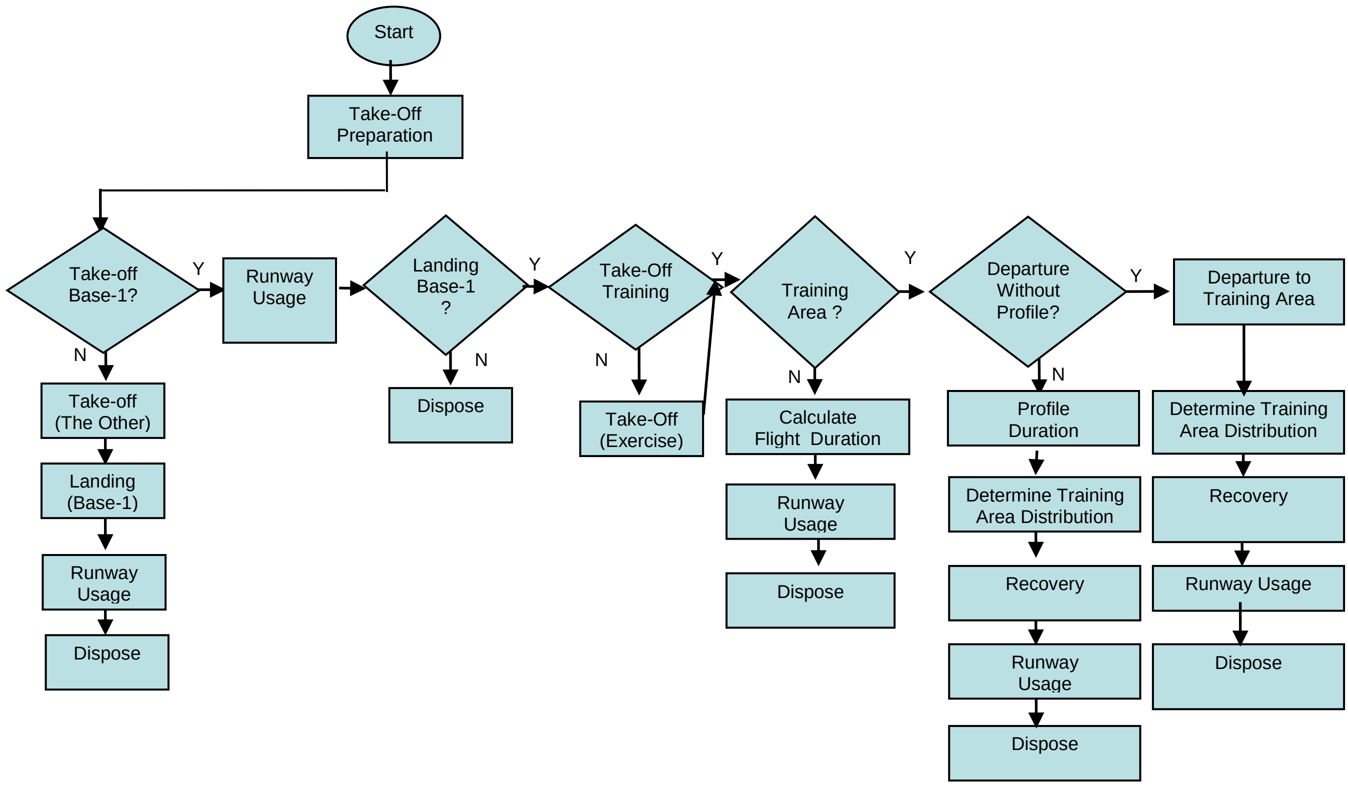

Figure 9 **Logic Model**

Simulation Model

The simulation model with several sub-modules is developed according to the steps in the flight model in ARENA 4.0. Following the take-off, for the departures that do not fly back to the Base-1 “The Other Flight Module”, for the number of A/Cs that take-off “Training Period Module” and “Exercise Period Module”, for not using the training area “Flight” module, for departure to training area without profile “No Profile Module” and for departure to training area with profile “Profile Module” are developed with respect to input data, its probabilities and distributions. These probabilities are actually the result of frequency usage of each training area and distributions are the result of duration spent in each training area. Since there are 14 training area for Base-1, we end up with a total of 28 probability and mission distributions for each training area in both training and exercise periods. “Flight Module” assumes that the duration of departure to or recovery from the training area takes 5 minutes and the rest of the flight is considered as part of mission flight. “Landing Module” is developed by using interarrival times of landing and used for determining the number of landing missions and associated with A/Cs.

VERIFICATION AND VALIDATION

Verification

Verification is the study to determine whether the simulation model is a representation of logic model or not. In other words, verification provides “modeling right” effort [5]. The flight cycle simulation model is first debugged, and then the simulation and logic model comparatively evaluated and check by expert users. As a result, the flight cycle model is verified without any error [6]. In order to control whether the output of the simulation is similar to the real input data, the comparison is made [7]. As a result of this comparison, it is concluded that the simulation model is built in a right way. The frequencies for going to the training areas can be grouped as low, moderate and high. The results of the model respond accordingly if changing the highest frequencies to the lowest or vice versa.

Validation

This stage is the expression of the notional model with the real model [8]. The validation of the assumptions made in the model was controlled by the experts in that area. White-Box validation is also been done in this study. With in the scope of this validation, the outputs of the simulation were inspected at the micro level. The values of the landings which were done to the other bases other than the departure airfield and the usage frequencies of the training areas were compared with the real values at the 95% confidence level. The outputs of the model were examined at the macro level at the Black-Box validation process. 5 replications were done and the results were handled at the 95% confidence level. The average number of the flights and the usage percentage of the runway obtained in the simulation were compared with the real data. The comparison results were presented in the Table 4.

Entity Name	Average (5 Rep.)	Average (Real)	Explanation
Following the take-off, the number of flights that land to the other bases.	$4{,}4 \pm 2{,}42$	4	White Box
The number of all take-offs	$34{,}20 \pm 8{,}5$	23,44	Black Box
Runway Usage	$0{,}21 \pm 0{,}05$	0,15	Black Box

Table 4 White/Black Validation

OUTPUT ANALYSIS

Based on the random input and random output, the replication and deletion method is used in analyzing the output. The length of one replication in simulation model is determined by analyzing the daily input data.

Determination of Replication Number

Five replications are conducted for each measures of performance in the model and the results are shown in Table-5. The required replication number is determined by taking into consideration of mean, standard deviation of output and acceptable error limit (ε)[9]. The formula used in determining the number of replication is below. 14 different training areas are considered in the simulation model, but only two of them are selected and applied output analysis techniques due to the usage frequency and importance.

$$R \geq \left(\frac{t_{\alpha/2,R-1} S_0}{\varepsilon} \right)^2$$

Variable	**Average (Sim)**	**Std. Dev. (S0)**	**Acceptable Error Limit (ε)**	**Required Replication Number (R)**
Total Number of Flights That Take-off	34,20	3,06	2 Flights	18
Total Number of A/C Take –off	66,40	6,49	4 A/C	20
Total Number of Flights that Take-off to the other Bases	4,40	0,87	1 Flight	6
Total Number of Flights that land to the Base-1	6,80	1,59	2 Flights	5
Total Number of A/C that land to the Base-1.	9,80	2,27	2 A/C	10
The probability of Flights to the other than training areas.	0,46	0,08	%5	20
The percentage of runway Usage	0,21	0,02	%1	31
The percentage of Training Area-K Usage	0,67	0,16	%10	19
The percentage of Training Area-T Usage	0,59	0,19	%10	31

Table 5 -The Calculation of Required Replication Number at the 95% Confidence Degree

Replication and Deletion Method

As seen in Table-5, since the highest required replication number is 31, the simulation is run with 31 replications. After determining the warm-up period, the effect of warm-up is deleted from the output. For each measures of performance, the 95 percent confidence interval is established and compared with the real data. The results are shown in Table-6.

Variable	Average (Sim)	Std. Dev. (S0)	Confidence Interval (95%)		Average (Real)
Total Number of Flights That Take-off	34,20	3,06	$25 \pm 2,71$	[21,97-27,39]	23,44
Total Number of A/C Take –off	66,40	6,49	$54 \pm 6,32$	[47,26-59,90]	49,64
Total Number of Flights that Take-off to the other Bases	4,40	0,87	$4 \pm 0,77$	[3,30-4,83]	4
Total Number of Flights that land to the Base-1	6,80	1,59	$10 \pm 1,23$	[8,58-11,03]	4,09
Total Number of A/C that land to the Base-1.	9,80	2,27	$14 \pm 2,13$	[11,57-15,84]	6,09
The probability of Flights to the other than training areas.	0,46	0,08	$0,43 \pm 0,08$	[0,35-0,50]	0,40
The percentage of runway Usage	0,21	0,02	$0,19 \pm 0,02$	[0,15-0,17]	0,14
The percentage of Training Area-K Usage	0,67	0,16	$0,66 \pm 0,12$	[0,53-0,57]	0,57
The percentage of Training Area-T Usage	0,59	0,19	$0,32 \pm 0,10$	[0,20-0,22]	0,20

Table 6 The Comparison Between Simulation Results and Real Data

Simulation results at the 95 % Confidence Degree and the input data are, generally within the acceptable error limits. The results of “Total Number of Flights that land to the Base-1” and “Total Number of A/C that land to the Base-1” are validated with the expert users.

RESULTS

When the simulation results and real results are compared, the simulation results are very close to the real applications, and the assumptions made in the model about take-off and landing durations are considered as true. Considering the number of flights and A/C associated with each flight, the runway usage is found low as expected. On the other hand, the usage of Training area-K is high, when considering the allocating more A/C to the Base-1, the usage of the training area-K will go higher and may effect the allocation decision. The usage of the training area-T, which is the second highest usage probability, does not have a preliminarily effect on the allocation of more new A/C to the Base-1.

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NETWORK DESIGN OF GREEN SUPPLY CHAINS UNDER ENVIRONMENTAL IMPACTS

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Abstract *— The rapidly growing industrial activities in emerging economies have been causing resource infertility and environmental problems. Also growing industrial and globalization lead to increase transportation activities. This reality requires supply chain networks to adopt an integrated management approach to resolve the conflict between production/distribution and environmental protection, and sustain the concept of this purpose. In this paper, we try to provide this purpose via embedding the environmental concerns to supply chain networks. The greenhouse gas emissions (CO_2, methane, etc.), air pollution, depletion of resources which begin with the industrial revolution are some of that results. An optimization model is developed to achieve this phase and also to balance the trade-off between cost and green influence. The objective of this paper is providing the optimum product flow within the green supply chain. A numerical experiment is conducted to show effective usage of the proposed model by decision makers.*

Keywords —Environmental impacts, green supply chain, network design, green gas emissions, optimization.

INTRODUCTION

A supply chain refers to all those activities associated with the transformation and flow of goods and services, including the flow of information, from the sources of materials to end users [1]. A typical supply chain consists of a number of production facilities to serve a number of market regions, and the production activities within the chain might be supplemented by a number of external suppliers. Also included in the supply chain are the transportation of goods from source to intermediate locations and ultimately to the end users. The traditional supply chain design problem comprises decisions as to the number and location of production facilities, the amount of capacity available at each facility, the assignment of each market region to one or more production facility, and selection of suppliers for sub-assemblies, components and materials [2].

Given the recent concerns on the harmful consequences of supply chain activities on the environment, enterprises now have started to take into account environmental factors in planning and managing the supply chain. The green supply chain (GrSC) design extends this definition by taking into account, within the design process, the following factors: (i) waste resulting from any processes within the chain, (ii) energy efficiency, (iii) greenhouse gas emissions, and (iv) legal environmental requirements. Among the listed factors, greenhouse gas emissions are by far the most prominent and the main source of these emissions within a supply chain are the transportation activities that take place between various components in the chain.

A supply chain network also includes of distribution operations and the associated transportation activities emit greenhouse gases. In our study, we consider greenhouse gas emissions and recyclable products factor in designing the GrSC. Supply chain activities are significant sources of greenhouse gas emissions and air pollution, also creating harmful effects on living health and leading to global warming [3]. International organizations or governments would encourage the decision makers to take measures to increase the aforementioned damages via limiting their environmental impacts. In an era with more environmental conscience on a global level (Kyoto, Social Responsibilities, Local Governments etc.), the enterprises and service providers could no longer reject indefinitely on the community of environmental costs and will be, in all probability, subjected to heavy environmental tax in the coming years [4]. It is clear that the first job has to adjust the transportation gas emissions to change the extant network to green one. Choosing new models, diesel motors, intermodal transportation [4], alternative energy resources etc. would be solutions for harmful gas emissions. To further develop supply chains for recyclable and recycled materials, it will be necessary to improve recycling technologies, to allow recyclable materials to be reprocessed into recycled materials of sufficient quality that they can compete with virgin materials.

In this study, we consider an optimized design of a closed-loop GrSC network design problem in which CO_2 emissions of logistics activities and return of recyclable products are explicitly considered. A penalty cost is used to reduce CO_2 gas emissions and encouraged the customers to use recyclable products through a profit incentive. Trucks' rental fees and purchasing costs of recyclable products can influence the environmental indicators in the model because of an existing a trade-off. The optimization also considers transportation costs and capacity allocation constraints. The rest of the paper is organized as follows. The next section presents a review of the literature on GrSC and CLSC. Then, we describe a mathematical model for the design problem. Results of computational experiments using a sample instance are given in the application section. Conclusions are given in last section.

LITERATURE REVIEW

This section presents an overview of the existing literature on GrSCs and CLSCs.

The Green Supply Chain

There is a large of amount of literature on supply chain network design concerned with environmental issues through the GrSC networks. Graedel and Allenby [5] defined Industrial Ecology is a systems view in which one seeks to optimize the total materials cycle from virgin material, to finished material, to component, to product, to obsolete product, and to ultimate disposal. A GrSC aims at confining the wastes within the industrial system in order to conserve energy and prevent the dissipation of dangerous materials into the environment [6]. Forkenbrock [7] estimates external costs for four representative types of freight trains. For each type of freight train, he estimated three general types of external costs and compares them with the private costs experienced by railroad companies. The general types of external costs include: accidents (fatalities, injuries, and property damage); emissions (air pollution and greenhouse gases); and noise. Sarkis [8] aimed to focus on the components and elements of GrSN management and how they serve as a foundation for the decision framework. For this, he explored the applicability of a dynamic non-linear decision model, defined as the ANP, for decision making within the GrSC. The decision support models for design of global supply chains, and assess the fit between the research literature in this area and the practical issues are handled in Meixell and Gargeya's [2] study. Sheu et al. [9] presented an optimization-based model to deal with integrated logistics operational problems of GrSC management. In the proposed methodology, a linear multi-objective programming model is formulated that systematically optimizes the operations of both integrated logistics and corresponding used-product reverse logistics in a given GrSC. Ferretti et al. [10] originated from an industrial case study in the field of the aluminum supply chain. The supply of molten metal represents a substantial benefit for the whole supply chain, because of the energy savings implicit in the method itself. Beamon [11] described the challenges and opportunities facing the supply chain of the future and described sustainability and effects on supply chain design, management and integration. Traditional and GrSCs are compared and contrasted via focusing several important opportunities in GrSC management in depth, including those in manufacturing, bio-waste, construction, and packaging.

The Closed-Supply Chain

The general CLSC network chain members can be classified into two groups [12]:

(1) Forward logistics chain members, including raw material suppliers, manufacturers, retailers and demand markets; (2) Reverse logistics chain members, including demand markets, recovery centers and manufacturers. Manufacturers and demand markets could be recognized as the nodes to combine the forward supply chain network and the reverse supply chain network together to form the CLSC network.

Fleischmann et al. [13] considered logistics network design in a reverse logistics context. Moreover, they used their model to analyze the impact of product return flows on logistics networks and then they showed that the influence of product recovery is very much context dependent. Guide et al. [14] took a contingency approach to build on the similarities and illustrate and integrate the differences in CLSCs, a product–process matrix is used as a foundation to examine the three cases representing Remanufacture-to-Stock (RMTS), Reassemble-to-Order (RATO), and Remanufacture-to-Order (RMTO). To fill the void in such a line of research, Min et al. [15] proposed a mixed-integer, nonlinear programming model and a genetic algorithm that can solve the reverse logistics problem involving both spatial and temporal consolidation of returned products. Kannan et al. [16] developed a multi echelon, multi period, multi product CLSC network model for product returns and the decisions are made regarding material procurement, production, distribution, recycling and disposal. Yang et al. [17] developed a model of a general CLSC network, which includes raw material suppliers, manufacturers, retailers, consumers and recovery centers. The objective of the paper is to formulate and optimize the equilibrium state of the network by using the theory of variation inequalities.

PROBLEM DEFINITION AND MODELING

In this paper, we consider a closed-loop supply chain design problem in which the chain members are broadly classified into two groups: (i) forward supply chain entities; (ii) the reverse supply chain. The former is used to produce and deliver products to end-users whereas the latter is used for recycling or waste-disposal of the same products. The network is structured as a typical 5-layer forward supply chain, namely (i) raw material supply, (ii) plants, (iii) warehouses, (iv) distribution centers and (v) customers (end-users). Let S denote the index set of suppliers, Q denote the index set of plants, V denote the index of warehouse, K denote the index set of distribution centers (DCs), L denote the index set of customers. Similarly, a 5-layer structure is considered for the used-product reverse supply chain, including (i) collecting centers, (ii) repairing centers, (iii) dismantlers, (iv) decomposition centers and (v) final disposal locations of waste material. Let M denote the index set of collection centers, U denote the index set of repairing center, P denote the index set of dismantlers, O denote the index set of disposal and D denote the index set of decomposition centers. Consider a supply chain network which consists of forward part G= (N, A), where N is the set of forward nodes and A is the set of forward arcs, and a reverse part G'= (N', A'), where N' is the set of reverse nodes and A' is the set of reverse arcs. Here, $N= S\cup Q\cup V\cup K\cup L$, $N' = M\cup U\cup P\cup O\cup D$.

An example configuration of the supply chain design problem considered in this paper is depicted in Figure 1.

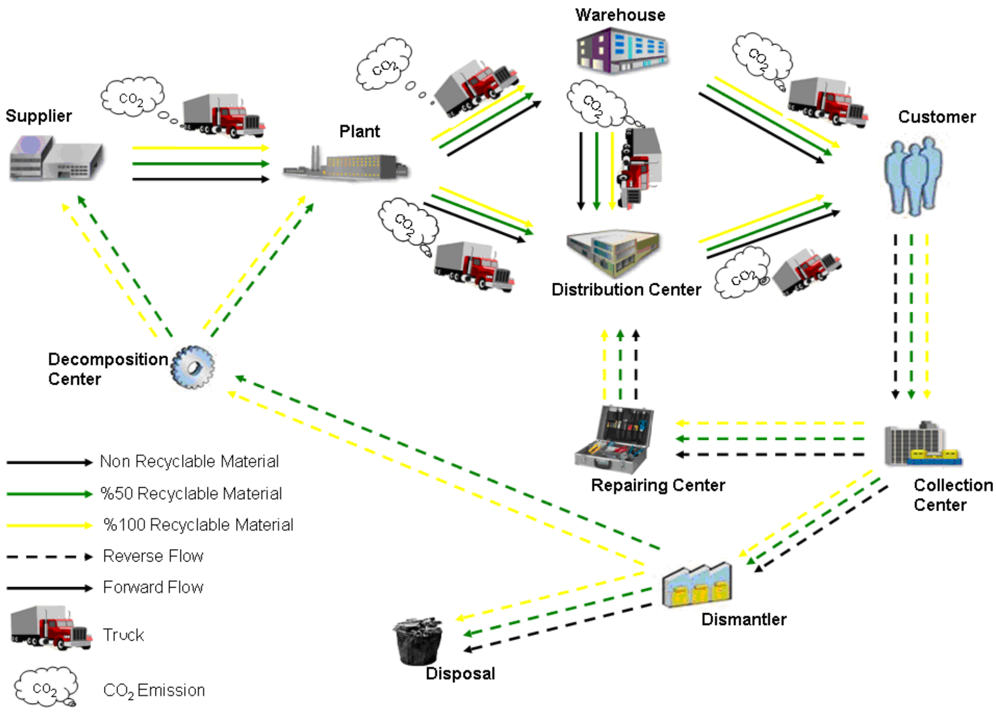

FIGURE 1
The Proposed Design CLSC Network across the GrSC

The network includes a number of suppliers that provide a number of different types of raw materials to plants in which they are transformed into the same number of different products. We denote by R the index set of raw/end products. Each product has its own recycling rate, specifying the amount by which the product can be recycled into a new one. For instance, a rate of 100% indicates that the used product can be fully recovered or transformed into a new one, whereas a rate of 50% denotes that the product can only partially be recovered.

Further assumptions on the problem are stated below:

- The demand of each customer for a product is deterministic and must be fully satisfied (i.e., no shortages are allowed). The demands and the transported materials are divisible amounts which is applicable in case of supply chains of gas or liquid products.
- The flow is only allowed to be transferred between two sequential echelons (except from a warehouse to a customer).
- The capacities plants, warehouses and centers (e.g., distribution) are limited and are known in advance.
- Transportation, purchasing, penalty and opportunity costs are deterministic and known a priori.
- The CO_2 emission rates for all transportation activities can be estimated (e.g., per gram per ton-mile as in [7].

The first three are standard assumptions for supply chain design also considered in other studies [9, 18, and 19]. One of the most important issues in designing closed-loop supply chains is reverse rates. Wang and Hsu [19] pointed out that in the recovery systems; a common assumption is that the amounts of the returned products. The recovery amount is assumed to be a percentage of the customer demand in the model. We denote by De_r^i the demand for product $r \in R$ by customer $i \in L$.

The overall closed-loop supply chain is composed of two main structures, the forward chain and the reverse chain. In the forward chain, the transportation operations from one layer to another are realized by a number of options. These options may consist of different modes of transport (e.g., rail, road, shipping, air) hence yielding a multimodal (but not necessarily an intermodal) transportation network, or a number of alternatives within a single mode of transport such as road transport in which different models of trucks are available (e.g., 0–3, 4–7, 8–11 years old). We denote by T denote the index set of available transportation options. Each transportation option $t \in T$ between two levels i and j of the forward-chain incurs a certain operation cost denoted by H_t^{ij}. For instance, H_t^{ij} where $i \in S$ and $j \in Q$ denotes the unit transportation cost from supplier i to plant j. Each transportation option also has an estimated amount of CO_2 emissions and this is denoted by CO_2^{ijt} where $i \in S$ and $j \in Q$ correspond to the indices of two different layers of the forward chain. We acknowledge that the calculation of amount of greenhouse gas, in particular CO_2, emitted by a certain mode of transport is complex and is typically a nonlinear function of a number of factors, including load, speed and coefficient of drag (see, e.g., Bektaş and Laporte [20] for estimation of emissions in the context of routing vehicles, and Fagerholt et al. [21], for calculating emissions in the context of shipping). To take into account such calculations within a strategic/tactical level network design problem such as the one we consider in our study would be impractical, hence it is more reasonable to use widely available estimates of emissions (such as ton per kilometer) at this level of planning. Once the network is designed, one can then use the aforementioned approaches to plan the detailed operational level activities using better estimations for the gas emissions.

Contrary to forward operations, the reverse component of the closed-loop supply chain is for either (i) repairing/refurbishing, (ii) recycling or (ii) disposal of a used product. For any of these operations to take place, used products need to be collected, through various means, from end-users and transported to collection centers. If a product is of such a nature that the can be either repaired or refurbished for a new sell, then it is transported to DCs from where it is once again delivered to end-users. To this end, we define the parameter α_{rmin} (α_{rmax}, respectively) which denotes the expected minimum (maximum, respectively) collection rate from customers to collection centers for product of type $r \in R$. Since there are bound to be losses in the reverse logistics network due to recycling operations or the conditions of the used products, we allow for such losses in our problem definition through the use of recovery rates. At each collection center, a used product is either deemed to be recoverable through repairing or refurbishing, or to be dismantled. In the former case, β_r specifies the repair/recycle rate of product of type $r \in R$ in each collection center and is delivered to repairing centers, and χ_r defines the rate at which a product of type $r \in R$ is repaired at each repairing center and transported to DCs. In the case of the latter, some components of the dismantled product cannot be reused and have to be disposed of. The parameter δ_r indicates, for each product of type $r \in R$, the expected fraction of the product that is to be disposed of. As for the reusable parts of a product of type $r \in R$, some are sent directly to suppliers and the corresponding rate for this operation is defined as ε_r, whereas the rest are sent to production plants.

The objective of the problem considered in this paper is the minimization the total cost which is composed of transportation, purchasing, and penalty costs associated with emissions and recyclable product while maximizing the amount of product which is recycled. Considering the potential effects oriented from corresponding governmental regulations, the environmental protection administration and social responsibilities, the greenhouse gas emissions is tried to minimize owing to a penalty cost and encourage the customers to use recyclable products owing to a opportunity price.

We now present a mathematical model of the problem described above.

Transportation costs;

H_t^{ij} is the rental fee of truck $t \in T$ during the transportation from node $i \in A$ to node $j \in A$;

C_r^{ij} is the unit transportation cost of product $r \in R$ from node $i \in A'$ to node $j \in A'$.

Greenhouse gas emission parameter;

CO_2^{ijt} is CO_2 emission rates of truck of model $t \in T$ during the transportation from node $i \in A$ to node $j \in A$.

Incentive parameter for recycling;

P_r^j is the opportunity profit of facility $j \in A$ because of choosing raw/end material $r \in R$.

Capacity parameter;

Ca_r^i is the capacity of raw/end material $r \in R$ at facility $i \in A$ and A'.

Truck capacity parameter;

B_t^i is the transportation capacity of truck $t \in T$ departs from facility $i \in A$;

The other parameters;

Pu_r^i is the unit purchasing cost of raw material $r \in R$ from supplier $i \in S$;

P_{CO_2} is the penalty cost for extra CO_2 emission.

Forward and Reverse logistic variables;

X_{rt}^{ij} is the amount of transported raw/end material $r \in R$ via truck of type $t \in T$ from node $i \in A$ to node $j \in A$;

Y_r^{ij} is the amount of transported product $r \in R$ from node $i \in A'$ to node $j \in A'$;

A_i^r is the total amount of raw material $r \in R$ purchased from supplier $i \in S$.

Mathematical formulation of the problem

Given the aforementioned assumptions and definitions, now it is turn to describe the mathematical model. The objective function, OBJF, is composed of the sum of four parts, OBJF1, OBJF2, OBJF3 and OBJF4. The individual components of the total cost function are presented below.

OBJF 1

$$\text{Minimize} \sum_{i\in A}\sum_{j\in A}\sum_{r\in R}\sum_{t\in T} X_{rt}^{ij} \cdot \sum_{i\in A}\sum_{j\in A}\sum_{t\in T} H_t^{ij} \tag{1}$$

OBJF1 minimizes the total cost of the transportation operations which are realized using different trucks in the forward logistics network.

OBJF 2

$$\text{Minimize} \sum_{i\in A'}\sum_{j\in A'}\sum_{r\in R} Y_r^{ij} \cdot \sum_{i\in A'}\sum_{j\in A'}\sum_{r\in R} C_r^{ij} \tag{2}$$

OBJF2 minimizes the total cost of transportation operations carried out in the reverse logistics network.

OBJF 3

$$\text{Minimize } P^{CO_2} \cdot \Big(\sum_{i\in A}\sum_{j\in A}\sum_{r\in R}\sum_{t\in T} X_{rt}^{ij} \cdot \sum_{i\in A}\sum_{j\in A}\sum_{t\in T} CO_2^{ijt}\Big) \tag{3}$$

OBJF3 represents the environmental concerns taken into account within the model, namely the minimization of CO_2 emissions resulting from the use of trucks within the forward logistics network.

OBJF 4

$$\text{Minimize} \sum_{i\in S}\sum_{r\in R} A_r^i \cdot Pu_r^i - P_r^j \cdot \Big(\sum_{i\in U}\sum_{j\in K}\sum_{r\in R} Y_r^{ij} - \sum_{i\in U}\sum_{j\in V}\sum_{r\in R} Y_r^{ij} - \sum_{i\in D}\sum_{j\in S}\sum_{r\in R} Y_r^{ij} - \sum_{i\in D}\sum_{j\in Q}\sum_{r\in R} Y_r^{ij}\Big) \tag{4}$$

Finally, OBJF4 is used to encourage the customers to choose and use recyclable products and this is done by minimizing the purchasing costs $(A_r^i \cdot Pu_r^i)$ minus the total opportunity profits which is gained via using recyclable products. As an example to how OBJF4 works, assume two different products one of which is cheap but not recyclable, and the other is recyclable but more expensive. If the second product is chosen, we will not to purchase it again due to its recyclability and also the environmental responsibility will be accomplished. We determine the price difference, which is caused by the re-purchasing cost minus recyclable cost, as an opportunity profit.

Facility capacity constraints in forward logistic

$$\sum_{j\in Q}\sum_{t\in T} X^{ij}_{rt} \le Ca^{i}_{r} \qquad \forall\ i \in S, r \in R \tag{5}$$

$$\sum_{j\in V}\sum_{t\in T} X^{ij}_{rt} + \sum_{j\in K}\sum_{t\in T} X^{ij}_{rt} \le Ca^{i}_{r} \qquad \forall\ i \in Q, r \in R \tag{6}$$

$$\sum_{j\in K}\sum_{t\in T} X^{ij}_{rt} + \sum_{j\in L}\sum_{t\in T} X^{ij}_{rt} \le Ca^{i}_{r} \qquad \forall\ i \in V, r \in R \tag{7}$$

$$\sum_{j\in L}\sum_{t\in T} X^{ij}_{rt} \le Ca^{i}_{r} \qquad \forall\ i \in K, r \in R \tag{8}$$

The constraints mainly contain two types: one is for limited capacities and the other is for the balance of the flow conversation in both of forward and reverse logistics. Equations (5), (6), (7), (8) represent the limit of the capacity and provide not to exceed these capacities for suppliers, plants, warehouse and distribution centers for each products, respectively in forward logistic.

Facility capacity constraints in reverse logistic

$$\sum_{j\in U} Y^{ij}_{r} + \sum_{j\in P} Y^{ij}_{r} \le Ca^{i}_{r} \qquad \forall\ i \in M, r \in R \tag{9}$$

$$\sum_{j\in V} Y^{ij}_{r} + \sum_{j\in K} Y^{ij}_{r} \le Ca^{i}_{r} \qquad \forall\ i \in U, r \in R \tag{10}$$

$$\sum_{j\in O} Y^{ij}_{r} + \sum_{j\in D} Y^{ij}_{r} \le Ca^{i}_{r} \qquad \forall\ i \in P, r \in R \tag{11}$$

$$\sum_{j\in S} Y^{ij}_{r} + \sum_{j\in Q} Y^{ij}_{r} \le Ca^{i}_{r} \qquad \forall\ i \in D, r \in R \tag{12}$$

Equations (9), (10), (11) and (12) guarantee that collection centers, repairing center, dismantlers and decomposition centers could not exceed the given capacity limit for each products, respectively in reverse logistic.

The trucks capacity constraints in forward logistic

$$\sum_{i\in S}\sum_{j\in Q}\sum_{r\in R} X^{ij}_{rt} \le B^{i}_{t} \qquad \forall\ t \in T \tag{13}$$

$$\sum_{i\in Q}\sum_{j\in V}\sum_{r\in R} X^{ij}_{rt} + \sum_{i\in Q}\sum_{j\in K}\sum_{r\in R} X^{ij}_{rt} \le B^{i}_{t} \qquad \forall\ t \in T \tag{14}$$

$$\sum_{i\in V}\sum_{j\in K}\sum_{r\in R} X^{ij}_{rt} + \sum_{i\in V}\sum_{j\in L}\sum_{r\in R} X^{ij}_{rt} \le B^{i}_{t} \qquad \forall\ t \in T \tag{15}$$

$$\sum_{i\in K}\sum_{j\in L}\sum_{r\in R} X^{ij}_{rt} \le B^{i}_{t} \qquad \forall\ t \in T \tag{16}$$

Equations (13), (14), (15) and (16) show that the trucks could not move more than their capacity limits during departing from suppliers, plants, warehouse and DCs, respectively in forward logistic.

$$\sum_{j\in Q}\sum_{t\in T} X^{ij}_{rt} = A^{i}_{r} \qquad \forall\ i \in S, r \in R \tag{17}$$

Equation (17) shows that the total amount of product $r \in R$ which is transported from supplier $i \in S$ to plants by truck $t \in T$ is equal the total amount of product $r \in R$ which is purchased from supplier $i \in S$.

The equilibrium constraints in forward logistic

$$\sum_{i\in S}\sum_{t\in T} X_{rt}^{ij} = \sum_{i\in V}\sum_{t\in T} X_{rt}^{ji} + \sum_{i\in K}\sum_{t\in T} X_{rt}^{ji} \qquad \forall\, j \in Q, r \in R \tag{18}$$

$$\sum_{i\in Q}\sum_{t\in T} X_{rt}^{ij} = \sum_{i\in K}\sum_{t\in T} X_{rt}^{ji} + \sum_{i\in L}\sum_{t\in T} X_{rt}^{ji} \qquad \forall\, j \in V, r \in R \tag{19}$$

$$\sum_{i\in Q}\sum_{t\in T} X_{rt}^{ij} + \sum_{i\in V}\sum_{t\in T} X_{rt}^{ij} = \sum_{i\in L}\sum_{t\in T} X_{rt}^{ji} \qquad \forall\, j \in K, r \in R \tag{20}$$

$$\sum_{i\in V}\sum_{t\in T} X_{rt}^{ij} + \sum_{i\in K}\sum_{t\in T} X_{rt}^{ij} \geq De_r^i \qquad \forall\, j \in L, r \in R \tag{21}$$

Equations (18), (19) and (20) satisfy the law of the flow of each products conversation by in-flow equal to out-flow for plants, warehouse and DCs, respectively, in forward logistic. Equation (21) is to satisfy the customer demand for each product.

The equilibrium constraints in reverse logistic

$$\alpha_{r\min}\Big(\sum_{i\in V}\sum_{t\in T} X_{rt}^{ij} + \sum_{i\in K}\sum_{t\in T} X_{rt}^{ij}\Big) \leq \sum_{j\in M} Y_r^{ij} \leq \alpha_{r\max}\Big(\sum_{i\in V}\sum_{t\in T} X_{rt}^{ij} + \sum_{i\in K}\sum_{t\in T} X_{rt}^{ij}\Big) \qquad \forall\, i \in M, r \in R \tag{22}$$

$$\beta_r\Big(\sum_{i\in L} Y_r^{ij}\Big) = \sum_{i\in U} Y_r^{ji} \qquad \forall\, i \in M, r \in R \tag{23}$$

$$(1-\beta_r)\Big(\sum_{i\in L} Y_r^{ij}\Big) = \sum_{i\in P} Y_r^{ji} \qquad \forall\, i \in M, r \in R \tag{24}$$

$$\chi_r\Big(\sum_{i\in M} Y_r^{ij}\Big) = \sum_{i\in K} Y_r^{ji} \qquad \forall\, i \in U, r \in R \tag{25}$$

$$(1-\chi_r)\Big(\sum_{i\in M} Y_r^{ij}\Big) = \sum_{i\in V} Y_r^{ji} \qquad \forall\, i \in U, r \in R \tag{26}$$

$$\delta_r\Big(\sum_{i\in M} Y_r^{ij}\Big) = \sum_{i\in O} Y_r^{ji} \qquad \forall\, i \in P, r \in R \tag{27}$$

$$(1-\delta_r)\Big(\sum_{i\in M} Y_r^{ij}\Big) = \sum_{i\in D} Y_r^{ji} \qquad \forall\, i \in P, r \in R \tag{28}$$

$$\varepsilon_r\Big(\sum_{i\in P} Y_r^{ij}\Big) = \sum_{i\in S} Y_r^{ji} \qquad \forall\, i \in D, r \in R \tag{29}$$

$$(1-\varepsilon_r)\Big(\sum_{i\in P} Y_r^{ij}\Big) = \sum_{i\in Q} Y_r^{ji} \qquad \forall\, i \in D, r \in R \tag{30}$$

Equation (22) describes the customer recovery relationship between the minimum and maximum recovery rate. Equations (23) and (24) provide the recycled product equilibrium from collection centers to repairing center and dismantlers, respectively. Equations (25) and (26) show the repaired product equilibrium from repairing center to DCs and warehouse, respectively. Equations (27) and (28) guarantee the recycled product equilibrium from dismantlers to disposal and decomposition centers, respectively. Equations (29) and (30) guarantee the recyclable product equilibrium from decomposition centers to suppliers and plants, respectively.

$$X_{rt}^{ij}, Y_r^{ij}, A_r^i \geq 0 \qquad \forall\, i, j \in A \text{ and } A', t \in T, r \in R \tag{31}$$

Finally, (31) imposes non-negativity restrictions.

COMPUTATIONAL EXPERIMENTS

General Information and Data

In this section, in order to evaluate the proposed model, we have generated a sample supply chain network based on a hypothetical data. We shall use a small example to illustrate the properties of the problem and to derive insights. Our interest is not in computational properties of the model or the complexities of solving the problem, but rather the shed light on the effect of the changes in various parameters of the problem on the performance measures, namely the four cost functions, and present managerial insights.

In the numerical example, we design a CLSC network which considers the environmental impacts. Consider the network in Figure 2. The network of the example contains two mainly part. The first part is forward logistic and consists of three suppliers, three plants, one warehouse, two DCs and five customers. Suppliers provide three kinds of raw materials which are 100% recyclable, 50% recyclable, non-recyclable raw materials, respectively. It is known that 100% recyclable products have to contain re-useable materials. But producing and using recyclable raw materials are expensive than the normal products because of standing the high technological processes and the 100% natural raw materials. So the decision maker faces a trade-off purchasing costs versus the recyclable rate. To present recyclable products to customers and consider greenness, the decision maker has to choose re-usable raw materials. Besides this environmental factor, we consider the greenhouse gas emissions in forward logistic. We assume that an outsourcing is used for only transportation. The 3PL firm presents three kinds of trucks for transporting which are 0-3 years, 4-7 years and 8-11 years old, respectively. Inherently, as aging the trucks, their rental fees will be cheaper. So, choosing always the oldest trucks are the best option but to consider greenness of the model, we pay the attention CO_2 emission of trucks. It is clear that as aging the trucks, their CO_2 emissions are also increased because of the engine differences. The data used for the example problem are given in Appendix.

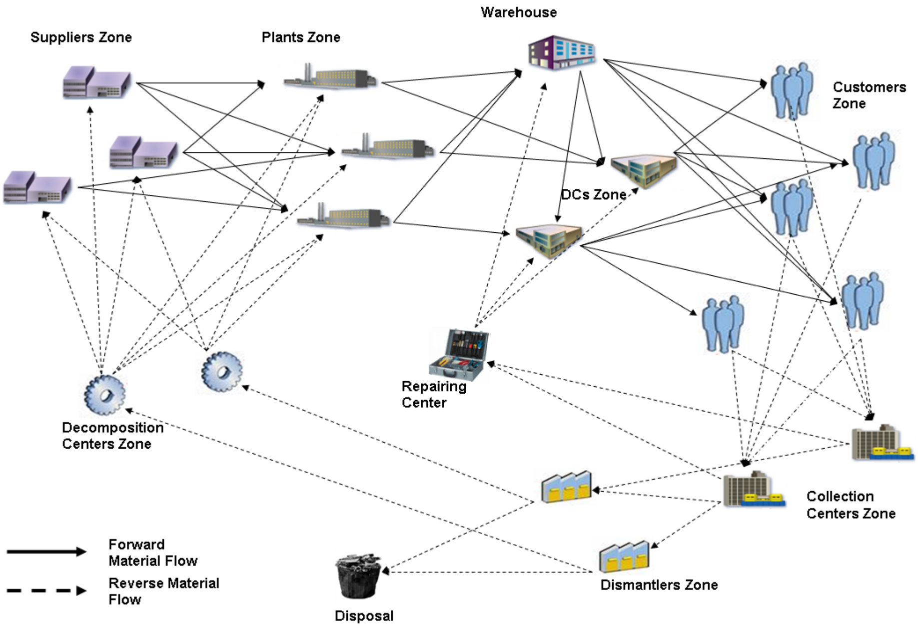

FIGURE 2
The Network of the Illustrative Example

The plants purchase raw materials in three kinds mentioned above from the suppliers. The plants, warehouse and DCs triangular has a flexible structure. After the production in plants, the end-products flow can be actualize to warehouse and also DCs. The warehouse sends the end-products to customers directly, and also it can be happen by DCs. The second part is reversing logistic and it contains two collection centers, two dismantlers, one repairing center, one disposal and two decomposition centers. The collection centers are responsible for collecting the used-products from customers.

Results for the Basic Configuration

In this example, with $|S|=3$, $|Q|=5$, $|V|=1$, $|K|=2$, $|L|=5$, $|M|=2$, $|U|=1$, $|P|=2$, $|O|=1$, $|D|=2$, $|T|=3$ and $|R|=3$, there are 445 variables and 602 constraints in the linear programming formulation. Using LINDO 6.1, we obtained an optimal solution for the basic configuration, the total costs for which are shown in Table 12. All the experiments are conducted on a notebook with the Intel Core2 Duo 1.66 GHz and 2 GB RAM and the required computation times are no more than one CPU second. The optimal solution for this basic configuration is given in the Appendix.

TABLE 12

Calculated Objective Function Values

OBJF	Definition	Value (% of the Total Cost)
OBJF1	Total transportation cost in the forward network	**53.9**
OBJF2	Total transportation cost in the reverse network	**12.56**
OBJF3	The total CO_2 penalty cost	**0.7**
OBJF4	Total purchasing costs	**32.84**

According to the results obtained by LINDO 6.1 package program, the total cost is 841251.00 $ (Table 12). Total transportation cost in forward logistic is calculated 53, 9 % of the total cost. This money is expended for transporting 90000 units product which are consist of 28000 unit %100 recyclable, 32500 unit %50 recyclable, and 29500 unit non-recyclable. All trucks emissions totally 317800 gr CO_2 gas during the all transportation in forward logistic. We determined a lower limit (2000 kg CO_2) for emissions, and a penalty cost for each a gr CO_2 after this lower limit. So, the decision maker paid 5890 $ (0, 7 % of the total cost) as the penalty cost. To answer all customers demand, totally 90000 units of raw material is purchased from three suppliers via paying 333600.00 $ (39, 6 % of the total cost). 27000 units of re-used products are collected from customers and sent to the collection centers. Because of preferring the recyclable raw materials, the decision maker gained 57382.80 $ (6, 76 % of the total cost) via saving the re-purchasing costs.

Scenario Analysis for Managerial Insights

When the results are examined, it is seen that some capacity restrictions for all facilities or reverse rate parameters affect the model directly. By extracting some parts of the objective functions or by changing the capacity limitations of facilities and reverse parameters, different scenarios can be applied to the model to examine the relations and trade-offs among model variables. Therefore, the solution of the model without any scenario and the results of the developed scenarios are compared in this section. By analyzing different scenarios of the model, we try to give a decision map to management of the supply chain. The scenarios are listed below:

Scenario 1: Increasing five times the capacities of suppliers, plants, warehouse, and DCs while the other parameters are constant.

Scenario 2: Increasing five times the recycling parameters of collection centers, repairing center, dismantlers, and decomposition centers while the other parameters are constant.

Scenario 3: Applying the scenario 1 and scenario 2 at the same time while the other parameters are constant.

At scenario 1, we want to see the effects on each objective when the forward facility capacities are increased with different percentage five times (Table 13).

TABLE 13

Increasing the Capacities at Scenario 1

Scenario 1	Suppliers Capacity	Plants Capacity	Warehouse Capacity	DCs Capacity
1	+ 3 %	+ 4 %	+ 5 %	+ 2 %
2	+ 6 %	+ 8 %	+ 9 %	+ 6 %
3	+ 9 %	+ 12 %	+ 13 %	+ 10 %
4	+ 12 %	+ 16 %	+ 17 %	+ 14 %
5	+ 15 %	+ 20 %	+ 21 %	+ 18 %

Due to insufficient capacity of recycling facilities, we have to stop at fifth repeat in all scenarios. Table 14 shows the changes on each objective functions value according to the Scenario 1.

TABLE 14

The Percentages of each Objective in the Total Cost according to Scenario 1

	Scenario 1				
Objectives	**1**	**2**	**3**	**4**	**5**
OBJF1	54.12	53.68	53.59	53.54	53.63
OBJF2	12.71	12.65	12.7	12.73	12.73
OBJF3	0.73	0.73	0.74	0.74	0.74
OBJF4	32.44	32.94	32.97	32.98	32.9
Total Purchasing Costs	40	39.82	39.87	39.9	39.82
Total Profit	7.56	6.88	6.9	6.92	6.92

Scenario 1 shows that increasing the capacity limits of forward facilities do not directly affect the sub-objectives. The main reason of this situation is that because of no changes about the demand, all sub-objectives costs are stabled including the total cost (Table 14). This scenario shows that if the decision maker wishes to decrease OBJF1, OBJF2, OBJF3, and OBJF4 costs, he/she does not have to try to increase forward facility capacities. Figure 5 shows the effects of Scenario 1 on sub and main objectives.

At scenario 2, we try to see the affects on each objective when the recycling rates are increased with different percentage five times (Table 15).

TABLE 15

Increasing the Recycling Parameters at Scenario 2

Scenario 2	$\alpha_{min/max}$	β_r	χ_r	ε_r
1	10-40 %	10 %	25 %	50 %
2	15-45 %	20 %	30 %	55 %
3	20-50 %	30 %	35 %	60 %
4	25-55 %	40 %	40 %	65 %
5	30-60 %	50 %	45 %	70 %

Table 16 shows the changes on each objective functions value according to the Scenario 2.

TABLE 16

The Percentages of each Objective in the Total Cost according to Scenario 2

	Scenario 2				
Objectives	**1**	**2**	**3**	**4**	**5**
OBJF1	55.73	55.18	54.73	54.36	54.10
OBJF2	4.49	6.59	8.61	10.57	12.46
OBJF3	0.73	0.72	0.72	0.71	0.71
OBJF4	39.05	37.51	35.94	34.36	32.73
Total Purchasing Costs	41.06	40.66	40.33	40.06	39.87
Total Profit	2.01	3.15	4.39	5.7	7.14

Scenario 2 shows that increasing the recycling parameters also increased the total profit which is gained returned products and reverse transportation costs. This increasing reflects the OBJF2 directly. As seen from the Table 16, total reverse transportation costs started from 4, 49 % and finished 12, 46 % of the total cost. This analysis shows that the recycling parameters do not directly affect the forward transportation costs (OBJF1). The changes on recycling parameters do not have any influence on CO_2 emissions amount (about 0, 71 %). According to Scenario 2, OBJF4 (total purchasing costs minus total profit) is linearly decreased from 317196.50 \$ to 273789.00 \$. While the purchasing costs are constant, increasing the gained profit also decreased OBJF4 costs.

TABLE 17

Increasing the Parameters at Scenario 3

Scenario	Suppliers Capacity	Plants Capacity	Warehouse Capacity	DCs Capacity	$\alpha_{min/max}$	β_r	χ_r	ε_r
1	+ 3 %	+ 4 %	+ 5 %	+ 2 %	10-40 %	10 %	25 %	50 %
2	+ 6 %	+ 8 %	+ 9 %	+ 6 %	15-45 %	20 %	30 %	55 %
3	+ 9 %	+ 12 %	+ 13 %	+ 10 %	20-50 %	30 %	35 %	60 %
4	+ 12 %	+ 16 %	+ 17 %	+ 14 %	25-55 %	40 %	40 %	65 %
5	+ 15 %	+ 20 %	+ 21 %	+ 18 %	30-60 %	50 %	45 %	70 %

As seen in Table 17, we increased the capacities of suppliers, plants, warehouse, and DCs with a certain percentage rates for five times. By the way, to see the effects of recycling part on the objectives, we defined different percentage parameters for collecting, repairing, dismantling, and decomposition. Table 18 shows the changes on each objective functions value according to the five scenarios.

TABLE 18

The Percentages of each Objective in the Total Cost according to Scenario 3

	Scenario 3				
Objectives	**1**	**2**	**3**	**4**	**5**
OBJF1	55.6	55	54.5	54	53.8
OBJF2	4.5	6.6	8.7	10.7	12.62
OBJF3	0.72	0.73	0.75	0.75	0.74
OBJF4	39.2	37.6	36	34.55	32.84
Total Purchasing Costs	41.2	40.8	40.5	40.27	39.99
Total Profit	2	3.2	4.5	3.99	7.15

It is educed that if the decision maker wishes to decrease the total costs by increasing the capacity and recycling parameters, it is useless according to the scenarios. Thus, the profit gained by recycling balances the reverse logistics cost. In this sense, total cost function behave stable as mentioned before. These scenario analysis shows that the capacity and parameters increasing directly affect the reverse transportation and recycling rates linearly. As a remarkable point that, the scenario analysis proved that reverse transportation costs must be decreased to get more profit from recycling products.

CONCLUSION

Changes in the state of the environment, leading to subsequent public pressure and environmental legislation have necessitated a fundamental shift in supply chain practices [22]. Anymore, the supply chain does not describe only the all production stage from raw material to end-product delivery. Thus, the concept of the supply chain has to be handled in a green frame. Therefore, to consider the ‘greenness’ and the serious legislations, the traditional structure of the supply chain will be inadequate. This shortage can be solved by assembling a product recovery process as called the CLSC.

SCM emphasizes on the strategic decisions between different kinds of objectives and also the core of SC is a decision making problem. The making right decision is an important problem in SCM and is the key to successful SCM. We know that decision makers want to handle all objectives together. Naturally, all objectives’ desired priorities also could be different. A scenario is considered in this paper where the main decision maker in SCM is faced with a decision-making problem, i.e. evaluating the different cost objectives in a green frame.

In this paper, we developed and proposed a multi objective mathematical model to solve the GrSC problems which are emerged because of environmental responsibilities. The distinguishing feature of the proposed model is considering the environmental effects on supply chains. First we explained why we developed this model via mentioning the greenness impacts and a CLSC in the introduction section. The reasons why we added the CO_2 emission factor and encouraging the recyclable using are clarified. In the literature section, we reviewed the model-based literature for the green and CLSC. We examined the ongoing and emerging issues in green CLSC. At third section, the minimizing the total cost model is given with its mathematical formulation. We aimed to minimize the total cost via;

- minimizing the transportation costs in both forward and reverse logistic,
- minimizing the total CO_2 emission amount,
- minimizing the total purchasing costs,
- maximizing the total opportunity profit in the model.

At fourth section, the model is tested with an illustrated example, and the promising results have shown the applicability of the proposed model with the solution procedure. The model results were compared for different scenarios. Then sensitivity analyses are realized to measure the sensitivity of the model results for different parameter values.

For further researches, the model could be extended in a few directions. For example, the uncertainty embedded in demand, capacity and recovery rates should be handled to facilitate practical applications. Another extension is associating the reverse part of this model with plants or other facilities in other supply chains. And as a last suggestion, the model’s environmental and greenness factors can be enlarged via adding noise pollution, accident risk and time assessment factors etc.

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APPENDIX

This appendix describes the data used in this research. The added deterrent penalty cost ($P_c^{CO_2}$ = 0.05 \$/gr than more 2000 kg CO_2) in model puts the decision maker into another trade-off situation which is penalty cost versus CO_2 emissions (Tables 1, 2, 3).

TABLE 1

The Rental Costs (\$/unit) of each Truck and the CO_2 Emissions (gr/unit) during the Transportation between Suppliers-Plants-Warehouse

	Suppliers									**Plants**		
	1			**2**			**3**			**1**	**2**	**3**
	Plants									**Warehouse**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**1**	**1**
Truck 1	3	2.5	3.2	2.8	2.6	3.1	3	2.5	3.3	1.5	1.4	1.8
Truck 2	2.2	2	1.9	2.3	2.1	1.7	1.9	1.8	1.6	1.2	1.1	1
Truck 3	1.5	1.7	1.3	2	1.5	1.6	1.45	1.76	1.8	0.9	0.7	0.6
	CO_2 Emission (gr/unit)											
Truck 1	0.9	0.9	1.1	1.2	1	0.8	0.7	1.1	1.2	1	0.9	1.1
Truck 2	1.3	1.5	1.6	1.4	1.2	1.4	1.3	1.7	1.4	1.3	1.2	1.5
Truck 3	1.7	1.8	1.9	1.6	1.5	1.7	1.5	1.7	1.9	2	1.3	1.7

TABLE 2

The Rental Costs (\$/unit) of each Truck and the CO_2 Emissions (gr/unit) during the Transportation between Plants-DCs

	Plants					
	1		2		3	
	Distribution Centers					
	1	2	1	2	1	2
Truck 1	2.6	2.4	2.7	2.4	2.5	2.8
Truck 2	2.1	2	1.9	2.1	2.3	2.1
Truck 3	1.7	1.6	1.9	1.7	1.8	1.5
	CO_2 Emission (gr/unit)					
Truck 1	0.8	0.7	0.9	1	0.7	0.8
Truck 2	1.4	1.3	1.6	1.5	1.2	1.4
Truck 3	1.8	1.9	2	1.6	1.8	1.9

TABLE 3

The Rental Costs (\$/unit) of each Truck and the CO_2 Emissions (gr/unit) during the Transportation between Warehouse-DCs-Customers

								DC									
	Warehouse							1					2				
	DC		Customers					Customers									
	1	2	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Truck 1	1.7	1.6	2.4	2.3	2.2	2.1	2.1	2.1	2.2	2.4	2.4	2.1	2	2.2	2.1	2.2	2.1
Truck 2	1.4	1.4	2.2	1.8	1.6	1.9	1.7	1.9	1.6	1.9	1.7	1.9	1.8	2.1	2.1	2.2	1.9
Truck 3	1.2	1.3	1.9	1.8	1.7	1.9	1.6	2	1.7	1.8	1.7	1.9	2.1	1.7	1.6	1.6	1.8
	CO_2 Emission (gr/unit)																
Truck 1	0.7	0.7	1.1	1.2	1	0.8	0.7	1.1	1.2	1	0.9	1.1	0.8	0.9	1.1	1.2	1
Truck 2	1.1	1.2	1.6	1.4	1.2	1.4	1.3	1.7	1.4	1.3	1.2	1.5	1.4	1.5	1.3	1.6	1.7
Truck 3	1.4	1.5	1.9	1.6	1.5	1.7	1.5	1.7	1.9	2	1.3	1.7	1.7	1.8	1.9	1.8	1.9

The capacity limits of suppliers, plants, warehouse, DCs and trucks are given in Tables 4 and 5.

TABLE 4

The Material Capacities of Suppliers-Plants-Warehouse-Distribution Centers (unit)

	Suppliers			Plants			Warehouse	Distribution Center	
Material	1	2	3	1	2	3	1	1	2
%100 Recyc.	10000	9000	11000	9500	11500	12500	22000	12000	11000
%50 Recyc.	11000	10000	12000	10500	11500	11500	19000	10000	9000
Non Recyc.	12000	11000	13000	11500	10500	12500	18000	11000	11000

TABLE 5

The Transportation Capacities of each Truck between Suppliers-Plants-Warehouse-DCs (unit)

Trucks	Suppliers	Plants	Warehouse	Distribution Centers
Truck 1	32000	35000	22000	18000
Truck 2	34000	37000	21000	17000
Truck 3	31000	34000	23000	19000

- Minimum and maximum collection rates of collection centers are assumed to be $\alpha_{r\min}$ = %30 and $\alpha_{r\max}$ =%60.
- According the decisions in collection centers, the products which need just repairing, are sent to repairing center (β_r = %40).
- After the repairing in repairing center, products could be sent to warehouse and also DCs (χ_r = %70, %30).
- The rest of the products in collection centers are transported to dismantlers (1-β_r =%60).
- After the dismantling processes, half of the secondary and total of the tertiary products are disposal ($\delta_{r:2,3}$ = %50, %100).
- Full of the primary and the rest of the secondary products are transported to decomposition centers.

According to decomposition situations, some of them are sent to suppliers (ε_r =%70) and the rest of them to plants (1- ε_r =%30).

All transportation in reverse logistic is actualized by the decision makers. Tables 6, 7 and 8 give the unit transportation costs between reverse facilities. All flow decisions in reverse logistic are calculated via considering the capacity information and customer demands in Table 9. We mentioned the encouraging factors at the beginning of paper. Using recyclable raw materials are better than re-purchasing these raw materials with a high cost. We determined an opportunity profit gained choosing recyclable raw materials and products (Table 10).

TABLE 6

The Unit Transportation Costs between Customers-Collection Centers-Dismantlers-Repairing Centers ($)

	Customers										Collection Centers					
	1		2		3		4		5		1	2	1		2	
	Collection Centers										Repairing Center		Dismantlers			
Material	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**1**	**2**	**1**	**2**
%100 Recyc.	1.2	1.3	1.2	1.4	1.2	1.3	1.2	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.3	1.2
%50 Recyc.	1.2	1.3	1.2	1.4	1.2	1.3	1.2	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.3	1.2
Non Recyc.	1.2	1.3	1.2	1.4	1.2	1.3	1.2	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.3	1.2

TABLE 7

The Unit Transportation Costs between Repairing C.-Warehouse-DCs-Dismantlers-Disposal-Decomposition Centers ($)

	Repairing Center			Dismantlers					
	1			1	2	1		2	
	Warehouse	DCs		Disposal		Decomposition Centers			
Material	**1**	**1**	**2**	**1**		**1**	**2**	**1**	**2**
%100 Recyc.	1.2	1.1	1.4	1.2	1.3	1.4	1.3	1.5	1.2
%50 Recyc.	1.2	1.1	1.4	1.2	1.3	1.4	1.3	1.5	1.2
Non Recyc.	1.2	1.1	1.4	1.2	1.3	1.4	1.3	1.5	1.2

TABLE 8

The Unit Transportation Costs between Decomposition Centers-Suppliers-Plants ($)

	Decomposition Centers											
	1			2			1			2		
	Suppliers						Plants					
Material	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
%100 Recyc.	1.1	1	0.9	1.2	1.1	0.9	1.1	1.2	1	1	1.1	1.2
%50 Recyc.	1.1	1	0.9	1.2	1.1	0.9	1.1	1.2	1	1	1.1	1.2
Non Recyc.	1.1	1	0.9	1.2	1.1	0.9	1.1	1.2	1	1	1.1	1.2

TABLE 9

The Material Capacities of Collection Centers-Repairing Center-Dismantlers-Decomposition Center (unit) and the Demands of each Customer (unit)

	Collection Centers		Repairing Center	Dismantlers		Decomposition Centers		Customers				
Material	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**4**	**5**
%100 Recyc.	6000	5400	4200	4000	4500	4600	4600	6000	4000	7000	5000	6000
%50 Recyc.	5000	5500	4100	4500	4800	4800	4800	6700	5700	6700	5700	7700
Non Recyc.	4500	4500	4050	4600	4000	4700	4700	5900	5900	6900	4900	5900

TABLE 10

Gained the Net Profit of Suppliers-Plants-Warehouse-DCs due to Recycling each Material ($) and Raw Material Purchasing Costs ($/unit)

	Suppliers			Plants			Warehouse	DCs	
Material	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**1**	**2**
%100 Recyc.	3.5	3.2	3.6	4	4.1	4.2	3.7	3.9	4.1
%50 Recyc.	2.7	2.5	2.9	2.9	3.1	2.7	2.5	2.8	2.9
Non Recyc.	-	-	-	-	-	-	1.9	1.8	1.9
				Purchasing costs ($/unit)					
%100 Recyc.	6	6.2	5.8	-	-	-	-	-	-
%50 Recyc.	3.2	3.5	3	-	-	-	-	-	-
Non Recyc.	2.3	2	2.1	-	-	-	-	-	-

Table 11 gives the optimum LINDO package program outputs of the example.

TABLE 11

The Optimal Solution of Numerical Example

Variable	Value	Variable	Value	Variable	Value	Variable	Value
X_{1123}	1000	Z_{322}	4700	K_{311}	2100	U_{11}	2352
X_{1211}	9500	Z_{332}	6900	K_{313}	1260	U_{12}	2730
X_{1221}	10000	W_{212}	100	K_{322}	2010	U_{13}	2478
X_{1231}	5500	W_{213}	3900	K_{323}	810	D_{12}	525
X_{1313}	500	W_{232}	300	K_{411}	1500	D_{13}	1310
X_{2213}	2000	W_{312}	7000	K_{412}	1280	D_{22}	2400
X_{2223}	1500	W_{322}	6700	K_{413}	1470	D_{23}	4000
X_{2233}	5000	W_{332}	6900	K_{422}	430	F_{111}	440
X_{2312}	5000	W_{411}	5000	K_{521}	1800	F_{121}	100
X_{2322}	8000	W_{421}	4600	K_{522}	2310	F_{122}	525
X_{2332}	6000	W_{431}	4900	K_{523}	1770	F_{221}	4500
X_{3113}	6000	W_{511}	1600	T_{11}	2400	F_{222}	2400
X_{3123}	8500	W_{513}	4400	T_{12}	2000	G_{131}	308
X_{3133}	6500	W_{523}	7700	T_{13}	1800	G_{231}	3220
X_{3312}	5000	W_{531}	5900	T_{21}	960	G_{232}	2047
X_{3322}	3500	E_{1222}	5700	T_{22}	1900	H_{131}	132
X_{3332}	6500	E_{1232}	5600	T_{23}	1740	H_{211}	1380
Y_{1211}	6000	E_{1422}	1100	S_{112}	1050	H_{222}	877
Y_{1221}	6700	E_{2111}	6000	S_{121}	3600	A_{11}	10000
Y_{1231}	5900	E_{2121}	6100	S_{122}	1950	A_{12}	11000
Y_{3121}	6800	E_{2122}	600	S_{123}	2700	A_{13}	5500
Y_{3131}	5600	E_{2131}	5900	S_{211}	540	A_{21}	7000
Z_{121}	2800	K_{111}	1200	S_{213}	1310	A_{22}	9500
Z_{131}	600	K_{112}	2010	S_{221}	900	A_{23}	11000
Z_{213}	11500	K_{121}	600	S_{222}	2850	A_{31}	11000
Z_{223}	11500	K_{123}	1770	S_{223}	1300	A_{32}	12000
Z_{233}	10500	K_{211}	1200	O_{1}	1008	A_{33}	13000
Z_{312}	10000	K_{212}	1710	O_{2}	1170		
Z_{313}	500	K_{213}	1770	O_{3}	1062		

DESIGNING GLOBAL SUPPLY CHAIN NETWORKS FOR MANUFACTURING COMPANIES

Pinar Bilge[1], Günther Seliger[2]

Abstract *— To cope with the increasing complexity of global competition and sustainability challenges, manufacturing company production activities are occurring increasingly in different countries. Value is being determined by international networks rather than domestic companies. This greatly increases the importance of supply chain design. From an industrial engineering perspective, a systemic understanding of the global network is crucial to understanding, planning and controlling supply chains. In this paper, the importance of supply chain design in establishing sustainable networks is outlined. Numerous studies have sought to address this challenge, however only a few offer concepts which are successfully applicable to the real business world. To identify appropriate approaches for introducing, establishing and improving global supply chain networks, this paper will analyze and evaluate existing concepts and recommend procedures for the internationalization of manufacturing.*

Keywords — Global supply chain design, internationalization of manufacturing

INTRODUCTION

Manufacturing companies position themselves in the market and in relation to their customers, enabling the company to secure competitive advantage. The internal and external conditions for the company change constantly. Coping with these challenges can be achieved through the development of global market and configuration of global production assemblies. The design of global supply chain networks while maintaining or enhancing competitiveness is of key importance.

This paper deals with the logistical aspect of the internationalization of business activities of manufacturing companies. The main concern is which supply chain design concept is best suitable to the specific needs of global manufacturing. Neither a scientific methodology nor the design algorithms to support this question exist at present. As a result decisions are made in an ad hoc or hierarchical manner.

This paper aims to identify supply chain design concepts based on the examination of pioneering contributions and to evaluate which could most suitably assist the management in meeting the challenges of the internationalization process. A range of recognized supply chain design models will be presented, with reviews of the scientific literature and modeling applied science. Based on detailed descriptions, the criteria for classification of supply chain design concepts will be derived from the analyzed models. The criteria reflect the requirements of supply chain concepts. Through an in-depth analysis rating the criteria, appropriate approaches will be identified for implementation in different phases of internationalization. Recommendations will be presented by comparing the models to assign the supply chain models to global manufacturing activities.

Supply Chain Design

Increasing competitive pressures necessitate manufacturing companies to offer lower prices for the same product, performance and quality. Meeting this challenge requires a cross-company supply chain design [1]. The design of a consistent logistics value chain primarily pursues the need to satisfy customer needs [2]. Customer requirements can often be contradictory and are related to price and quality inversely. This inherent contradiction contributes to a highly dynamic demand in which competition focuses increasingly upon the

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adaptability of a given company’s value chain structure. The flexible design of the value chain becomes a central component of competitiveness. At the same time the aim is to maximize the profitability of the company across the entire value chain [3-5].

The Supply Chain Design (SCD) hereby refers to the design of an integrated, global production and logistics network based on the manufacturing products and their markets for a strategic time horizon [2]. The design of supply chain networks concerns the infrastructure, all characteristics and elements of the network, material, information and financial flows. The SCD includes the design and the distribution of tasks and holistic optimization of the global value chain network. An international manufacturing network involves the consideration of regional advantages, effects of economies of scale and the scope and risks of global business activities [4, 6].

Goetschalckx identifies the objectives of SCD as reduction in cost and inventory, profit maximization, responsiveness and flexibility [7]. These high demands on the SCD lead to greater complexity, increasing the number of influencing factors. The relevance of supply chain management in science and its practices has therefore proliferated in the past few decades. Chopra and Meindl present the design of supply chain networks as long-term strategic task, suggesting that the design of supply chains has increased in importance during that period. [2].

Supply Chain Research Publication Statistics

Within the theoretical sciences, scientific work is divided into terminological (definitional), descriptive, explanatory and pragmatic (formative) species, and in applied sciences it is divided into modeling (normative) and simulative species [8]. In the case of companies and organizations, science is not limited to the definitional and descriptive formation of terms, but rather expresses its findings in designed models. The company management can then derive recommendations for a given case.

Goetschalckx provides a statistic summary of how many scientific papers have been published based on the supply chain research up to the year 2002 [9]. The number of publications related to topic and type is shown in TABLE 7 for comparison purposes. The literature mostly focuses on logistics, supply chain and supply chain management. Goetschalckx’s statistics also show that the majority of scientists undertook descriptive or analytical studies. However, the number of scientific contributions concerning design declines significantly, and even more so when it comes to the configuration and modeling of value chains. Another observation is that global logistics are much less examined than regional supply chains. Manufacturers typically set up logistics strategies regarding internal and external influencing factors. Since the number of influencing factors increases in global supply chain concepts, they are considered to be more difficult to manage than domestic supply networks.

TABLE 7
SUPPLY CHAIN RESEARCH PUBLICATION STATISTICS

Topic\Type	Descriptive	Design	Modeling
Supply Chain	14.638	1.215	326
Global Supply Chain	972	698	188
Supply Chain Management	692	-	-
Logistics	6.045	-	-
Global Logistics	35	-	12
Material Handling	1.239	852	208
Facilities Planning	162	62	15
Warehousing	191	91	15

In the following section this paper will focus mainly on the descriptive and explanatory studies regarding the design of supply chain networks and address several mathematical modeling articles. Publications will be reviewed to assess whether or not they qualify to support decision makers by global manufacturing activities. A few of them will be selected for the final evaluation.

State of the art modelling of Supply Chain Design

In this section the state of the art of scientific research and selected SCD-models are presented and analyzed by their impact factors. Numerous SCD-models have been discussed in scientific literature so far, which have approached the design of networks systematically from various points of view. All approaches shall assist the management in decision making to forge strategic value-added processes within manufacturing networks [10].

The purpose of the following assessment is to establish criteria to match SCD-models with manufacturers. In the analysis, the descriptive and explanatory models are important due to their scope and requirements but they do not purport to be complete. Approaches are classified according to their scientific background into two categories: modeling and logistics. The analyses in the modeling category are based on mathematical optimization models, while those from the logistics category emphasize mostly economic theories and logistics concepts from scientific research. Contributions which only offer solutions for isolated issues and individual cases are excluded.

Category "Modeling"

The modeling category provides a wide range of deterministic optimization models. It develops mathematical models and algorithmic relationships, while other approaches provide only enhancements to existing models. The optimization approaches are compared by the influencing factors they consider: Planning horizon, objective function, uncertainty, number of products, suppliers, manufacturing processes, taxation of profit, customs, local content, exchange rates, transport modes and throughput time [9-10].

One of the oldest, linear and integer optimization models was contributed by Haug (1985) [11]. His model includes the assumptions about suppliers and macroeconomic factors such as taxes, tariffs and exchange rates in a multi-period objective function. However it still lacks the profit and cost orientation introduced by Hodder (1986) [12]. Hodder's model also includes multifactorial analysis of risk factors. Since both models take into account only one product, they can be used only under very limited conditions [10]. A model developed slightly later by Canel (2002) also arises from just one product [13]. The unique feature of his model is the integration of the marketing aspect in quantitative production planning. The coordination of the marketing and manufacturing remains an omission from all other optimization approaches. These three concepts provide a solution for **only a single product** and will not be considered below.

The following contributions broaden the field of investigation to a **multi-product approach**. Cohen (1991) records an unlimited number of products in the algorithm and forms a section-wise linear function, followed by a concave cost function. Amongst other factors, it includes the fixed and variable costs and expenses [14]. Cohen generates several cost-oriented alternative solutions.

Vidal and Goetschalckx (1997) analyze the recent mixed-integer models with a widespread cost orientation, assessing whether these models are suitable to international manufacturing and distribution networks [15]. In another publication, Schmidt (2000) directs his focus toward the investigation of different levels of supply chain networks. He constructs an appropriate model for each of the strategic, tactical and operational network levels [16]. A later review by Vidal and Goetschalckx (2001) takes into account the taxation of profits as well as the exchange rate by spreading the global transport costs across different international locations. They propose a heuristic method for linear programming [17]. A similar procedure with tax levies on all costs is configured by Tsiakis (2008), who adds operational and financial restrictions in its objective function [18]. Again, both approaches are designed only **for a single manufacturing process** [10]. After (2002) introducing a second manufacturing process and local content rules in his research field, Kouvelis examines the impacts of individual factors on the global network structure [19]. Shortly afterwards his contribution was revised by Martel (2005) who adds suppliers, manufacturing processes and exchange rates as further influencing factors in the optimization model. He also addresses similar production factors in make-to-stock products [20].

The point of criticism of the studies presented by Cohen, Vidal and Goetschalckx, Schmidt, Kouvelis, Martel and Tsiakis relates to the **short-term planning horizon of only one period**. This threatens the validity of long-term forecasts and thus the strategic planning processes within the company.

Some scientists such as Mohamed (1999) and Papageorgiou (2001) detected this absence earlier on and took into account several periods in network planning [21-22]. Mohamed deals with the impact of exchange rates on value creation networks at the company level. Papageorgiou focuses on the early stages of the product life cycle as the phase of product development and introduction. Oh (2006) was the first to consider the duty drawbacks in terms of their importance, types and control [23]. These three approaches succeed at **optimizing only a single factor** such as the profit in a mathematical function. Therefore, they are regarded inadequate in the investigation of this work.

Three models remain that **optimize more than one variable**. Guillen (2005) concentrates on the performance of a supply chain and evaluates it based on many criteria in a two-stage stochastic model. His model also involves uncertainties [24]. A decade earlier, Arntzen conducted (1995) research which dealt with three parts of a network: procurement, production and distribution. His approach also includes an unlimited number of manufacturing processes, production methods, different transport modes and throughput times. It gained the widest acceptance in the scientific community in comparison to the previously mentioned publications [25]. Kohler (2008) builds upon it with another model which includes the impact of suppliers and exchange rates on the manufacturing network. This contribution provides an extensive approach to the previously stated as well as further factors, and is therefore an adequate detailed representative for the optimization models in the present work [10].

Category “Logistics”

Shapiro and Heskett (1985) are known for conducting the oldest supply chain based research, designing a strategy-oriented configuration of supply chain networks. The three generic modes of competition (product innovation, customer service and cost leadership) base the configuration of practical supply chain systems. Due to its similarity with Fisher’s SCD-creation, this paper does not elaborate on their results [26]. Fisher’s research (1997) divides products and supply chains into two types, and examines their match to each other [27]. Fisher’s model is comparable to Fine’s (1998) that recommends an ideal supply chain through efficient procurement processes. Fine’s approach aims at modular and integral design elements of procurement structures. This contribution is not addressed further, because procurement and distribution are not considered operationally in manufacturing. Building on Fisher’s model, Klaas (2002) extended the logistics configuration for additional mechanisms of coordinating the flow of goods. Furthermore, he distinguishes between two dimensions for the design of the company’s supply chain strategy [28]. The first dimension differentiates between a cost- and a flexibility-oriented logistics for innovative products. The second dimension distinguishes forecast-oriented logistics from order-driven logistics for standard products. Several concepts for supply chains can be designed for single or multiple products, individually or modularly. Further analysis of Klaas will not be necessary in this research as he contributes only a small share of a holistic SCD. Dicken (1986) sets some separate conditions and provides four possibilities for the international arrangement of location decisions in manufacturing networks. These are centered global production facilities, manufacturing in the host country, product specialization of production facilities and transnational vertical integration of manufacturing locations. His model displays the same problems as Fine’s approach, because it is lacking in **business areas** such as procurement and distribution. Dicken’s work is therefore also not presented in further detail [29].

Similar to the current geographic arrangement of Dicken’s production facilities, Dornier (1998) also forms alternative specifications for a successful supply chain concept. He describes the potential of SCD based on various factors. This model is evaluated in the next section [30]. Kampker (2005) develops a methodology to design an efficient SCD, similar to Dornier’s use of economic analysis. His holistic approach analyzes internal and external influencing factors of a manufacturer, and consequently directs a well-grounded decision making process. His contribution is discussed below [31]. Cooper (1993) is another scientist who defined logistics strategies as a function of product characteristics in management decision making processes. The emphasized product characteristic aspects play a prominent role in the SCD as factors for formulating success in different strategic alternatives. Aspects of Cooper’s model are therefore examined in detail within the following evaluation [32]. Chopra and Meindl (2006) contribute to a comprehensive overview of supply chain management and, to considerable extent, to its overall organization. They develop a four-stage model for the design of supply chain networks for internationalization projects, which will be assessed below [2].

Through the discussion of SCD-models, six contributions were identified that are relevant for this paper and will be the subject of the following analysis. The selected models for the design of logistics networks in manufacturing will be analyzed for influencing factors in the following section according to the literature reviews of Cooper, Fisher, Dornier, Kampker, Kohler, Chopra and Meindl.

Evaluation of Supply Chain Design Models

The goal of this chapter is a review of the selected SCD-models. First, the criteria by which the models are evaluated are described. The evaluation method used for the assessment is introduced in the following section, after which its implementation and results are presented. Finally, recommendations for the efficient design of supply chain networks are explained.

Derivation of the Evaluation Criteria

The prevailing market conditions, the objectives of the corporate manufacturing strategy, the internationalization strategy and the supply chain strategy determine the requirements for a SCD [33]. The supply chain is customized to a particular company and its manufactured products. These influence factors lay the foundation for upcoming confrontations with the selected SCD-concepts. Their assessment will be based essentially on nine criteria described below.

The design of supply chain networks can only contribute to success if all relevant factors are recognized and measured in accordance with the company's strategic plan. Therefore, the choice and consideration of the necessary internal and external factors is crucial for a profitable SCD [34]. This points to the importance of **"variety of factors"** considered as the first criterion for assessing the SCD-approaches.

The choice of facility location is dictated by the company's core competencies, product portfolio and target markets, and also by location conditions and infrastructure in particular. The selection of suitable production plant locations and their geographical position is a prerequisite to efficiently designing a logistical production network [1]. Therefore, the SCD-models are evaluated according to the criterion **"location choice"**.

Globally distributed business functions and activities are important in the selection of appropriate production sites. In practice, the SCD-concepts are primarily utilized to support decision making for the geographical distribution of value adding manufacturing activities, taking into account strategic, organizational and political factors. The **"ability to transfer the SCD-models to other countries and emerging markets"** proves also to be a necessary criterion in relation to the BRIC (Brazil, Russia, India and China) and the Next-Eleven (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, South Korea, Turkey, and Vietnam) countries.

Facing different regional cultures and resources on the one hand and volatile conditions and future uncertainty on the other set a condition for flexibility in logistics networks. The extent to which the SCD-approaches consider the current situation and dynamic changes is evaluated by the criterion **"need for flexibility"**.

Decision-makers are required to respond flexibly and promptly to new market demands and customers. Analyzing the prevalent state of the company based on previous data is insufficient and needs to be enhanced by **"global market dynamics"**. This criterion examines the extent to which the SCD-concepts need to be adapted to market dynamics.

Transnational activities in dynamic markets face higher risks than regional activities [35]. Risks such as demand uncertainties, political and financial risks may cause a discrepancy, digressing from the original purposes of profitability and competitiveness. The degree of **"risk factors"** is considered by the evaluation of SCD-alternatives.

The above factors should not be considered separately but rather in relation to each other as well as the SCD. The requirements of the company and dynamic markets are strongly associated with all influencing factors, i.e. the impact of an internal factor on the SCD can be based on the characteristics of an external factor [35]. Such loops can be managed with appropriate **“cause-effect relationships”**. This serves as an additional qualitative criterion for the assessment of SCD-models and for their suitability to the internationalization of business activities.

Many factors and the cause-effect relationships between them are examined by science in considerable detail. In most publications, the supply chain is designed to meet the needs of particular businesses and is developed by mathematical methods, computer-based applications, and econometrics or policy instruments. Regardless of the conditions and limitations of the approaches, every model contributes its own facet to facilitate the decision-making. The following evaluation will review the extent to which the identified six SCD-models can be used as a **“guide for decision-making”** in manufacturing companies.

The effective matching of the designed supply chain network with the required conditions of business is essential. Some contributions provide concrete **“recommendations to managers”** based on theoretical concepts or experiences of the researchers. This criterion analyzes whether the SCD supports the decision-makers in this manner.

The next section of this review documents the evaluation of the selected SCD-models.

Evaluation of the SCD-Models based on Selected Criteria

A direct comparison of the SCD-models is not possible, since they vary greatly in their classification. Instead, a qualitative assessment should be chosen and explained, which demonstrates the extent to which aspects of the described criteria were taken into account in the SCD-concepts. The models are analyzed according to the proposed criteria to ensure adequate assessment of the approaches. The results are presented in an evaluation matrix in TABLE 8, and explained to derive recommendations for manufacturing companies.

TABLE 8
SCD-EVALUATION MATRIX BASED ON SELECTED CRITERIA

SCD-Model / **Criteria**	Cooper	Fisher	Dornier	Kampker	Chopra and Meindl	Kohler
Year	1993	1997	1998	2005	2006	2008
Variety of factors	o	-	+	+	+	+
Location choice	o	-	+	+	+	+
Risk factors	o	o	+	o	+	+
Global market dynamics	+	+	+	+	+	o
Need for flexibility	+	+	+	o	+	-
Ability to transfer the SCD-models to emerging markets	+	o	+	o	+	o
Cause-effect relationships	+	+	+	o	o	-
Guide for decision-making	-	o	-	+	+	o
Recommendations to managers	-	+	o	o	+	-

The assessment methodologies include cost-benefit analysis, ranking procedure and optimization. Several methodologies are primarily related to determining the relevance of the criteria (e.g. ranking procedure) while others concern determining figures and weighting (e.g. value benefit analysis) [36]. SCD-models evaluated in this paper cannot be easily quantified or weighted. For this reason, further evaluation is carried out by ranking the introduced SCD-models. Ranking procedure is one of the best known and clearest assessment procedures in scientific analysis. It compares the advantages and disadvantages of each aspect verbally. The ranking method delivers arguments in the form of relative values to link and compare different options to each other. This paper evaluates the selected nine criteria using a three-scale ranking. The three assessment levels are defined so that the applicability of the criterion is indicated by the plus sign (+). The middle level is a zero (o), which bisects the two extremes of positive or negative value. The minus (- represents the negative value, i.e. each criterion in the model considered to be inaccurate or insufficiently considered.

TABLE 8 summarizes the results in an evaluation matrix and lists the SCD-models chronologically. Accordingly, the differentiation between the six concepts and their classification in the three-scale ranking is compared using the criteria. The assessment of the SCD-models demonstrates that the analyzed scientific approaches contribute to but do not complete a holistic SCD. The next section summarizes the results as recommendations for ways in which manufacturing companies can implement these concepts in the design of their international logistics networks.

Recommendations with Reference to global Supply Chain Networks

This section summarizes the results of TABLE 8 in deriving recommendations for manufacturing companies by their internationalization activities, referencing the SCD.

The logistics costs and services are among the critical success factors for internationalization projects. The study "Internationalization of Logistics Systems" researched instances of market entry for Chinese and German companies including the SCD [37]. The researchers came to the conclusion that the sooner the logistical aspects of the internationalization projects were integrated into management decisions, the lower the logistics costs became. This also increases the performance level and competitiveness.

Decision-makers can assign a SCD-model relevant to their internationalization phase and act accordingly by creating their own supply chain network. Here, manufacturers are divided into three groups depending upon their stage of the internationalization process.

The first group includes companies at the **early phase of the global manufacturing** process, e.g. regional companies which aim to develop a global footprint for entry into new international markets [29]. Kampker, Chopra and Meindl offer SCD-concepts describing a detailed, multi-level decision process to choose the appropriate strategy for the design of supply chain networks. In both approaches there is a holistic view of corporate and external factors. It covers the integration of international market dynamics and the resulting demands on the SCD to meet the rapidly changing customer needs. These models support the company's management in their plans of developing a global footprint as well as the choice of facility locations given additional strategic analysis.

Manufacturing companies, which already operate in international markets, are situated in the **middle phase of the global manufacturing** process. Their target is mostly to facilitate an improved geographical distribution of their production skills, capacities and resources in existing and new business locations. The SCD-models of Cooper, Fisher, and Dornier, which are distinguished by their consideration of the cause-effect relationships between the influencing factors, support the decision-makers of such enterprises. These contributions, with an ideal type of strategy alternatives, serve as the best practice in a benchmarking project to develop business based relationships and to derive a successful supply chain strategy. The framework as a typology outlining the strategic role of plants can only be applied toward qualitative network design [31]. The skills, capacities and resources of plants are reclassified through a mixed calculation of manufacturing facilities in order to guarantee the required level of responsiveness despite the challenges of volatile demand and conditions.

In the third group are international companies that aim to improve their existing logistics nets after the first implementation of internationalization activities in a **later phase of the global manufacturing** process. Kohler's SCD-model provides quantitatively practicable options to optimize the supply chain network in accordance with business objectives of the company under given preconditions [4]. Algorithms to optimize the SCD indicate the predefined goals expressed through the influencing factors. The mathematical optimization of a design model is only possible with constant targets and given circumstances. Decisions based on optimization are usually made according to a limited number of aspects. Typically, ERP-systems are implemented to achieve network optimization by determining the required variables and creating optimization algorithms [1].

Conclusion

A number of challenges for the design of international supply chain networks arise from the globalization of markets, business concentration upon core competencies, focus on customer needs, and regional circumstances. The consideration of all factors within the company and externally requires a systematic strategy for determining appropriate decisions concerning the supply chain network. This research shall ensure a holistic approach to supply chain assessment considering different conditions from a global perspective based on the fundamental SCD-concepts.

The paper reviewed various SCD-models and selected those which were commonly applicable to global manufacturing activities. Six models with different characteristics by the scientsists Cooper, Fisher, Dornier, Kampker, Kohler, Chopra and Meindl are identified as relevant and best able to meet the specific requirements of an appropriate SCD-model. Useful aspects in these studies are assessed together and established as nine criteria to evaluate the selected SCD-concepts: Variety of factors, location choice, risk factors, global market dynamics, need for flexibility, ability to transfer the SCD-models to emerging markets, cause-effect relationships, guide for decision-making, and recommendations to managers. The extent to which the SCD-models meet the criteria for forming an ideal SCD was evaluated through a three-tiered ranking procedure with positive, neutral and negative assessment levels. The assessment of SCD-approaches demonstrates that the models of Kampker, Chopra and Meindl assist only regional manufacturing companies at the initial phase of their internationalization process with a multi-level guideline to choosing the right facility location. The concepts of Cooper, Fisher, and Dornier provide a framework for international manufacturing companies already in the middle phase of the internationalization process. They outline strategic roles for qualitative application to redesign the supply chain net and redistribute their skills, capacities and resources through cause-effect relationships. The SCD-model proposed by Kohler is ideal for internationally active companies in an advanced stage phase of internationalization, and allows the mathematical optimization of supply chain networks with certain aspects.

Manufacturers aim to fulfill customer requirements as well as maintain and extend competitive advantage in order to ensure long-term value creation and company success. Further research is needed on global SCD to develop a method for the construction procedure of case based supply chain networks. Its implementation should enable decision makers to analyze the relevance of all influencing factors for their unique situation. Future research should focus on global supply chains and encompass more influencing factors and a variety of international manufacturing activities. The insights identified in this paper will support channel research efforts along the evaluated SCD-models and give the opportunity for development of global SCD models in future research.

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LOGISTIC AND DISTRIBUTION NETWOK PRACTICES OF COMPANIES AND ANALYZING EFFECTS OF TRUST, CONTRACTS, PERFORMENCE AND LONG TERM ADAPTION FACTORS ON SELECTION OF LOGİSTİCS PARTNERS: A RESEARCH WITH DUZCE INDUSTRIAL ZONE COMPANIES

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***Abstract* ─** *Logistic services provide a competitive advantage for businesses by reducing costs and increasing profitability. Selecting right distribution channel and making right decision about logistics related activities are important. The majority of companies in Turkey ignores strategic importance of logistics and distribution concepts and can't take advantage of them. In this study, effects of adaption factors (such as trust, contracts, financial performence, strategic performence, satisfaction and long term adaption) on selection of logistic service providers and supplier related decisions are analyzed. This study aims to take into account the logistic and distribution channel choices of companies and the factors affecting these elements. A survey is conducted and the study utilizes factor analysis, tukey test and structural modeling analysis by using SPSS 15.0 and AMOS 7.0 programs.*

Keywords ─ *Logistics, Supply Chain Management, Outsourcing, Distribution, Distribution Channel Selection*

INTRODUCTION

Internationalization of companies has brought the period of rapid transportation opportunities. Globalization, integrated logistics systems and the development of information systems have reshaped world trade rules and eventually the physical trade flows. Businesses, no matter which market segment they belong to, have had to develop a strategic worldwide network systems to meet customer demand effectively and to have competitive advantage. This resulted with worldwide organization of logistics and supply chain management activities. Many innovations were made to improve the logistics systems. The establishment of new international distribution centers to create distribution network and the development of new systems to identify and follow transportation route on digital media are examples. Despite this, within the entire supply chain management process may encounter a number of bottlenecks and bottleneck in a single firm may effect the flows in entire chain.

The logistics management activities provide inbound and outbound transportation management, fleet management, warehousing, material handling, order completion, logistics network design, inventory management, supply and demand planning and third party logistics services. Supply chain management consist of supply and procurement, conversion and all planning and management activities include logistics service providers. This also include the coordination of channel members such as customers, agents, suppliers and 3rd party service providers. [13]

Logistics management activities group under three headings; the first one is supply logistics (the logistics between the manufacturer and the supplier), the second one is production logistics (The logistics in manufacturing process) and the third one is distribution logistics (the logistics between the producer and the customers).

Contracts

In recent years, the number of firms that prefer to cooperate with outside companies for their logistics related responsibilities is growing rapidly. The studies in this area deal with aspects such as determination and exploitation of the contract types and their implication on the parties involved in the contract, motivation of contractual structures, the legal issues in contracting environments, and selection of the contractor. [1]

Performance based logistic contracts are becoming more and more common, as they represent a clear benefit to both parties. On the one hand, the customer only pays for the results achieved, thus maximizing the return on their investment. On the other hand, the contractors are given the necessary freedom and responsibility to innovate and apply their domain knowledge and experience, within a context of financial motivation and incentives [15]. In this research, examining that if firms are doing any contruct with logistic service providers which include all aspects of transportation conditions.

Long Term Adaption

For a long term compititive advantage, firms must make long term cooperation with logistic service providers. This must be a culture in business life, especially to maintain the profitability. On the other hand, the contracts have a critical role on long term adaptions of firms. Contracts between logistics providers and users are not becoming shorter; rather, the trend is in the opposite direction, Since capital investment for infrastructure, transportation equipment, and IT necessitate closer collaboration between providers and users, because of high switching costs. The technological investment, inparticular, is one reason behind the need for closer, longer-term collaboration: The contracts may also have a built-in flexibility that can be adjusted, depending on energy prices and demand-supply conditions, both of which can result in significant fluctuations in logistics costs. Thus, while logistics providers seek multiyear contracts, they ensure that their rates are not locked in[2].

Trust

Trust is a common means of reducing social complexity and perceivedrisk of transaction by raising the expectation of a positive outcomeand perceived certainty regarding the expected behavior of the trustee [16]. In contrary to the belief, t rust based relationships have not disappeared as a result of the active adoption of IT tools; rather, they may have been strengthened, precisely because of technologies that have been introduced to eliminate transaction costs. Evolving technological challenges to user-provider integration make userprovider relationships *more,* not less, complex, which, in turn, functions to increase switching costs. Therefore, userprovider relations require longer-term relationships with close cooperation [2].

Satisfaction

One principle of logistics is a management philosophy that effectively determines the needs of the customer. Ensuring operational quality at each stage in the process should ensure that the quality of the final product will satisfy the final customer [8].

Performance

Logistics performance is essential for firms to successfully operate efficient and effective international facility networks." In particular, logistics" role is to provide time and place utilities, which allow for both the movement of materials among geographically dispersed production facilities and the delivery of finished products to global consumers. The importance of coordination to global competitive advantage suggests that logistics should play a central role in decisions regarding the configuration and coordination of global operations [7].

LITERATURE

There has been many studies related to logistics management activities. A literature review has been made about the studies related to the performance, long-term adaptation, satisfaction, trust and contracts.

The research made by Özcan (2008) about the logistic activities of small and medium-size enterprises, emphasizes the importance of logistic management for companies in order to grow and survive in increasing compititive conditions [12].

Ergülen and Kazan (2006) wanted to create a model which minimizes the cost of distribution with integer linear programming to compose distribution strategy [6].

Yılmaz and *et al* (2002) researched the dependency concepts in relations of manufacturer-dealer and the affects of dependency on loyalty, collaboration and satisfaction. According to results of the study, the dependency concepts, that has groups of three; original investment, replacement of availability and the importance of main company, has a significant impact on collaboration, satisfaction and loyalty which is important in effectiveness of long term business relations. According to other result, when the main company has an high percieved value about the dealer, the dealer also has high level satisfaction [17].

Sodhi ve Sun (2009) created a model related to supply chain collaboration performance. It’s focused on five factors which may affect strategic and operational performance between suppliers. These factors are information exchange, trust, joint partnership management, relationship-spesific assets and partner asymmetry. According to results of the study, information Exchange has affect on operational performance , but also no affect on strategic performance. Trust factor has no affect on strategic performance. Joint partnership has affect on strategic performance. Also, relationship-spesific assets has affect on strategic performance. But, partner asymmetry has no affect on both of strategic and operational performance [14].

In the research which made by Bilginer and *et al* (2008), the factors affecting logistic activities in process efficiency were evaluated. For this purpose, the eight factors have emerged as a result of the factor analysis performed. The correlation and regression analysis were carried out in order to determine the impact and the relations of these factors with organizational performance. As a result of analysis, innovation has 31%, suppliers relations has 15%, change management has 17% and communication has 8% impact on organizational performance. Supply efficiency and envirolmental responsibility have no significant impact and order processing variable has negative impact too [3].

In the research which made by Kayabaşı and Özdemir (2008), the approach of production companies to performance management in logistic management activities were examined and the expectation-benefit difference analysis was applied. According to this study, organizational performance has two sub-factors; market performance and financial performance. How the expectations of performance management activities (Y) are affected from performance management activities (X_1) and market performance (X_2) and financial performance (X_3) that are sub-factors of operational performance of logistic activities are examined with multi regression analysis. 26% of expectations of logistic activities are derived from performance activities and organizational activities. The multi linear regression model of the study is $Y = 1{,}582 + 0{,}197.X_1 + 0{,}162.X_2 + 0{,}171.X_3$. [9]

Nevins and Money (2008) made a research about performance activities of import distribution channels, trust, culture and distribution efficiency. Some part of likert questions in our study has adapted from this work. Short term adaption, culture dissimilarity, individualism, trust, contracts, distribution efficiency and performance (strategic, operational and satisfaction) factors are discussed. According to results, distribution efficiency factor is in relation with channel performance, especially strategic and financial performance. Trust factor has strong positive impact on all aspects of performance. As contracts are used with high amounts, distribution efficiency factor affect strategic performance negatively, but also, don't affect financial performance and satisfaction factors. Contracts and trust factors have no impact on performance. Individualism has negative impact on performance perceptions. Culture dissimilarity affects the satisfaction in channel relations, because of trust impact. Short term adaption has no significant impact on channel performance. [11]

RESEARCH

The Aim of the Study

The aim of this study is to reveal the affects of trust, contracts, performance, satisfaction and long term adaption factors for logistic service providers.

Limitations of the Study

This study was conducted with total of 50 companies out of 375 registered companies in Düzce Organized Industrial Zone. Although we visited 65 companies, some companies were reluctant to answer and we collected answer from 50 companies. The return rate is 50/375. There are 67 registered firms in organized industrial zones and 375 registered firms in Düzce chamber of commerce. There are 21 firms that keep activities going in industrial zones. The questionnaire is administered face to face with 50 operating firms.

Research Method

The data is analyzed by using SPSS 15.0 and AMOS7.0 programs. Maximum likelihood method on AMOS program is used to reveal effective factors on activities that companies outsource from logistic service providers. To create an accurate model for AMOS application, the factors of the study are determined by applying factor analysis in SPSS program.

Sampling Process

A questionnaire is administrated with companies face to face. The questionnaire include closed-ended questions as well as 5 point likert questions about toughts of companies for their outsourcing activities from logistic service providers. Questions are adapted from the literature ans we assume that their reliability have been tested before.

Model and Hypotheses of the Study

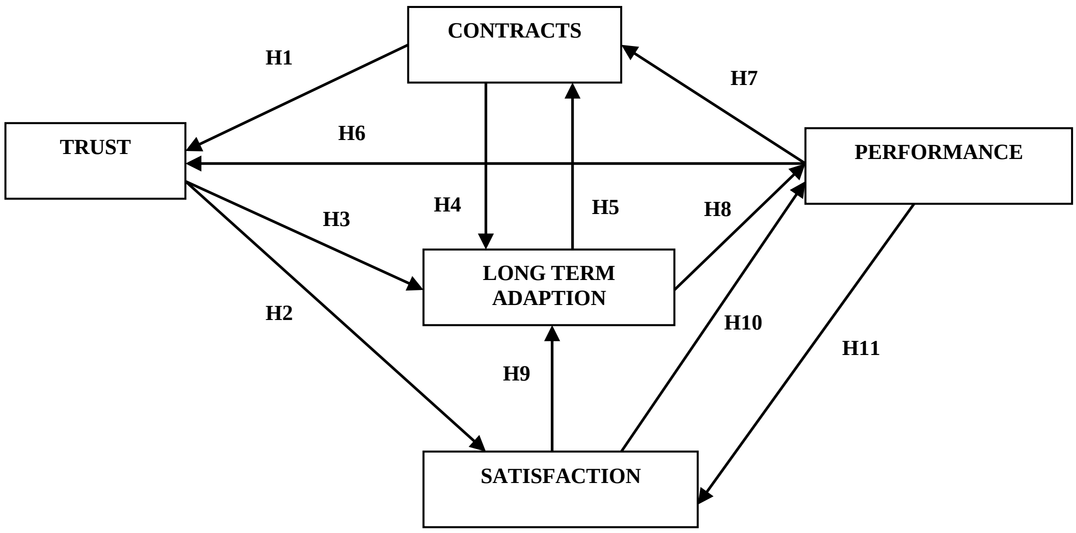

FIGURE 1
Model of The Study

H1: The contracts factor has impact on the trust factor
H2: The trust factor has impact on the satisfaction factor
H3: The trust factor has impact on the long term adaption factor
H4: The long term adaption factor has impact on the contracts factor
H5: The contracts factor has impact on the long term adaption factor
H6: The performance factor has impact on the trust factor
H7: The performance factor has ımpact on the contracts factor
H8: The long term adaption factor has impact on the performance factor
H9: The satisfaction factor has impact on the long term adaption factor
H10: The satisfaction factor has impact on the performance factor
H11: The performance factor has impact on the satisfaction factor

Findings of the Study

The findings are analyed in three stages; demografics of enterprises, factor analysis and structural modeling analysis.

Demographics

52% of the participating companies serve in industrial products category, 46% produces cunsomer products category and 2% of participating companies serve in both categories. Companies belong to 18% in wood products sector, 18% textile products sector, 16 % metal products sector, 8% food products sector, 8% building materials sector, 6% machine industry, 4% outomotive supply industry and 22% in other sectors. Compaies serve to 16% in national markets, 12% in international markets and 72% in both of markets. Related to employee capasity, 32% of participating companies have 10-49 employers, 48 % have 50-249 and 20% have more than 250 employers. The companies which have 10-49 employers are recognized as small-sized, having 50-249 employers are recognized as medium-sized and having more than 250 employers are recognized as large-sized. In this study, most of the companies which are participated are in medium-sized business category.

Results of Factor Analysis

TABLE 1
Factor Analysis

QUESTION	FACTOR				
	Performance	**Trust**	**Long-Term Adaption**	**Contracts**	**Satisfaction**
37. The relation with this firm ensured us rapid sales growth	0,918				
36.The relation with this firm ensured us high sales volume	0,888				
38.Relation with this firm increased our competitiveness	0,806				
40.Relation with this firm increased our local market share significantly	0,761				
30. The representatives of this firm are reliable		0,867			
31.The representatives of this firm are honest with us		0,820			
29.This firm will provide comfort to us in decisions concerning to the market		0,673			
27.This firm keeps its promises		0,603			
45. A firm hopes from a logistic firm to work together for a long time			0,879		
44. When a firm starts to work with a logistic firm, it may work for a long time			0,845		
46. Maintaining a long framework with a logistic firm should be a business culture in this product category.			0,815		
32. Relation with this firm is executed with a contract firstly				0,868	
34. The results, rights and obligations of finishing up the relation with this firm are determined by a contract				0,862	
33. We make aggrement at the level of sharing knowledge with each other				0,660	
41. Our venture with this firm has been pleasure					0,942
42. Our venture with this firm has been successful					0,789

After conducting factor analysis, logistic suppliers related factors are grouped under five categories; trust, contracts, performance, long term adaption and satisfaction. There are 16 questions in the questionnaire belong to these factors and the reliability of these questions are tested with a comman used test Cronbach Alpha. As a result, the reliability of data is 0,86 which can be considered as high.

Reliabilities of each individual factor is as follows; turst (0,54), satisfaction (0,61), contracts (0,57), performance (0,74) and long term adaption (0,60).

It's required to measure the adequacy of the sample in order to apply factor analysis. Fort his purpose, KMO Barlett's test is used. KMO results suggest that our sample is adequate at 0,66 level and Barlett's test's result which is 0,000 is high level. So, there is a strong relationship between our variables. Factor loads of questions asked in factor analysis and under which factor these loads are complied are explained in Table 1.

Results For Structural Modeling Analysis

This research which examine the affects of factors about logistic suppliers on each others has been analyzed by using maximum likelihood method and AMOS 0.7 program. Structural Modeling Analysis is used to reveal the degrees for the effectivenes of each factors about logistic suppliers on each others.

Model estimation results in the following adequate statistics :

TABLE 2
Model Adequacy Values

Model Değerlendirme Kriterleri	Model
Chi-square ($\chi 2$) value (CMIN)	3,807
Degree of Freedom (SD)	4
P-value	0,000
$\chi 2$ / SD (CMINDF)	0,952
Normalized Fit Index (NFI)	0,914
Relative Fit Index (RFI)	0,677
Incremental Fit Index (IFI)	1,005
Comperative Fit Index (CFI)	1,000
Tucker-Lewis Index (TLI)	1,025
Root Mean Square Error of Approximation (RMSEA)	0,000

According to the above table, the chi-square fit value derived is 3,807. This value was small since the sample of the research was small. Whereas the fact that the figure which is obtained by dividing the ki-square fit value to degree of freedom is higher than 3 demonstrates a good fit, those which are higher than 5 demonstrate only a sufficient fit. The value obtained in 0,952 indicates that the data is in perfect compliance with the model, which means our model is a valid model. Another assessment criteria, Root Mean Square Error of Approximation (RMSEA) has been found as 0,000. RMSEA value being smaller than 0.05 demonstrates a perfect fit, and value up to 0.08 demonstrates that there is only a good fit. Again according to this result, the model is in perfect fit with the data. RFI, IFI, CFI, TLI and NFI values range between 0 to 1, and the perfectness of fit increases as these values approach 1.

TABLE 3
Standard Regression Rates

Hypothesis	Factor	Relationship	Faktör	Standard Coefficient	Significance
H8	PERFORMANCE	«	ADAPTATION	,216	P = 0,500
H3	ADAPTATION	«	TRUST	,851***	P ‹ 0,001
H11	SATISFACTION	«	PERFORMANCE	,889***	P ‹ 0,001
H5	CONTRACT	»	ADAPTATION	,962***	P ‹ 0,001
H1	TRUST	«	CONTRACT	,200	P=0,436
H7	CONTRACT	«	PERFORMANCE	,148	P=0,338
H4	ADAPTATION	»	TRUST	,719***	P ‹ 0,001
H10	PERFORMANCE	«	SATISFACTION	1,243***	P ‹ 0,001
H2	SATISFACTION	«	TRUST	,999***	P ‹ 0,001
H6	TRUST	«	PERFORMANCE	,396	P=0,156
H9	ADAPTATION	«	SATISFACTION	,256	P=0,301

***P<0,05; H_0=Rejected

According to Table-3;

Long Term Adaption→ Performance, Contracts→ Trust, Performance →Contracts, Performance → Trust and Satisfaction → Long Term Adaption hypothesis are rejected (P>0,10). Corresponding; Trust →Long Term Adaption, Performance → Satisfaction, Contracts → Long Term Adaption, Long Term Adaption → Contracts, Satisfaction → Performance and Trust → Satisfaction hypothesis have been significant (p<0,10).

According to these results, where as the contracts of companies made with suppliers explain 96% of long term adaption in their relationships, the trust factor explain 85% of this. Long term adaption has 72% impact on contracts. Where as the trust in each companies other explain 100% of satisfaction factor, strategic and financial performances of companies explain 89% of satisfaction. Also, satisfaction factor has 124% high level impact on performance factor.

According to standardized total effects, direct affects and indirect effects, where as long term adaptation factor has 0,72 direct effect on contracts factor, it has 0,23 indirect effect on. The direct effect of contracts on long term adaption is 0,96 and its indirect effect is -0,43. Whereas the direct effect of satisfaction factor on performance factor is 0,89, its indirect effect is-0,39.Whereas the direct effect of performance factor on satisfaction factor is 1,243, its indirect effect is -0,76. Whereas trust factor has 100% direct effect on satisfaction, it has no indirect effect.

Table-4 shows covariance of factors. Covariance indicates the trends factors change together. If covariance value is upper than 0, it means that two of variables increase together, ıf covariance value is lower than 0, it means that two variable decrease together. If that is equal to 0, it means that two variables are independent from eachothers.

TABLE 4

Covariance Matrix

FACTORS	TRUST	CONTRACTS	PERFORMANCE	SATISFACTION	LONG TERM ADAPTION
TRUST	,583				
CONTACTS	,404	1,005			
PERFORMANCE	,120	,043	,535		
SATISFACTION	,233	,226	,070	,573	
LONG TERM ADAPTION	,290	,442	-,055	,259	,795

CONCLUSION AND RECOMMENDATIONS

In this study, a questionnaire which tries to measure service related attributes of logistic providers for different sectors of manufacturing industry has been used. Our interest was especially on, effectiveness and effective measures of the trust between firms, contracts written with service providers, strategic and financial performance provided by suppliers to firms, long- term collaboration and satisfactions level between servicer providers and receivers.

According to results, enhanced long-term cooperation with logistic service providers may be a businness culture. The trust of the parties to each other and contracts made within expectations from each other through this trust have effects on this long-term adaption. Considering effective measures of this factors, it's seen that the both of factors have well enough effect and the contracts factor has more effect. Further, in terms of interactions, it's seen that the adaptation factor explains most part (72%) of contracts factor. Whereas the strategic and financial performances provided by logistic suppliers to firms have well enough effect on satisfaction factor, in terms of interactions, the performance arising from satisfaction has an high value of 124%. Moreover, the trust of collaborators with each other affects to 100% of satisfaction factor is also seen clearly.

Considering direct and indirect effects, it's seen that the direct effects of factors on each others are more than indirect effects of them, even, indirect effects are not significant. But also, the performance factor has indirect effect as much as its direct effect on satisfaction factor. Here, the indirect effect that mentioned is the influence degree of strategic and financial performance that supliers provide to firms on satisfaction through over the company's expectations according to contracts, trust in the framework and long term collaboration factors. Showing companies will provide the performance so as the degree of satisfaction, other factors that can be said to be of much effect on the satisfaction.

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OPTIMIZING THE SUPPLY CHAIN STREAMLINING OF THE KONYA SUGAR INDUSTRY

Turan Paksoy [1], Eren Özceylan [2]

Abstract *— In this paper, a supply chain network for Konya Sugar Industry (KSI) is considered. The chain consists of six suppliers' area (sugar beet farms), two factories, and several retailers as customers. We try to optimize the whole chain via minimizing the total transportation costs. The approach presented in this paper aims at preserving a constant supply while minimizing the associated costs. The corresponding optimization models and solution procedures are introduced and applied to the case study problem. This proposed model also takes a photo of the sugar stream in the factory. We have studied the whole supply chain, analyzed end-customers demand and logistics costs, and developed appropriate transportations to derive optimal distribution practices. To formulate the model, we benefit all operating realities, production levels at the various manufacturing plants, storage capacities at production and distribution facilities, transportation and routing costs, and actual material flows between supply chain nodes. The proposed model is based on a linear programming. The model is solved by LINDO 6.1 optimizer package program, and discussed obtain optimum results.*

Keywords — Logistics management, supply chain design, sugar streamlining, optimization.

INTRODUCTION

A supply chain begins with the providing of raw materials, through the manufacturers, warehouses, retailers, and the end-users. Where appropriate, supply chain also consist recycling or re-using of the products or materials over the past decade. As a promising part of supply chain, network optimization has become a subject of increasing interest in recent years, to academics, consultants and business management. But supply chain activities are variety sector by sector. So there could not be standard supply chain networks and management mentalities. Owing to optimizing current distribution network, efficient and effective results should be achieved and obtained.

Sugar was chosen as a case study because essentially it has two different supply chains, with different social, economic and environmental impacts and benefits. These are (i) a local supply chain involving the production, processing and marketing of sugar beet grown, and (ii) a global supply chain involving the production, processing and marketing of cane sugar grown, primarily, in developing countries. Sugar was also selected because it is a major consumption product, sourced both from domestic and developing country production. Sugar is consumed directly, but is also an important ingredient in many popular and widely consumed foodstuffs and beverages, e.g. chocolate, confectionery, soft drinks etc [1].

A sugar industry is a large value chain containing the sectors of sugarcane growing, harvesting of cane, cane transport to the mill, mill processing, and sugar transportation to the port, storage, marketing and shipping to customers. Supply-chain management typically involves improving efficiency and reducing costs by ensuring that all stages of an operation (such as processing or transportation) are engaged at as close to full capacity as possible, with minimum unnecessary costs or risks. Leaders in the sugar industry are expanding their ideas of a supply chain to encompass collaborative efforts to diversify production and manage natural resources for the benefit of all parties. They recognize that stakeholders in the sugar industry need community, consumer and shareholder confidence in their products and management practices [2].

This paper investigates modeling approaches and support tools that could be valuable in solving KSI supply chain network problems. The study proceeds in the following manner. The first part of the paper briefly reviews sugar industry and production process of sugar. Then the literature review which is related

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supply chain optimization and sugar industry is emphasized. Then the main scope of the study is given via developed mathematical model to solve the case in KSI. The model is fixed based on a linear programming to optimize the supply network consists of suppliers (harvesting the sugar beet), factories (Konya and Çumra Sugar Factory) and customers (retailers, private label companies). We explain in detail the mathematical formulation of the model with its constraints, objectives and parameters. Then we proposed a numerical example based on a reel case data to test the model. At last, we provide the research results and discussion for managerial implications.

SUGAR INDUSTRY and PRODUCTION PROCESS

Sugar is extracted from two different raw materials i.e., sugarcane and sugar beet. While both produce identical refined sugar, sugarcane is grown in semi-tropical regions, accounts for around two-thirds of world sugar production and sugar beet is grown in temperate climates, and accounts for the balance one third of world production. Cane sugar accounts for around 75% of all sugar production. Brazil, the European Union and India are the largest sugar producers [3].

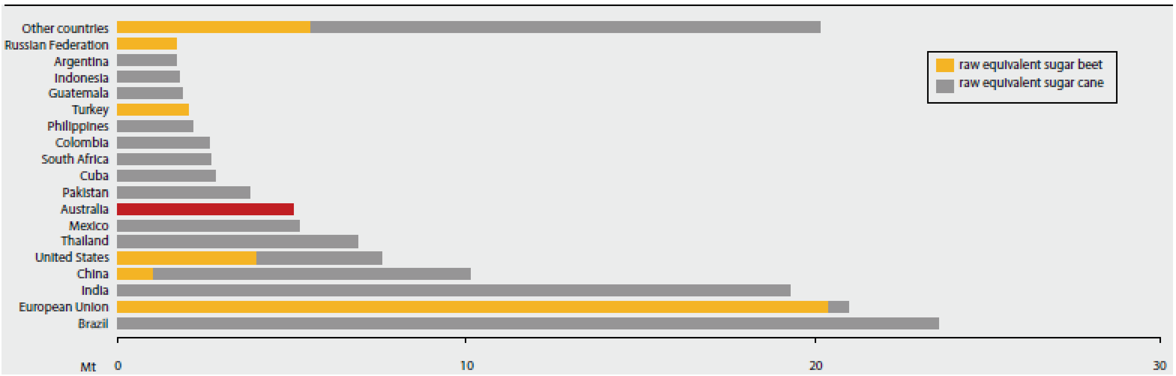

FIGURE 1
World Raw Sugar Production [3]

Sugarcane yields about 2,600,000 tons of sugar per year. The sugar beet is a beetroot variety with the highest sugar content, for which it is specifically cultivated. While typically white both inside and out, some beet varieties have black or yellow skins. About 3,700,000 tons of sugar is manufactured from sugar beet. Other sugar crops include sweet sorghum, sugar maple, honey, and corn sugar. The types of sugar used today are white sugar (fully refined sugar), composed of clear, colorless or crystal fragments; or brown sugar, which is less fully refined and contains a greater amount of treacle residue, from which it obtains its color. The European Union, the United States, and Russia are the world's three largest sugar beet producers, although only the European Union and Ukraine are significant exporters of sugar from beets. The U.S. harvested 1,004,600 acres (4 065 km²) of sugar beets in 2008 alone. Canada is ranked 31st in world sugar beet production. Beet sugar accounts for 30% of the world's sugar production [4].

Top Ten Sugar Beet Producers - 2005 (million metric tons)	
France	29
Germany	25
United States	25
Russia	22
Ukraine	16
Turkey	14
Italy	12
Poland	11
United Kingdom	8
Spain	7
World Total	**242**

FIGURE 2

Top Ten Sugar Beet Producers [4]

All sugar is produced from sugar beet in Turkey. There are a total of 33 sugar refineries in Turkey. Out of this total, 22 factories are owned and run by the Turkish Sugar Corporation (TSC), five are owned by PANKOBIRLIK (those in Amasya, Kayseri, Konya, Çumra, and Bogazliyan), three are owned by the private sector (in Adapazari, Kutahya, and Aksaray), and three (in Ilgin, Bor, Ereğli) were transferred to the Privatization Administration, but have not yet been privatized. The Adapazari and Aksaray refineries began production in 2007. The Bogazliyan plant is also started production by the end of October 2006 [5].

Total area of sugar beet is still estimated at 330,000 hectares. Nearly one half of this total is the area for TSC farmers, estimated at 160,000 hectares. The average sugar beet yield is estimated around 43 MT per hectare compared to 45 MT per hectare a year ago. The yields are slightly lower for the TSC refineries, but slightly higher for other refineries. Similarly, polar sugar content, which is estimated similar to the previous year on the average, is estimated lower for the TSC refineries than other refineries.

Production Process

Sugar production process includes several steps (Fig. 3). These are listed below [6]:

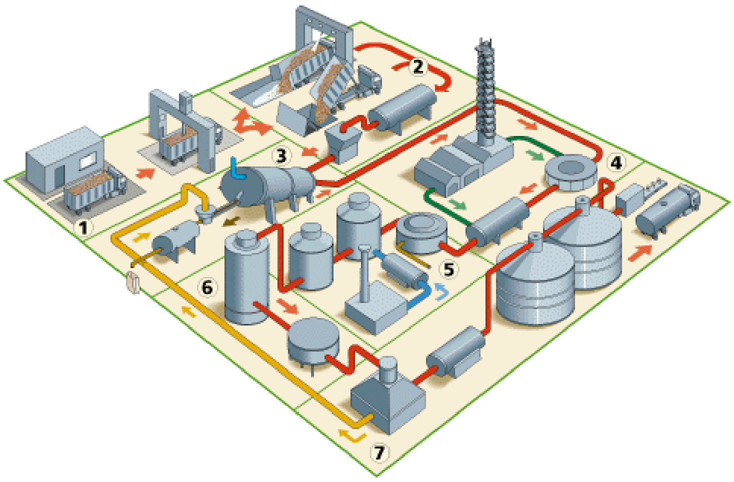

FIGURE 3
The Sugar Production Process [6]

Harvesting the beet: The harvesting of the sugar beet or the "campaign" as it is known, starts around the end of September and continues until mid-January. The beet is taken by lorry from the harvested field to sugar processing factories.
1.Weighing And Sampling: Once inside the factory grounds the lorries drive over a weighbridge where their gross weight is automatically measured. At the same time a sample of the particular load is taken to determine the sugar percentage and the amount of tare in the overall load. Tare may consist of clay, stones, beet tops, etc. It is deducted from the gross weight of the load in order to determine the net weight of clean beet delivered.
2.Unloading: There are two systems of unloading-dry unloading and wet unloading. When dry unloading, the beet is conveyed from the lorry by a series of conveyer belts to open air silos where it is stored. In wet unloading the beet is washed from the lorry by mean of a powerful jet of water. Beet is transferred from the silos to the factory by means of water. En route to the production process, stones and grass are removed in a series of stone and grass catchers. The beet is thoroughly washed before processing to remove all traces of clay and sand.
3.Diffusion: The actual sugar is inside the beet and has to be extracted. In order to extract the sugar the beet is first cut up into elongated slices. Sugar is then extracted from the beet by diffusing it out with hot water. This is done in a large vessel specially designed for this purpose. Beet slices are fed in continuously at one end and hot water at the other end. A solution of sugar emerges from one end and the exhausted beet slices emerge from the other. The exhausted beet slices, or pulp, are mixed with molasses then dried and sold as an animal feed.

4.Saturation: At the diffusion stage other substances are extracted from the beet as well as the sugar. But before sugar can be produced in a white crystalline form it is necessary to remove as many of these non-sugars as possible. This part of the process is referred to as juice purification.
5.Evaporation: The purified juice is a sugar solution containing approximately 14% sugar and 1% non-sugars. It is now necessary to concentrate this solution. This is done by boiling off water from the solution in large vessels known as evaporators. On entering the evaporators, the solution contains approximately 14% sugar. On leaving the evaporators it contains approximately 60%.
6.Vacuum Pans: In order to turn the sugar into a crystalline form it is now necessary to evaporate still more water. This is done at a reduced temperature and pressure in large vessels known as vacuum pans. Syrup is fed to the pans and as the water is evaporated off, the crystals of sugar begin to grow. When the pan is full it contains about 50 tones of a mixture of sugar crystals in syrup. The contents are then discharged into large holding vessels known as crystallizers.
7.Centrifugals: The next step in the operation is to separate the sugar from the syrup. This is done in automatically controlled machines known as centrifugals. In them the syrup is spun off and the sugar crystals remain. The wet sugar is then dried, screened, cooled and sent to large bulk storage silos each of which can contain up to 50,000 tones. The syrup from the centrifugals still contains a lot of dissolved sugar. This syrup is put back through two more boiling stages in order to extract still more sugar. The final syrup from which it is no longer practical or economical to extract more sugar is known as molasses. It contains some sugar together with non-sugars which were not removed at the juice purification stage. It is mainly used for animal feed.

The total time from beet washing to white sugar is about twelve hours. Depending upon sugar content of the beet, 100 tones of beet will give approximately 12-14 tones of sugar and 3-4 tones of molasses.

LITERATURE REVIEW

Numerous researches have worked in this field. A deterministic, mixed integer, non-linear programming with economic order quantity technique to develop global supply chain network is presented [7]. A mathematical programming model by using stochastic sub-models to design an integrated supply chain which involves manufacturers, warehouses and retailers is developed [8]. Recently, however, there has been increasing attention placed on the performance, design, and analysis of the supply chain as a whole. This attention is largely a result of the rising costs of manufacturing, the shrinking resources of manufacturing bases, shortened product life cycles, the leveling of the playing field within manufacturing, and the globalization of market economies. Addition to this, Beamon [9] provided a focused review of literature in multi-stage supply chain modeling and defined a research agenda for future research in this area.

Higgins et al. [10] presented an application of an optimization model to the mill region with the objectives of maximizing sugar yield and net revenue in relation to harvest date and crop age. Six years of block productivity data classified according to district, crop class, variety, harvest date, harvest age, cane yield and sugar yield, were used to generate the input parameters for the model. Other inputs were sugar price, growing and milling costs, and transport and crushing capacity. With current crushing capacity and harvest season lengths, an application of the model to maximize sugar yield showed a 4% increase in sugar yield compared to current practice, but a 23% decrease in net revenue due to a shorter crop cycle with less ratoons before replanting. Optimizing with respect to net revenue, gave a 3% gain in sugar yield with an 8% gain in net revenue. When crushing capacity was allowed to increase for current season lengths, the model showed a 14% gain in net revenue given fixed milling costs. It is concluded that there is scope for optimizing harvest date to improve profitability in this mill region given current harvest season lengths and land area.

Petrovic et al. [11] modeled supply chain behaviors under fuzzy constraints. Their model showed that, uncertain customer demands and deliveries play a big role about behaviors. A new algorithm which was based on genetic algorithm to design a supply chain distribution network under capacity constraints for each echelon is developed [12]. Yan [13] tried to contrive a network which involves suppliers, manufacturers, distribution centers and customers via a mixed integer programming under logic and material requirements constraints. Gaucher et al. [14] have been developed a modeling approach based on two complementary models to simulate on a weekly basis the planning and operation of mill supply throughout the season. The first model compares weekly and total sugar production for a season. The second model focuses on the simulation of logistic chains, and enables the impacts of technological and structural changes on daily harvest and transport capacities to be assessed. Both models can be used to support discussion and negotiation between growers and millers regarding evolutions in the supply chain management. Sustainable Development Commission (SDC) realized a project which name is Sustainability of Sugar Supply Chains [15]. The aim was to explore the social, economic and environmental impacts of the global and local supply chains and suggest how both could be made more sustainable. Ioannou [16] reported on the aspect of the project that addressed the redesign of Hellenic Sugar Industry in Greece distribution network. The goal was to reduce the 3.5 million US$ transportation cost, which constituted almost 40% of the field operating expenses, and improve customer service. He studied the supply chain, analyzed customer demand and logistics costs, and developed appropriate transportation models to derive optimal distribution practices. Without resorting to radical restructuring of the existing logistics operations, but through optimal planning of inter-node material transfers, annual savings of almost one million US$ and improved demand coverage were achieved. Based on a case study from Venezuela, the production of raw sugar is investigated. The approach presented in the paper aimed at preserving a constant supply while minimizing the associated costs. The entire planning problem was structured in a hierarchical fashion: (1) cultivation of the haciendas, (2) harvesting, and (3) dispatching of the harvesting crews and equipment. The corresponding optimization models and solution procedures were introduced and applied to the case study problem [17]. Ahumada and Villalobos [18] reviewed the main contributions in the field of production and distribution planning for agri-foods based on agricultural crops. They focused particularly on those models that have been successfully implemented. The models are classified according to relevant features, such as the optimization approaches used, the type of crops modeled and the scope of the plans, among many others. Through their analysis of the current state of the research, they diagnosed some of the future requirements for modeling the supply chain of agri-foods.

Piewthongngam et al. [19] proposed a framework of cultivation planning to cope in the Thai Sugar Industry. The focus of the cultivation plan was a long-term plan to determine the cultivation time, the cultivar selection and the corresponding prospective harvesting time window for each field such that overall sugar production is optimized. The crop growth model and a mathematical model were employed for yield simulation and optimization task. The crop growth model enabled decision-makers to visualize cane production of each individual field at different dates with different cultivars and allow decision-makers to apply the mathematical programming to cultivation planning. The suggested framework has the potential to increase sugar production by 23% when compared to the traditional method. The aim of the study is to report on trends in the components of the sugar supply chain in South Africa (SA) over the period 1998/99-2002/03. This entailed estimating how the farm value (what farmers get for the sugarcane that they sell), the processing and refining spread, and the transport, handling and wholesale spread for sugar changed from year to year. Before analyzing these trends, the study briefly described pricing in, and the structure of, the market for refined sugar in SA. Some policy implications of the results were considered in the conclusion [20].

Mele et al. [21] addressed the design of supply chains (SC) for sugar/ethanol production with economic and environmental concerns. The design task was formulated as a bi-criterion mixed-integer linear program (MILP) that simultaneously minimizes the total cost of the network and its environmental performance over the entire life cycle of the product (i.e., sugar and ethanol). The capabilities of their approach were highlighted through a case study based on a real scenario, for which a set of Pareto optimal alternatives was calculated. A decision-support tool based on a mixed integer linear model for the design of sugarcane SC was developed. The approach considered the minimization of the total SC costs and environmental impact, which is determined according to the Life-Cycle Assessment principles. The solution was a set of Pareto optimal alternatives, i.e. SC configurations with associated strategic planning decisions. The capabilities of the proposed framework were illustrated through a case-study designed on the basis of the current situation in Argentina [22]. Paiva and Morabito [23] developed an optimization model to support decisions in the aggregate production planning of sugar and ethanol milling companies. Their model is based on industrial process selection and production lot-sizing models. Their goal is to help the decision makers in selecting in industrial processes used to produce sugar, ethanol and molasses, as well as in determining the quantities of sugarcane crushed, the selection of sugarcane suppliers and sugarcane transport suppliers, and the final product inventory suppliers, and the final product inventory strategy. They tested their model in Brazilian mill as a case study.

THE OPTIMIZATION PROBLEM

This section focuses on the formulation of the proposed linear programming model. The linear programming model is formulated to determine the beet flow between haciendas, production areas, packaging lines and customer zones. The objective of the model is to minimize the overall transportation costs under the limitations of beet grown areas, production and packaging lines. The proposed mathematical model is written as follows:

We use the following *indices*:

i	set of huge sugar beet haciendas	h	set of packaging types for crystal sugar
j	set of production facilities	e	set of packaging types for cube sugar
m	set of packaging lines for crystal sugar	v	set of packaging types for liquid sugar
n	set of packaging lines for cube sugar	u	set of packaging types for beet pulp sugar
o	set of packaging lines for liquid sugar	k	set of private label customers
s	set of packaging lines for beet pulp	l	set of customers requiring beet pulp
w	set of weeks during picking the beets		

The model *parameters* are defined as follows:

a_{iw}	Sugar beet capacity of hacienda *i* per week *w* (tons/week)
b_j	Production capacity of facility *j* (tons)
C_m	Packaging capacity of packaging line *m* (kg)
C_n	Packaging capacity of packaging line *n* (kg)
C_o	Packaging capacity of packaging line *o* (lt)
C_s	Packaging capacity of packaging line *s* (kg)
P_h	Size of packaged type *h* (kg)
P_e	Size of packaged type *e* (kg)
P_v	Size of packaged type *v* (lt)
P_u	Size of packaged type *u* (kg)
D_{kh}	Demand of customer *k* for packaged *h* (unit)
D_{ke}	Demand of customer *k* for packaged *e* (unit)
D_{kv}	Demand of customer *k* for packaged *v* (unit)
D_{lu}	Demand of customer *l* for packaged *u* (unit)
C_{ijw}	Cost of transportation from hacienda *i* to production facility *j* in week *w* (tl/tons)
C_{mkh}	Cost of transportation from packaging line *m* to customer *k* (tl/unit)
C_{nke}	Cost of transportation from packaging line *n* to customer *k* (tl/unit)
C_{okv}	Cost of transportation from packaging line *o* to customer *k* (tl/unit)
C_{slu}	Cost of transportation from packaging line *s* to customer *l* (tl/unit)
α	Percentage of usable beet amount for production (%)
π	Percentage of obtained liquid sugar from crystal sugar (%)
β	Percentage of occurred beet pulp amount from sugar production (%)

The model *decision variables* are defined as follows:

X_{ijw}	Quantity of sugar beet transport from hacienda *i* to production facility *j* in week *w* (tons)
Y_{jm}	Quantity of crystal sugar transport from production facility *j* to packaging line *m* (kg)
Z_{jn}	Quantity of cube sugar transport from production facility *j* to packaging line *n* (kg)
W_{jo}	Quantity of liquid sugar transport from production facility *j* to packaging line *o* (lt)
T_{js}	Quantity of beet pulp transport from production facility *j* to packaging line *s* (kg)
Q_{mkh}	Quantity of packaged *h* transport from packaging line *m* to customer k (unit)
R_{nke}	Quantity of packaged *e* transport from packaging line *n* to customer k (unit)
I_{okv}	Quantity of packaged *v* transport from packaging line *o* to customer k (unit)
H_{slu}	Quantity of packaged *u* transport from packaging line *s* to customer k (unit)

The *objective function* of the developed model is written as follows:

Minimizing

$$\sum_i\sum_j\sum_w X_{ijw}.C_{ijw}+\sum_m\sum_k\sum_h Q_{mkh}.C_{mkh}+\sum_n\sum_k\sum_e R_{nke}.C_{nke}+\sum_o\sum_k\sum_v I_{okv}.C_{okv}+\sum_s\sum_l\sum_u H_{slu}.C_{slu} \quad (1)$$

The objective function (1) seeks to minimize the overall transportation cost between all the points of the distribution network and assumes that this cost is a linear function of the per unit distance travel cost. The first part of the objective function tries to minimize the transportation cost between haciendas and production facilities. The rest parts of the function deal with minimizing the transportation cost between packaging lines and customer zones.

The *constraints* of the model are shown as follows:

$$\sum_j X_{ijw} \le a_{iw} \qquad \forall_{i,w} \tag{2}$$

$$\sum_m Y_{jm} + \sum_n Z_{jn} + \sum_o W_{jo} + \sum_s T_{js} \le b_j \qquad \forall_j \tag{3}$$

$$P_h \sum_k \sum_h Q_{mkh} \le C_m \qquad \forall_m \tag{4}$$

$$P_e \sum_k \sum_e R_{nke} \le C_n \qquad \forall_n \tag{5}$$

$$P_v \sum_k \sum_v I_{okv} \le C_o \qquad \forall_o \tag{6}$$

$$P_u \sum_l \sum_u H_{slu} \le C_u \qquad \forall_s \tag{7}$$

$$\sum_m Q_{mkh} \ge D_{kh} \qquad \forall_{k,h} \tag{8}$$

$$\sum_n R_{nke} \ge D_{ke} \qquad \forall_{k,e} \tag{9}$$

$$\sum_o I_{okv} \ge D_{kv} \qquad \forall_{k,v} \tag{10}$$

$$\sum_s H_{slu} \ge D_{lu} \qquad \forall_{l,u} \tag{11}$$

$$\alpha \sum_i \sum_w X_{ijw} = \sum_m Y_{jm} + \sum_n Z_{jn} + \sum_o W_{jo} \qquad \forall_j \tag{12}$$

$$\beta.\alpha \sum_i \sum_w X_{ijw} = \sum_s T_{js} \qquad \forall_j \tag{13}$$

$$\sum_j Y_{jm} = P_h . \sum_k \sum_h Q_{mkh} \qquad \forall_m \tag{14}$$

$$\sum_j Z_{jn} = P_e . \sum_k \sum_e R_{nke} \qquad \forall_n \tag{15}$$

$$\pi . \sum_j W_{jo} = P_v . \sum_k \sum_v I_{okv} \qquad \forall_o \tag{16}$$

$$\sum_j T_{js} = P_u . \sum_l \sum_u H_{slu} \qquad \forall_s \tag{17}$$

$$X_{ijw}, Y_{jm}, Z_{jn}, W_{jo}, T_{js}, Q_{mkh}, R_{nke}, I_{okv}, H_{slu} \ge 0 \qquad \forall_{i,j,m,n,o,s,w,h,e,v,u,k,l} \tag{18}$$

Equation (2) forces the sugar beet quantity from each hacienda *i* to be equal or less than the harvesting capacity of the hacienda during any week *w*. Equation (3) ensures that the sugar quantity which is transported to all packaging lines is equal or less than the production facilities capacity. Equations (4-7) provide that all packaged sugar types (crystal, cube, liquid) and beet pulps which are transported to customer zones must be equal or less than the packaging capacities of each packaging line. Equations (8-11) guarantee the satisfaction of each customer. These constraints ensure that all packaged sugar and beet pulps are delivered from the appropriate packaging lines to customers. Equation (12) forces the whole quantity sugar beet received from haciendas to be transferred from the production facilities to the respective packaging lines. Equation (13) shows that a certain percentage of total sugar beet quantity received from haciendas is equal to the quantity of beet pulp. Equations (14-17) ensure that the total sugar quantity which is transferred from production facilities to each packaging line is equal to the total sugar packages which are delivered to each customer. Equation (18) guarantees that the problem decision variables take non-negative real values.

APPLICATION OF THE PROPOSED MODEL TO THE CASE STUDY

We tested the proposed approach for the KSI which is mentioned in the following subsection.

Konya Sugar Industry

KSI was established in 1952 by a capital of 10.000.000.-TL (Turkish Liras) under the partnerships of Beet Planters production Co-ops of Konya, Eskisehir, Aksehir, Ilgin. The foundation of KSI, the first sugar plant of the company, was laid on 13th September of 1953; the machinery and facilities of the plant were given out to a German REDE company by contract. The production was commenced on 19th September of 1954. The initial capacity of the plant was 1.800 tons/day and the first cropped area was designated as 13.000 hectares. The plant achieved a beet slicing capacity of 2.700 tons/day in 1966, 6.000 tons/day in 1978, and 10.000 tons/day in 1997. In order to utilize the molasses and wet pulp through by products, plant for dried pulp with molasses with a total production capacity of 400 tons/day, consisting of 3 units was put into use in 1977 and enriched feed facility with a capacity of 20 tons/hour was put into use in 2003. An investment valued at $ 50 Million was made in order for KSI to be modernized and overhauled again in accordance with the newly developing technologies. As a consequence of these investments, the daily capacity of processed beet rose, the rate of sugar remaining in molasses fell, the expenditures of fuel and workmanship reduced. Thus, the company carried an interest of approximately $ 167 Million in 10 years. Furthermore, with environmental consciousness, the company established industrial wastewater treatment plant, state of the art technology product in KSI. Thus, while this facility using less water contributed favorably to environmental stability, treated water attained the properties which could be used in agricultural irrigation. KSI received the certificates of TSE-ISO-EN 9000 Quality Management System, TS-13001 TSE-HACCP Hazard Analysis and Critical Control Points, TSE-ISO EN-22000 Food Safety Management System, TS-ISO-EN 14.000 Environmental Management System. KSI became a giant industrial enterprise directing Turkish agricultural sector as 52nd big company within the biggest 500 industrial enterprises of Turkey [24].

The foundation of Çumra Sugar Industry (CSI), the second sugar plant, was laid on 2003. CSI with a beet processing capacity of 14.000 tons/day, which was completed within a period less than one year, commenced the production on 2004. The establishment of new facilities which were integrated with CSI were proceeded and the first liquid sugar production facility of Turkey, which had a yearly capacity of 52.000 tons at the beginning, was established initially. The capacity of the liquid sugar facility was doubled through a new investment in January 2007 and achieved the capacity to produce 140.000 tons of liquid sugar per year. The crystal sugar, which is the primary production matter, was aimed to be made use of better and product range was aimed at in its introduction to the market; facilities of crystal sugar packaging, cube sugar production were completed and the products were introduced to the market by having been focused on the investments in this respect. Bio-ethanol facility with the production capacity of 84.000.000 liters/year commenced the production in September 2007 by having been completed in CSI, which will contribute to prevent reduction of the reserves of fossil fuels and rise of their costs, reduction of petroleum import in Turkey which is not petroleum rich and the global pollution [24].

Case Study Application

The purpose of the application is to give a sample of the sugar type production/distribution as well as the shipping assignments produced by the model. For the application, we consider the network from haciendas to private label customers and pulp customers. At first echelon we use a dynamic modeling via adding period (four weeks). We try to optimize the sugar flow between haciendas-production facilities- packaging lines-customer zones (Fig. 4). KSI is able to produce various types of sugar. We handled crystal, cube and liquid ones which are most consumed and beet pulps as co-product. Beets are picked from six haciendas areas (Seydisehir, Kulu, Beysehir, Altinekin, Cumra, Cihanbeyli) nearby Konya city. After collecting them in four weeks, they are transported to production facilities (Konya and Cumra). The model is solved by using LINDO 6.0 solver on a Pentium IV 3.2 GHz personal computer for the parameters presented in the following tables with the intention of obtaining optimal values.

TABLE 1
The Size of the Model and the Other Parameters

i: 6	j: 2	m: 2	n: 2	o: 2	β: 25%	P_v: 1, 5 lt
s: 2	w: 4	h: 3	e: 3	v: 2	P_h: 25, 50, 1000 kg	P_u: 500, 1000 kg
u: 2	k: 9	l: 5	π: 55%	α: 85%	P_e: 1, 2, 5 kg	

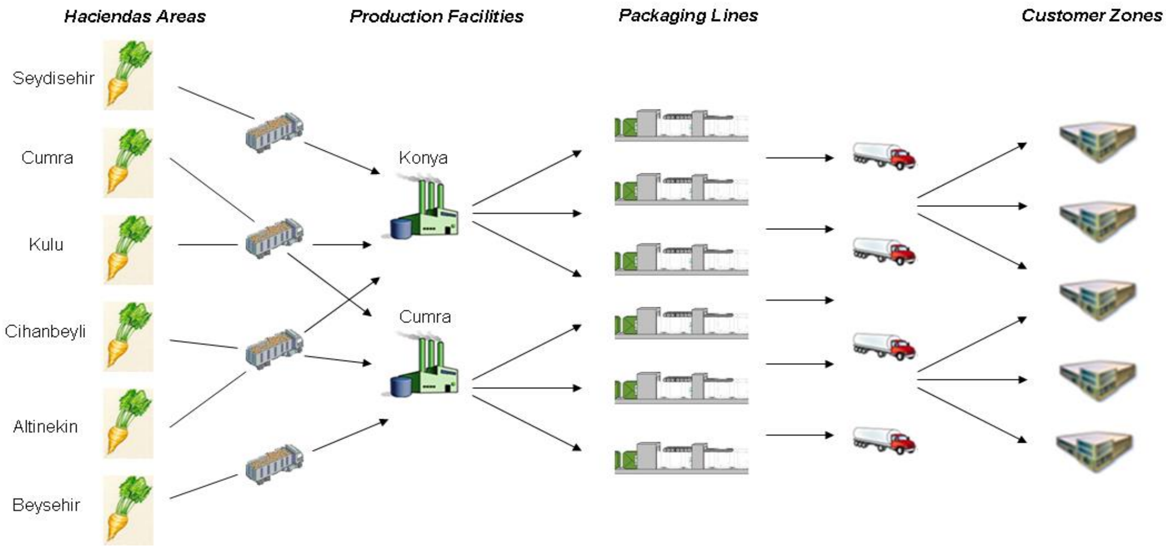

FIGURE 4
Sugar Production/Distribution Flow of the Case Study

TABLE 2
The Transportation Costs Between Haciendas (i) and Production Facilities (j)

Haciendas	**Konya**				**Cumra**			
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
Seydisehir	3	2.8	2.7	3	4	4.2	4.5	3.9
Kulu	4	3.5	3.6	4.1	3	3.1	2.8	2.6
Cumra	3	3.2	2.6	3	0.8	0.9	0.8	0.7
Cihanbeyli	2.5	3	3.2	3.1	3.5	4	3.8	4
Beysehir	3.6	3.2	3.8	3.3	2.8	2.9	2.6	2.7
Altinekin	2.5	2.1	2.6	2.3	3	3.2	3.1	2.9

TABLE 3
The Transportation Costs between Packaging Lines (m, n, o) and Customers (k)

		Private label customers								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	25 kg	0.12	0.11	0.13	0.12	0.11	0.11	0.12	0.13	0.12
***m*: 1**	**50 kg**	0.24	0.23	0.22	0.23	0.24	0.25	0.26	0.25	0.24
	1000 kg	4.3	4.2	4.1	4.2	4.3	4.2	4.1	4.2	4.3
	25 kg	0.11	0.12	0.14	0.13	0.15	0.13	0.11	0.12	0.13
***m*: 2**	**50 kg**	0.23	0.22	0.23	0.24	0.25	0.24	0.22	0.23	0.24
	1000 kg	4.4	4.3	4.2	4.1	4.2	4.3	4.2	4.2	4.1
	1 kg	0.05	0.04	0.03	0.02	0.03	0.04	0.06	0.03	0.02
***n*: 1**	**2 kg**	0.09	0.08	0.08	0.09	0.09	0.09	0.09	0.08	0.08
	5 kg	1.3	1.2	1.1	1.2	1.3	1.2	1.1	1.2	1.3
	1 kg	0.01	0.02	0.04	0.03	0.05	0.03	0.01	0.02	0.03
***n*: 2**	**2 kg**	0.09	0.08	0.09	0.09	0.08	0.09	0.08	0.09	0.09
	5 kg	1.4	1.3	1.2	1.1	1.2	1.3	1.2	1.2	1.1
***o*: 1**	**1 lt**	0.01	0.02	0.04	0.03	0.05	0.03	0.01	0.02	0.03
	5 lt	0.09	0.08	0.09	0.09	0.08	0.09	0.08	0.09	0.09
***o*: 2**	**1 lt**	0.01	0.02	0.04	0.03	0.05	0.03	0.01	0.02	0.03
	5 lt	0.09	0.08	0.09	0.09	0.08	0.09	0.08	0.09	0.09

TABLE 4

The Transportation Costs between Packaging Line (s) and Customers (l)

		Beet pulp customers				
		1	**2**	**3**	**4**	**5**
s: 1	**500 kg**	3	2.8	3.1	3.2	2.8
	1000 kg	32	32	34	33	31
s: 2	**500 kg**	2.9	2.8	2.9	3.1	3.2
	1000 kg	31	32	32	31	30

TABLE 5

Capacities of each Hacienda during any Week

	Haciendas					
Weeks	**Seydisehir**	**Kulu**	**Cumra**	**Cihanbeyli**	**Beysehir**	**Altinekin**
1	17000	18000	19000	17000	18000	19000
2	18000	17000	19000	19000	18000	19000
3	19000	18000	18000	19000	18000	18000
4	19000	19000	17000	19000	19000	19000

TABLE 6

Capacities of Production Facilities and Packaging Lines

	j: 1	***j:*** 2	***m:*** 1	***m:*** 2	***n:*** 1	***n:*** 2	***o:*** 1	***o:*** 2	***s:*** 1	***s:*** 2
Capacities	160000	270000	230000	270000	65000	73000	45000	55000	100000	120000

TABLE 7

Demands of each Private Label Customers (k)

		Private label customers								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	25 kg	100	100	100	100	100	100	100	100	100
h	**50 kg**	50	50	50	50	50	50	50	50	50
	1000 kg	10	10	10	10	10	10	10	10	10
	1 kg	1000	1000	1000	1000	1000	1000	1000	1000	1000
e	**2 kg**	500	500	500	500	500	500	500	500	500
	5 kg	100	100	100	100	100	100	100	100	100
v	**1 lt**	1200	1200	1200	1200	1200	1200	1200	1200	1200
	5 lt	300	300	300	300	300	300	300	300	300

TABLE 8

Demands of each Beet Pulp Customer (l)

		Beet pulp customers				
		1	**2**	**3**	**4**	**5**
u	**500 kg**	6	4	4	5	6
	1000 kg	7	6	7	7	5

The model presented here has many input parameters, as can be seen in the previous Tables 1-8. In this example, there are 1208 constraints and 226 total variables. Using LINDO 6.0 with 3(s) elapsed time, we obtained the optimal solution as shown in Table 9.

TABLE 9
Optimum Outputs of the Model

Variable	Value	Variable	Value	Variable	Value	Variable	Value	Variable	Value
$\mathbf{X}_{113}$	19000	$\mathbf{Q}_{152}$	50	$\mathbf{R}_{132}$	500	$\mathbf{R}_{283}$	100	$\mathbf{H}_{212}$	7
$\mathbf{X}_{223}$	15272	$\mathbf{Q}_{161}$	100	$\mathbf{R}_{133}$	100	$\mathbf{R}_{293}$	100	$\mathbf{H}_{221}$	4
$\mathbf{X}_{224}$	19000	$\mathbf{Q}_{163}$	10	$\mathbf{R}_{141}$	1000	$\mathbf{I}_{111}$	1200	$\mathbf{H}_{222}$	6
$\mathbf{X}_{321}$	19000	$\mathbf{Q}_{173}$	10	$\mathbf{R}_{151}$	1000	$\mathbf{I}_{121}$	1200	$\mathbf{H}_{231}$	4
$\mathbf{X}_{322}$	19000	$\mathbf{Q}_{183}$	3	$\mathbf{R}_{163}$	100	$\mathbf{I}_{122}$	300	$\mathbf{H}_{232}$	7
$\mathbf{X}_{323}$	18000	$\mathbf{Q}_{191}$	100	$\mathbf{R}_{173}$	100	$\mathbf{I}_{131}$	1200	$\mathbf{H}_{241}$	5
$\mathbf{X}_{411}$	17000	$\mathbf{Q}_{192}$	50	$\mathbf{R}_{182}$	500	$\mathbf{I}_{132}$	300	$\mathbf{H}_{242}$	7
$\mathbf{X}_{521}$	18000	$\mathbf{Q}_{211}$	100	$\mathbf{R}_{191}$	1000	$\mathbf{I}_{142}$	300	$\mathbf{H}_{252}$	5
$\mathbf{X}_{523}$	18000	$\mathbf{Q}_{212}$	50	$\mathbf{R}_{192}$	500	$\mathbf{I}_{151}$	1200	$\mathbf{Y}_{11}$	78200
$\mathbf{X}_{524}$	19000	$\mathbf{Q}_{222}$	50	$\mathbf{R}_{211}$	1000	$\mathbf{I}_{152}$	300	$\mathbf{Y}_{22}$	56800
$\mathbf{X}_{612}$	19000	$\mathbf{Q}_{243}$	10	$\mathbf{R}_{212}$	500	$\mathbf{I}_{161}$	1200	$\mathbf{T}_{11}$	8328
$\mathbf{X}_{613}$	18000	$\mathbf{Q}_{253}$	10	$\mathbf{R}_{221}$	500	$\mathbf{I}_{162}$	300	$\mathbf{T}_{12}$	10992
$\mathbf{X}_{614}$	19000	$\mathbf{Q}_{262}$	50	$\mathbf{R}_{222}$	100	$\mathbf{I}_{171}$	1200	$\mathbf{T}_{22}$	30507
$\mathbf{Q}_{113}$	10	$\mathbf{Q}_{271}$	100	$\mathbf{R}_{242}$	500	$\mathbf{I}_{181}$	1200	$\mathbf{Z}_{21}$	9500
$\mathbf{Q}_{121}$	100	$\mathbf{Q}_{272}$	50	$\mathbf{R}_{243}$	100	$\mathbf{I}_{182}$	300	$\mathbf{Z}_{22}$	13000
$\mathbf{Q}_{123}$	10	$\mathbf{Q}_{281}$	100	$\mathbf{R}_{252}$	500	$\mathbf{I}_{191}$	1200	$\mathbf{W}_{21}$	36545
$\mathbf{Q}_{131}$	100	$\mathbf{Q}_{282}$	50	$\mathbf{R}_{253}$	100	$\mathbf{I}_{192}$	300	$\mathbf{W}_{22}$	7636
$\mathbf{Q}_{132}$	50	$\mathbf{Q}_{283}$	7	$\mathbf{R}_{261}$	1000	$\mathbf{I}_{212}$	300		
$\mathbf{Q}_{133}$	10	$\mathbf{Q}_{293}$	10	$\mathbf{R}_{262}$	500	$\mathbf{I}_{241}$	1200		
$\mathbf{Q}_{141}$	100	$\mathbf{R}_{113}$	100	$\mathbf{R}_{271}$	1000	$\mathbf{I}_{272}$	300		
$\mathbf{Q}_{142}$	50	$\mathbf{R}_{123}$	100	$\mathbf{R}_{272}$	500	$\mathbf{H}_{151}$	6		
$\mathbf{Q}_{151}$	100	$\mathbf{R}_{131}$	1000	$\mathbf{R}_{281}$	1000	$\mathbf{H}_{211}$	6		

According to obtained optimum results, the objective function is 515355.60 TL. As seen from Table 9, 54000, 38000, 88272, and 57000 tons of sugar beet are collected from the haciendas and transported to production facilities, respectively. 135000 kg crystal sugar, 22500 kg cube sugar, 44181 lt liquid sugars are produced via processing these sugar beets. 49827 kg beet pulps are occurred as co-product after the sugar production. 900 units of 25 kg packaged; 450 units of 50 kg packaged; 90 units of 1000 kg packaged crystal sugar are transported to private label customers. 9000 units of 1 kg packaged; 4500 units of 2 kg packaged; 1000 units of 5 kg packaged cube sugar are delivered from cube sugar packaging lines to customers. 10800 units of 1 lt packaged and 2700 units of 5 lt packaged liquid sugar are delivered to private label customers. At last, 25 units of 500 kg packaged and 32 units of 1000 kg packaged beet pulps are sent to customers who require pulps.

CONCLUSION

Optimizing the product flow with assigning transportation areas is a very complex task of the supply chain to perform manually in practice. This is due to supplying a large number of transportation of different types of product, adhering the capacities, and adhering to capabilities of production and changing product types. The contribution of this research is optimizing the sugar production/distribution network flow with developed linear mathematical model. The aim of the paper is to ensure that providing how many tons beet are adequate to answer and satisfy all customers according to their different sugar type demands (crystal, cube, liquid and pulp as co-product). The paper consists of four parts basically. At first part, we try to give the situation of sugar production especially beet sugar and the development in Turkey sugar industry. Then we give a literature review about supply chain network modeling deal with sugar production/distribution. At third part, the objective of the paper, the developed mathematical model is given with its indices, parameters, variables, objective function and constraints. At last, the proposed model is applied to a case study in KSI at fourth part, and the results are discussed.

The model has been overcome the complexity situations in sugar flow between haciendas and end-customers. The model provides useful insights for the decision makers, helping them to better comprehend the variables and important issues that are being considered in the KSI case study. The proposed logistic model allows seeing the capacity conditions, bottlenecks and weekly management of sugar beets supply.

For the future researches, analyzing the effects of uncertainties in the parameters, changing constraints, robust optimization techniques could be considered. Also as addition, the company may develop similar model to optimally locate, layout and manage capacities of its multiple warehouses. Cultivation of the haciendas, harvesting, and dispatching of the harvesting crew and equipments could be embedded to model.

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OPTIMIZATION ON ROUND TRIP CYCLE TIME OF UNINTERRUPTED SUPPLY CHAIN FOR SIEMENS HEALTHCARE SPARE PARTS

Yüksel, Cem Sonat[1], Güven, Sevilay[2], Dinsel, Alper[3], Gelibolu, Gürkan[4]

Abstract — *Siemens Healthcare products are critical devices like MRs, tomography scanners, x-Rays, etc which are distributed all over Turkey. Spare part supply chain initiates from Siemens Healthcare World Distribution Center(WDC) at Erlangen, Germany where nearly 50 000 different type of spare parts are stored. Uninterrupted supply chain starts from WDC and includes all steps of logistics operation until the parts are returned back to WDC. All used/damaged spare parts has to be returned to WDC within 50 days where any discrepancy causes severe daily penalties. Spare parts are ordered by Siemens Turkey in daily ad-hoc basis and the fast airfreight and logistics services are operated by Schenker Arkas Logistics combined with local customs broker. Project has been started with a total inbound operation time 3-7 days and with a round trip cycle time exceeding 50 days hence causing penalties. Optimization of the supply chain is realized by a group of professionals from Siemens Healthcare Division, Siemens Supply Chain Division, Schenker Germany Airfreight Division and Schenker Arkas Turkey (airfreight, logistics and IT departments). Siemens Healthcare product database and import/export ERP's are tied up with Schenker shipment Tracking and Ordering Systems on IT wise via extensive EDI implementation. Additional customer specific tracking mechanisms are implemented where the aim was to ensure end-to-end traceability of spare parts and measure the performance of entire operation.*

Keywords — uninterrupted supply chain, healthcare, optimization, airfreight shipment tracking, event tracking, service quality increase, collaboration, purchase order management, spare parts logistics

CONDITIONS BEFORE OPTIMIZATION

Siemens Healthcare devices are highly critical machines like tomography, Xray, ultrasonography devices where continuous operation and quick maintenance is one of the major selection criterias. Devices are distibuted all over Turkey which increases the complexity of spare parts distibution planning due to road conditions and availability of national airports. Spareparts are distiributed (for Turkey) from World Distribution Center (WDC) in Erlangen, Germany. After usage, all damaged spare parts has to be returned to WDC in 50 days. Parts not returned in 50 days are due to severe penalties according to internal rules of Siemens.

Before the USC Optimization Project the spare parts supply chain was managed internally by Siemens Healthcare and Procurement Departments and Schener Arkas was only the transportation partner (FIGURE 1). Inbound operations were around 3-7 days even for Istanbul and return operations were exceeding 50 days limit and some penalties had occured. The aim of the project was to cut the inbound operations to 1-3 days and return cycle time below 40 days.

Key point in optimization was to install full tracebility of the ordered spare parts and share this information with operation teams. The existing IT infrastructure has to be enhanced to increase the tracebility.

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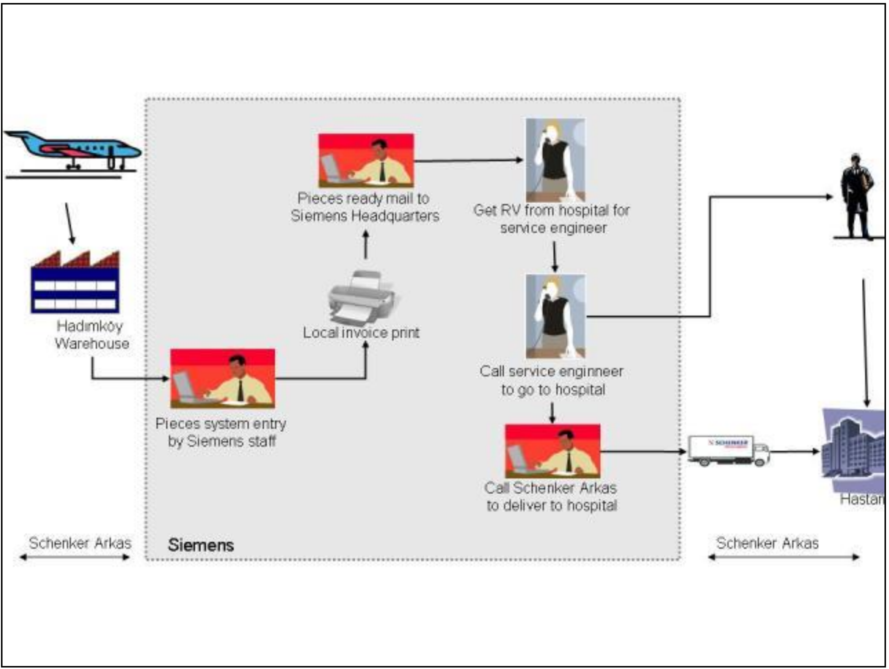

FIGURE 1
Process flow before USC Optimization Project

INBOUND LOGISTICS

Inbound logistics consists of below process steps :

- Order entry by Siemens and its transfer to Siemens Germany via internal EDI (Siemens TR)
- Order packing and export documents preparation before pick-up time (WDC)
- Pick-up of orders and preparation of flight documents (Schenker Germany)
- Goods are transported through night flight and arrive to Turkey at 2:30 am
- Electronic customs registration and documents delivered to customs broker before 10:30 (Schenker Arkas Airfreight Dept)
- Customs clearance of each order (local customs broker)
- Preparation of local invoice and dispatch notes (Schenker Arkas Hadımköy Logistics Operations)
- Taking the goods from the airport bonded warehouse and dispatch to hospital
- Getting appointment from the related person in the hospital (Siemens USC)
- Organising field maintenance enginneer to receive the spare part in the hospital (Siemens USC)

Optimization project started by analysing the spare part order times (FIGURE 2). Pick-up time in WDC

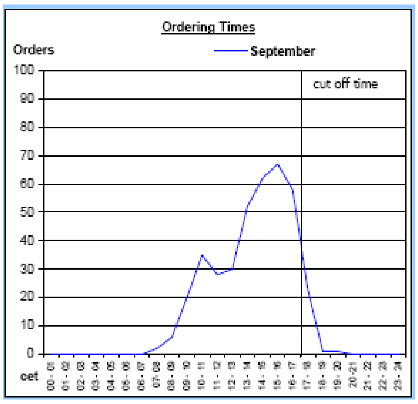

FIGURE 2
Order times distribution

was 17:30 (CET) before the project. Analysis of ordering times showed that most of the maintenance work was done in the afternoon hence important amount of parts were ordered ofter 17:00. Schenker Germany have obtained 1 hour push forward in pick-up times by negotiating shipment delivery cut-off times with the airfreiht carrier Lufthansa. Hence pick-up time 18:30 (CET) at WDC have given enough time to order parts to Siemens Turkey. This important change increased especailly “next day” deliveries in Istanbul area.

IT infrastructure and traceability enhancement

There exists an EDI connection between Siemens Turkey, Siemens Germany and Schenker Germany (FIGURE 3)

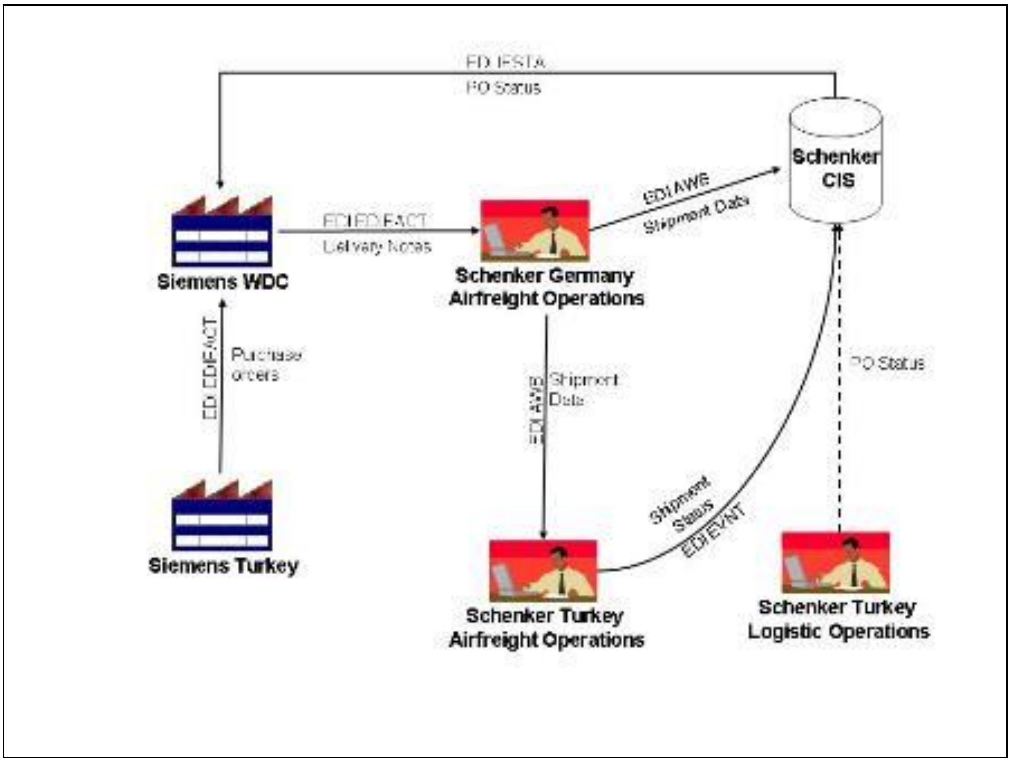

FIGURE 3
Siemens - Schenker EDI Infrastructure

The Purchase orders created by Siemens Supply Chain Management(SCM) are transfered instantly to Siemens Healthcare WDC for immediate processing. Every PO has a unique number (ex 4500420115) WDC prepares the orders, creates Delivery Notes and sends the data to Schenker Germany via EDIFACT. Every delivery note has a unique number which is also the main index for goods tracking (ex SIM410084738956). Schenker Germany Airfreight operations receives the dispatch notes and consolidates daily orders (15-20 average) to form a shipment and assigns Schenker unique Track and Trace number (STT). Shipment data is instantly transferred to Schenker Arkas Airfreight via internal Schenker AWB messaging system including PO details. All data is visible in Schenker Customer Information system (CIS) under project code WWECTL. Schenker Arkas Airfreight operational system creates shipment status events and all these events are sent to CIS for customer visibility. CIS also translates shipment and PO level events to Siemens standart tracking events and sends them back to Siemens.

During the optimization analysis, the team determined that multitude of shipments and their related events were creating operational difficulty if operations were working with the shipments/POs one by one. Thus, project team decided to create a detailed automatic report out of CIS and make it produced everyday in a given time. Another problem was that final distribution addresses of each PO was not visible in CIS because every shipment was addressed to Siemens Turkey for commercial customs clearing. We have decided to add manual events to CIS on PO level (special information SIC event) which will show the final delivery address and city of each PO. The report is created for the last 90 days showing almost the whole history of each PO (FIGURE 4) Event update authorisation is also given to customs broker who will key in manually the CCD-custom cleared event. The events showing inland domestic distribution of each PO is manually keyed in directly to CIS on PO level. Report also shows instant performance measures for Schenker airfreight operations, customs clearance operations and domestic distibution operations seperately.

DRB	CCD	SIC (IST) Reason Text-Delivery Address	AWR	AWR Reason text	CDD	DLN	EIW	RDD	RDD Reason Text	DLV	DLV Reason Text
28.06.2010 08:02:00	29.06.2010 12:50:00	000;34-GEMI INSA SANAYICILER#			29.06.2010 08:00:00	29.06.2010 08:30:00		29.06.2010 16:15:00	000;34-GEMI INSA SANAYICILER#	29.06.2010 16:00:00	000;34-GEMI INSA SANA
28.06.2010 08:02:00	29.06.2010 12:50:00	000;33-MERSIN DEVLET HASTANESI#			29.06.2010 08:00:00	29.06.2010 08:30:00	29.06.2010 16:00:00	30.06.2010 16:00:00	000;33-MERSIN DEVLET HASTANESI#	30.06.2010 15:30:00	000;33-MERSIN DEVLET
28.06.2010 08:02:00	29.06.2010 12:50:00	000;14-IZZET BAYSAL BOLU HASTANESI#			29.06.2010 08:00:00	29.06.2010 08:30:00	29.06.2010 16:00:00	30.06.2010 11:00:00	000;14-IZZET BAYSAL BOLU HASTANESI#	30.06.2010 10:30:00	000;14-IZZET BAYSAL B
29.06.2010 13:32:00	30.06.2010 09:45:00	000;DEPO#	30.06.2010 14:00:00	000;DEPO#	30.06.2010 14:00:00					30.06.2010 14:00:00	000;DEPO#
29.06.2010 13:32:00	30.06.2010 09:45:00	000;DEPO#	30.06.2010 14:00:00	000;DEPO#	30.06.2010 14:00:00					30.06.2010 14:00:00	000;DEPO#
29.06.2010 13:32:00	30.06.2010 09:45:00	000;34-RADYOMAR SAGLIK#	30.06.2010 14:30:00	032;34-RADYOMAR SAGLIK#							
29.06.2010 13:32:00	30.06.2010 09:45:00	000;34-BAKIRKOY SADI KONUK HAST.#			30.06.2010 08:00:00	30.06.2010 08:30:00		30.06.2010 13:00:00	000;34-BAKIRKOY SADI KONUK HAST.#	30.06.2010 12:40:00	000;34-BAKIRKOY SADI
29.06.2010 13:32:00	30.06.2010 09:45:00	000;16-MEDICAL PARK SAG. HIZ.BURSA#			30.06.2010 08:00:00	30.06.2010 08:30:00	30.06.2010 16:00:00	01.07.2010 11:00:00	000;16-MEDICAL PARK SAG. HIZ.BURSA#	01.07.2010 10:30:00	000;16-MEDICAL PARK
09.07.2010 07:58:00	12.07.2010 10:20:00	000;61-KARADENIZ TEKNIK UNIV.#			12.07.2010 08:00:00	12.07.2010 08:30:00	12.07.2010 16:00:00	14.07.2010 16:00:00	000;61-KARADENIZ TEKNIK UNIV.#	14.07.2010 15:30:00	000;61-KARADENIZ TEK
09.07.2010 07:58:00	12.07.2010 10:20:00	000;61-KATU#			12.07.2010 08:00:00	12.07.2010 08:30:00	12.07.2010 16:00:00	14.07.2010 16:00:00	000;61-KATU#	14.07.2010 15:30:00	000;61-KATU#
16.07.2010 08:44:00	13.07.2010 10:45:00	000;01-BASKENT UNIV#			13.07.2010 08:00:00	13.07.2010 08:30:00	13.07.2010 16:00:00	14.07.2010 16:00:00	000;01-BASKENT UNIV#	14.07.2010 15:40:00	000;01-BASKENT UNIV#
16.07.2010 08:44:00	13.07.2010 10:45:00	000;01-FUZYON TESHIS GORUNTULEME#			13.07.2010 08:00:00	13.07.2010 08:30:00	13.07.2010 16:00:00	14.07.2010 16:00:00	000;01-FUZYON TESHIS GORUNTULEME#	14.07.2010 15:40:00	000;01-FUZYON TESHIS
16.07.2010 08:44:00	13.07.2010 10:45:00	000;34-AMERIKAN HASTANESI#			13.07.2010 08:00:00	13.07.2010 08:30:00		14.07.2010 11:00:00	000;34-AMERIKAN HASTANESI#	14.07.2010 10:30:00	000;34-AMERIKAN HAST
16.07.2010 08:44:00	13.07.2010 10:45:00	000;DEPO#	13.07.2010 13:30:00	000;DEPO#	13.07.2010 13:30:00					13.07.2010 13:30:00	000;DEPO#
16.07.2010 08:44:00	13.07.2010 10:45:00	000;DEPO#	13.07.2010 13:30:00	000;DEPO#	13.07.2010 13:30:00					13.07.2010 13:30:00	000;DEPO#
16.07.2010 08:44:00	13.07.2010 10:45:00	000;34-ADC SAGLIK HIZM.#			13.07.2010 08:00:00	13.07.2010 08:30:00		13.07.2010 14:30:00	000;34-ADC SAGLIK HIZM.#	13.07.2010 14:15:00	000;34-ADC SAGLIK HIZ
08.07.2010 09:38:00	09.07.2010 12:35:00	000;DEPO#	09.07.2010 15:00:00	000;DEPO#	09.07.2010 15:00:00					09.07.2010 15:00:00	000;DEPO#
13.07.2010 12:40:00	13.07.2010 15:00:00	000;34-IBB KADIN SAGLIGI MERKEZI#			14.07.2010 08:00:00	14.07.2010 08:15:00		14.07.2010 10:00:00	000;34-OZEL ARAC IBB#	14.07.2010 09:30:00	000;34-OZEL ARAC IBB#
13.07.2010 12:40:00	14.07.2010 12:50:00	000;34-BASKENT UNIVERSITESI#			14.07.2010 08:00:00	14.07.2010 08:30:00		14.07.2010 15:30:00	000;34-BASKENT UNIVERSITESI#	14.07.2010 15:15:00	000;34-BASKENT UNIVE
13.07.2010 12:40:00	14.07.2010 12:50:00	000;42-NUMUNE HASTANESI#			14.07.2010 08:00:00	14.07.2010 08:30:00	14.07.2010 16:00:00	15.07.2010 16:00:00	000;42-NUMUNE HASTANESI#	15.07.2010 15:45:00	000;42-NUMUNE HASTA
15.07.2010 07:53:00		000;45-CELAL BAYAR UNIV.#			16.07.2010 08:00:00	16.07.2010 08:30:00	16.07.2010 16:00:00	19.07.2010 11:00:00	000;45-CELAL BAYAR UNIV.#	19.07.2010 10:30:00	000;45-CELAL BAYAR UI
15.07.2010 07:53:00		000;35-KOCAELI UNIVERSITESI#			19.07.2010 08:00:00	19.07.2010 08:30:00	19.07.2010 16:00:00	19.07.2010 11:00:00	000;35-KOCAELI UNIVERSITESI#	19.07.2010 10:30:00	000;35-KOCAELI UNIVEF
16.07.2010 08:04:00	19.07.2010 10:35:00										
16.07.2010 08:04:00	19.07.2010 10:35:00	000;34-INTERNATIONAL HOSPT.#			19.07.2010 09:00:00	19.07.2010 09:15:00		19.07.2010 12:30:00	000;34-INTERNATIONAL HOSPT.#	19.07.2010 12:15:00	000;34-INTERNATIONAL

FIGURE 4
CIS Report Example

The project team determined below processes concerning spare parts distribution :

- Direct delivery shipments : POs dispatched directly from airport bonded warehouse to hospital
- Delayed delivery shipment : POs received to Schenker Arkas Hadımköy Logistic Center(HLC) for later delivery
- Replenishment orders : POs ordered for stock in Schenker Arkas HLCr
- Changed orders : POs whose delivery address have been changed after dispatching from WDC

Before optimizaton project all goods were taken to Schenker Arkas HLC for neutralisation of documents which was adding one day delay to all shipments. The aim of the project team was to minimize the delayed delivery cases and maximize direct delivery. Replenishment orders had to be distinguished as their shipment performance ends when they touch to Schenker Arkas HLC.

Siemens Supplier performance tracking system receives shipment status events from Schenker CIS and calculates the performance internally. To be able to reflect above processes, a new set of event translation had to be worked during the project. New events like CDD (Delivery order received) , PDL (Changed Order case) have been defined and their translations implemented.(Table1)

TABLE 9
Event translation table between Schenker CIS and Siemens SITRIS

Process step	CLP MS	IFTSTA status	Schenker status	Meaning, message creation event
Creation loading list WDC Neu-Isenburg	L310	IFTMIN	n.a.	Shipping order
Pick-up confirmation	L311	130	PKD	Confirmation generated on issue of AWB
Flight departure	L320	IFCSUM-V	DEP	Scheduled departure time from FRA
Flight arrival	L330	40	ARR	Actual flight arrival time to IST
Arrival,	L335	45	DRB	Documents ready for pick-up by broker
Customs cleared	L350	12	CCD	Customs clearance finished
Out for delivery	L360	35	CDD	Delivery note received
Delivered	L400	21	DLV	Final delivery at ship-to-address
Re-routed		76	PDL	Transport re-arranged, in terms of shipment handed over to another party on instructions received from shipper/ consignee

Another problem defined during the optimization was large number of people in Turkey and in Germany were working on the portions of the same data set and sharing information&documents was one of the key blocking point. Project team decided to implement a new tool Schenker Collaboration Platform, SchenkerNET dedicated only to Healthcare Spare parts supply chain. Created as a specific web site for the project, SchenkerNet receives the documents via email, keeps project master data and follow up tables can be shared on-line by both parties for process tracking.

FIGURE 5
SchenkerNet Collaboration platform

One key factor was to receive the PO documents (invoices showing final delivery address of each PO) as early as possible in the morning by Schenker Arkas Airfreight and HLC logistics operations. It is obtained that Schenker Germany Airfreight Operations sends the complete set of documents to SchenkerNet mailbox on 21:00 CET so the next day early morning all documents are ready for all operations in Turkey.

Inland Logistics Operations Re-organization

Following the IT enhancements on both sides, chaining of operation to gain time was possible. Main improvement was obtained when neutralization of goods (Siemens goods receipt action, printing of Siemens Delivery Note and local invoice, printing Schenker Arkas delivery note) was made parallel to customs clearance actions. Thus when customs clearance was finished, handling of the goods were made on the dispatch vehicle of Schenker Arkas and goods were ready to dispatch immediately. New logistics organization is shown on FIGURE 6

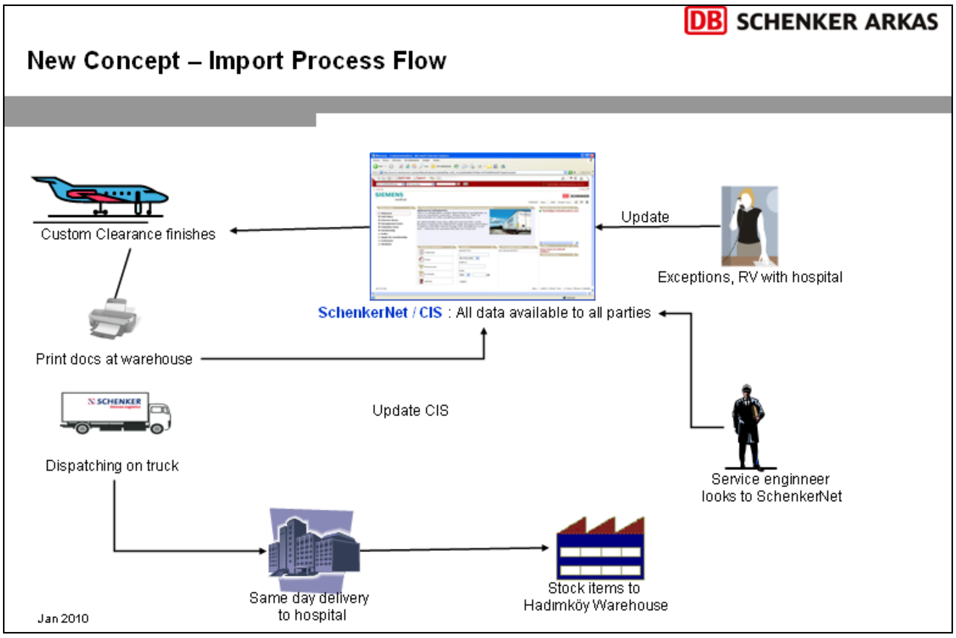

FIGURE 6
New concept of logistics distribution

With above concept, the next day delivery to Istanbul area became possible. Documents were prepared early in the morning following the status information received from customs broker. Upon receipt of goods from airport bonded warehouse, immediate handling and document neutralization is realized on the vehicle and goods are dispatched to Istanbul hospitals immediately. The evolution of the direct delivery and delayed delivery shipments can be seen on FIGURE 7.

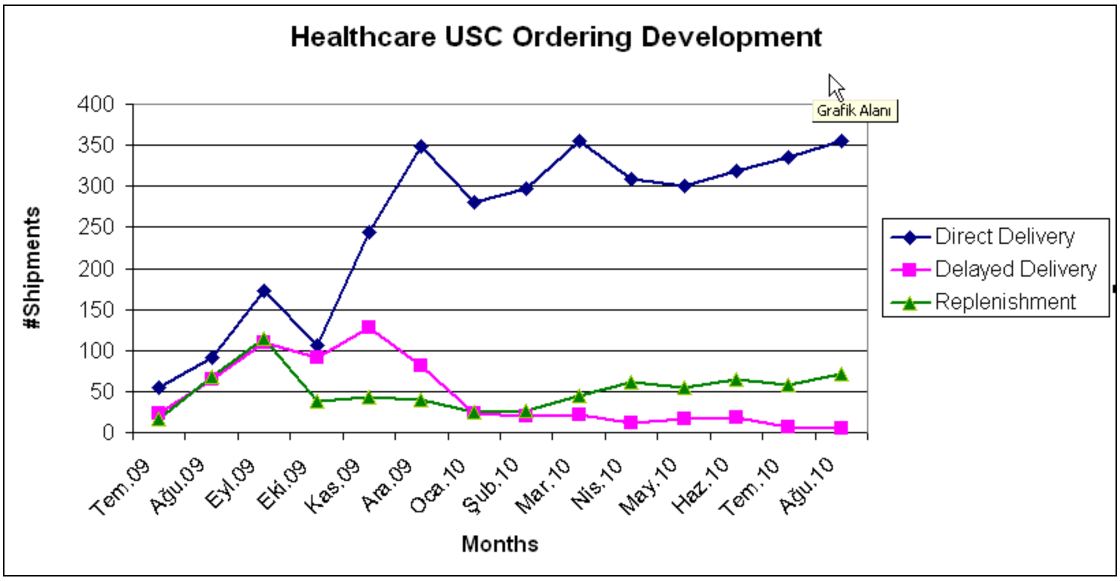

FIGURE 7
Spare parts delivery modes evaluation

REVERSE LOGISTICS

Damaged healthcare spare parts had to be returned to WDC upon usage of the received part in the hospital. Siemens internal rule is to return the damaged parts to WDC 50 days after dispatch date (round trip). The reverse logistics starts with the pick-up order of USC to Schenker Arkas HLC created on SchenkerNet on a specially designed form. Parts are collected to HLC, controlled, related documentation is prepared then informed to Siemens Turkey for preparation of export documents. Upon completion of export and customs documents goods are consolidated and returned to WDC by Schenker Arkas airfreight export operations. Following CIS, we can determine the WDC inbound date of every PO. (FIGURE 8)

Main problem here again was to share the different portions of the same data set by a large number of people. Most of the steps were not measurable as all parties were working on different ERP's. The project team decided to create a follow up excel table on SchenkerNet and all operations are marked by milestones according to Siemens internal procedures. As the damaged parts return to Germany in mixed order, it is decided to enter all received parts to return table immediately after their arrival to Turkey. This immediate registration helps us to keep track of the round trip cycle time as it is measured from WDC pick-up date. This process flow also enabled to track complete operations and measure the performance of each operational group.

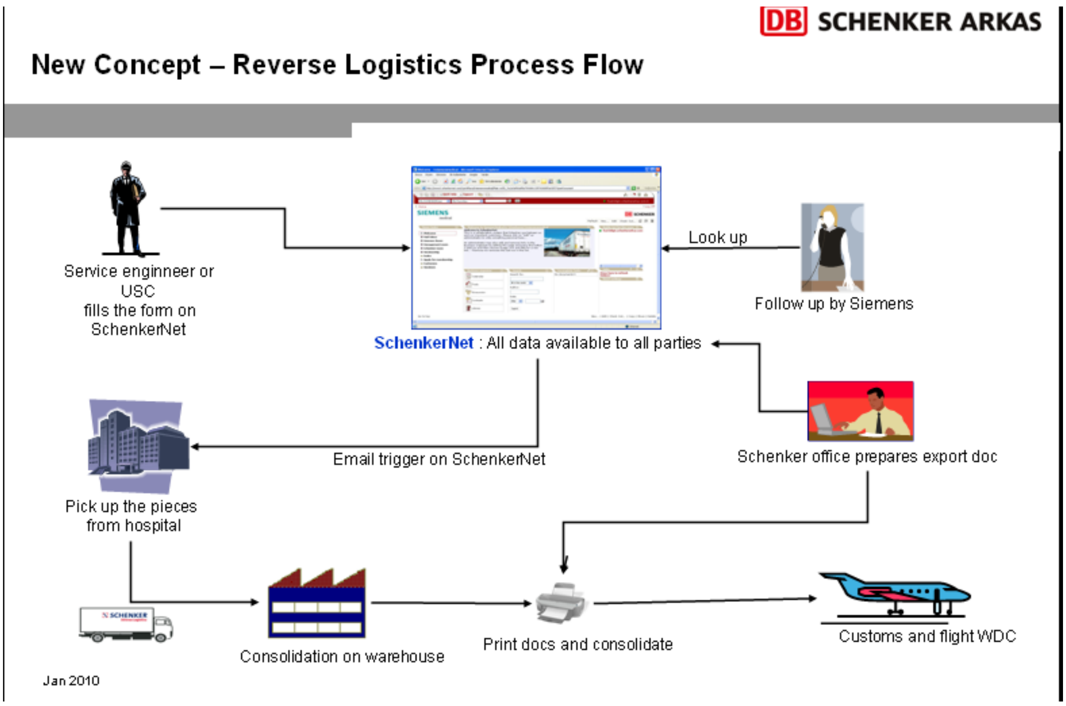

FIGURE 8
Reverse logistics process flow

Action	deadline	responsible	Expected Day #
Complete all necessary forms(GA form etc.) and put them into the box		CSE	0
Prepare DN for return		CSE	0
Leave part at customer site or drop at MNG location		CSE	0
Send notification to H CSSC(Healthcare Customer Services Support Center)		CSE	0
Fill in pick-up order form at Schenkernet (RD200)		CSSC	0
Enter pick-up order date in Spare Part prog.		CSSC	0
Enter or automaticly create pick-up order date in Schenker's reports acc. to pick-up order date at Schenkernet	until daily report(17:00h)	Schenker	0
Pick-up spare part from customer site (RD310)	in 24hrs after RD200 (pick-up order)	Schenker	1.
Enter pick-up date in Schenker's reports	until daily report(17:00h)	Schenker	1.-2.
Delivery of collected spare part to WH (RD400)	acc. to standart delivery times list	Schenker	2.-4.
Enter arrival date to WH in Schenker's reports and Spare Part prog.	until daily report(17:00h)	Schenker	2.-4.
Complete handling of return parts -Open and physical check of the spare part -Check forms and documents -Take "Reason of Return" data on GA form -Check serial number(where necessary) -Enter "Reason of Return" data in Spare Part prog. -Take Batch data(Rep/Orj/FoC) from Spare Part prog. -Movement of parts to export WH(5300) in SAP for non-defective parts. **-Enter the completion date in follow-up files(Schenkernet etc.)**	in 24hrs after RD400 (arrival to WH)	Schenker	3.-5.
Distribute the current list of return materials in WH every day	by 17:00h every day	Schenker	3.-5.
Packing order towards Schenker for normal and FoC exports seperately (RS100)	twice a week (e.g.: Mon and Thu)	SCM	5.-7.
Attach documents, forms and labels(FV etc.) for every part	in 24hrs after RS100(packing order)	Schenker	5.-8.
Pack the consolidated shipment	in 24hrs after RS100(packing order)	Schenker	5.-8.
Send the follow-up file including packing data immediately after packing (RS300)	in 24hrs after RS100(packing order)	Schenker	5.-8.
Prepare export list (Target: Tue and Fri)	in 2 hrs after receiving packing data	SCM	5.-8.
Create export invoice in SAP (Target: Wed and Mon)	in 24hrs after receiving export list	Healthchare	6.-9.
Print export invoice and complete IMEX processes	in 24hrs after receiving invoice	SCM	7.-11.
Send customs clearence and waybill instructions to Customs Broker(Sies) and to Schenker	in 24hrs after receiving invoice	SCM	7.-11.
Send original documents to customs broker and Schenker (Target: Thu and Tue)	in 24hrs after receiving invoice	SCM	7.-11.
Registration of Customs Declaration	in 24 hrs after CC instruction	Customs Broke	7.-12.
Transport to customs area (RS310) (Target:Fri and Wed)	in 24hrs after waybill instruction	Schenker	8.-12.
Clearence of export customs (Target:Fri or Wed)	in 24hrs after RS310	Customs Broke	8.-13.
Start of international transport (RS320) (Target:Fri and Wed)	in 24hrs after completion of CC	Schenker	8.-14.
Enter export date and EX..number in Spare Part prog.	until daily report(17:00h)	Schenker	8.-15.
Send one copy of waybill to SCM	asap	Schenker	9.-15.
Delivery of shipment to WDC (RS400) (Target: Mon and Thu)	in 48 hrs after RS320	Schenker	**9.-16.**

FIGURE 9
Reverse logistics process milestones

TABLE 10
Reverse logistics performance

Months	*Jan.10*	*Feb.10*	*Mart 10*	*Apr.10*	*May. 10*	*Jun.10*	*Jul.10*	*Aug.10*
Returned Materials		149	212	237	344	342	819	325
Average Cycle Time		30	32	36	34	31	32	33
Average Process Time		12	12	13	10	9	9	10

Folllowing the implementation of reverse logistics tracking, round trip cycle time of spare parts have been reduced to <40 days which gives flexibility to processing and “exoneration from penalty” right to Siemens USC.

CONCLUSION

After implementation of new organisation and tracking system, Siemens USC spare parts total delivery time (from pick-up in Germany to final delivery to hospital) for direct deliveries have been reduced on average to 2,53 days for Istanbul and 3,86 days for Anatolia including weekends (Aug 2010). The reflection of the new organisation to Siemens USC customers is also measured by Siemens. According to Happy Call survey conducted by Nielsen on every quartal with about 300 customers of Siemens, the satisfaction index about provision of spare parts increased by 14,1% (from 71 to 81) (FIGURE 10)

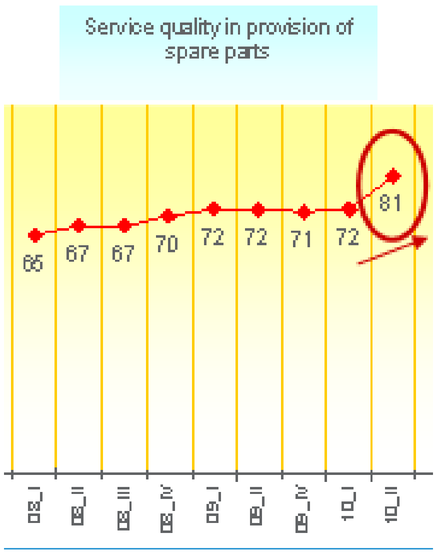

FIGURE 10
Service quality survey

This impressive increase in service quality of spare parts highly contributed to reinforce general satisfaction index in loyalty level.

DETERMINATION OF TEAMS IN GROUPS OF TURKISH FOOTBALL FEDERATION THIRD LEAGUE CLASSIFICATION GROUPS BY GENETIC ALGORITHMS

Dr. İbrahim Zeki Akyurt[1], Dr. Timur Keskintürk[2], Barış Kiremitci[3] Serap Kiremitci[4]

Abstract - *In this paper we have emphasized the use of genetic algorithms both as a tool and applicable to the formation of Sports League Groups. Determination of team members of each group is considered as a set partitioning problem which has diverse application fields. As most of the set partitioning problem variants are NP-hard combinatorial optimization problem, classical exact solution methods are confined to small size problem instances, we proposed a genetic algorithm approach for this problem. The primary objective of this paper is the determination of teams of each group for the purpose of minimizing the total travel distance taken by the teams of Turkish Football Federation Third League Classification Groups which have 5 separate groups and 53 different teams during the season of 2009-2010. While calculating the total travel distance matrices, distances between each team were obtained from Google Maps. The comparison of the computational results of proposed genetic algorithm and the actual Turkish Football Federation results was made and reported. It is found that almost 13 % percent improvement in solution value can be achieved. All the results were displayed in tables and on the maps.*

Key Words- Football League, Genetic Algorithms, Set Partitioning Problem, Turkey

SET PARTITIONING PROBLEM

The Set Partitioning Problem (SPP) is known to be NP-hard and it can be used to model many important real-world decision problems [1] including those involving railroad crew scheduling, truck deliveries, airline crew scheduling, tanker routing, information retrieval, switching circuit design, stock cutting, assembly line balancing, capital equipment decisions, location of offshore drilling platforms, some other facility location problems, political districting [2]. The problem is NP-Hard therefore heuristic algorithms have been developed. Since obtaining the results of the large size problems with standard methods, is very hard and complicated.

Set Partitioning problem can be formulated as follows:

$$Min \sum_{j}^{N} c_j x_j$$
$$Ax = e$$
$$x_j = \{0,1\}$$

A=(a_{ij}) is an $m*n$ matrix which consists of 0 and 1 (elements). c is an arbitrary n-vector, $e=(1,\ldots,1)$is an m-vector and N ={1,...,n}. If the rows of A are associated with the elements of the set M={1,...,m} and each column a_j of A with subset of M_j of those i € M such that a_{ij}=1, then SPP is the problem of finding a minimum-weight family of subsets M_j, j € N ,which is a partition of M, each subset being weighted with c_j.[2]

As SPP has wide applicability in many real – life problems, it has both exact and heuristics methods for its solution. The most common one of them, are those based on linear programming.

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There are different methods among the exact methods. The most classic one is to solve SPP with linear programming. It has noted that obtaining the solution is very easy in small size instances with this one. [3]-[4]-[2]. The other method among the exact ones is branch and bound method.

There are many papers concerning heuristic methods for the solution of SPP [5][6][7][8][9][10][11][12][13]. Genetic algorithms (GA) and Tabu Search are the heuristic methods used for. In references [14][15] [16][17][18][19], genetic algorithms is used for the solution of SPP and usually the application is about airline crew scheduling. Besides Tabu search method has also used to solve SPP [20][21].

In literature, Güngör ve Küçüksille [22] has used SPP in Football Leagues. They have seperated 51 teams into three groups in Turkish Football League B Cathegory with a GA based approach. In seperation of the groups, distances between the teams are minimized..

In this paper, the teams in Turkish Football Federation (TFF) Third League Classification Groups during the season of 2009-2010 are dealed with. There are 53 teams in 5 seperate groups. The first four groups are composed of 11 teams and the last group is composed of 9 teams. During the season, two matches are played between for each of the team and the other competitors in the same group. In the study comparison of the groups determined by the Turkish Football Federation (TFF) and by the proposed genetic algorithm was made according to the total distance taken by the teams during the whole season. The other constraints (if any) are not taken into consideration in the group assignment process.

GENETIC ALGORITHMS FOR SP PROBLEM AND APPLICATION

Genetic algorithms (GAs) which is a population-based meta-heuristic technique, was developed by Holland.[23][24] (Goldberg, 1989; Reeves, 1995) GA evolves a population of individuals encoded as chromosomes by creating new generations of offspring through an iterative process until some convergence criteria are met[25]. Solution values (variables) are represented in the vectors named chromosomes. This representation may be binary coding or actual values can also be used. For a given number interval, initial solutions are generated with values determined randomly. This group of solutions produced with the number of chromosomes (population size) is called Initial Population. Then the quality of each solution candidates is evaluated according to the problem-specific fitness function. Fitness function in our model is considered as minimization of the total travel distance. The creation of new generation population belonging to the next iterations, are made through GA operators like selection, crossover and mutation. The steps of GA are as follows:

Step 1: Generation of Initial Population
Step 2: Determination of Fitness Value
Step 3: Selection
Step 4: Crossover
Step 5: Mutation
Step 6: If stopping criterion is not achieved, go to the second step.
Step 7: Select the best solution as the result.[26][27]

The objective of this paper is the determination of teams of each group for the purpose of minimizing the total travel distance taken by the teams of Turkish Football Federation (TFF). The problem formulation and the notation is given as follows:

Notations:

N	:	Number of Teams
n	:	Team index n=1,..,N
K	:	Number of Groups
k	:	Group index k=1,.., K
V	:	Set of Teams
T_k	:	Number of teams in group k
S_k	:	Set of teams in group k, $S \leq V$
$c_{(x_i x_j)}$	:	Distance between team x_i and x_j, $\forall (i,j) \in V$
x_i	:	Problem variables, $\forall i \in V, x_i = [1, N]$

and integer formulation of Mathematical Model (Problem) is

$$\min \sum_{k=1}^{K} \sum_{i \in S_k} \sum_{j \in S_k} c_{[(x]_i, x_j)}, \quad i \neq j$$

Subject to:

$$|S_k| = T_k, \quad k = 1, \ldots, K$$

x_i =[1,N] and integer

In the problem, there are integer variables for each of the teams. These integer variables can take values between 1 and the total team number (N). According to this, there are variables as many as the team numbers and they can take integer values between [1, N] interval. In GA, variables are defined in genes within chromosomes. Each of the chromosomes represents an alternative solution as shown in Figure 1.

Groups	Group 1								Group 2								Group 3			
Team	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4
Chromosome	13	18	2	9	5	15	10	20	4	12	8	16	1	19	14	6	11	17	3	7

First group's first team

FIGURE 11
Chromosome Example

As can be seen in example chromosome, there are three groups which are composed of 8, 8 and 4 teams respectively and there are 20 teams totally. Permutation encoding is used here and each of the genes represents a team which takes place in the related group. Fitness function is the sum of total travel distance of each teams with all the others in the same group, reciprocally as indicated in the equation.

Crossover and mutation are two important operators that make changes in existing chromosomes in the search for better solutions. The aim of the crossover is to exchange of information between the chromosomes, so it enables creating new and better individuals (chromosomes). In binary and real-value coding, crossover step is taken by changing one side of the predetermined crossover point between two strings reciprocally. Thus, two new different individuals are obtained. In permutaion encoding in order to prevent unfeasible solutions, one-point crossover is used like in Figure 2. Mutation consists of randomly modifiying some gene(s) of a single individual at a time to further explore the solution space and ensure, or preserve, genetic diversity. The occurance of mutation is generally associated with a low probability [27].

Parent 1	13	18	2	9	5	15	10	20	4	12	8	16	1	19	14	6	11	17	3	7
Parent 2	4	9	13	2	8	18	20	5	12	14	1	16	19	10	3	17	15	6	11	7
Child	13	18	15	9	5	2	10	20	4	8	12	14	1	16	19	3	17	6	11	7

Mutation　Crossover point

FIGURE 12

Creation of New Generation

Modified population by crossover and mutation steps, are eliticized with Selection step. ile değiştirilen population Selection ile daha elit hale getirilir. Chormosomes with a better fitness value, have higher probability of being chosen for the next generation. Ones with worse fitness are eliminated and ones with better fitness are reproduced and the population size remains constant. This loop continues till getting the predetermined iteration number.

In this study, the object is the determination of teams of each group for the purpose of minimizing the total travel distance taken by the teams of Turkish Football Federation Third League Classification Groups which have 5 separate groups and 53 different teams during the season of 2009-2010. The first four groups are composed of 11 teams and the last group is composed of 9 teams. Distances between the teams are calculated by a developed program with using coordinates as road distance in terms of kilometers which have obtained from the website of Googlemaps.com.

In GA crossover rate was determined 0.9 mutation rate was determined 0.001 and the population size was determined 20. Algorithm was coded with MATLAB R2009 and implemented in an Intel(R) Pentium(R) 4 CPU 3.20 GHz, 480 MB RAM configured PC for 1000 iterations, 100 times. Comparative results are presented in Table 1.

TABLE 11
Results of The Problem

	TFF	GAs (Mean)
Total Distance	292164,4	253800,8
Average Deviation of Groups Distance	653,0317576	1371,493333
Average Deviation of Teams Distance	1239,386686	1561,851691
Standard Deviation of Teams Distance	1700,976937	2185,013234
Standard Deviation of Groups Distance	724,0845	1736,731471
CPU	-	15,0198732

When the results are considered, proposed GA result is a good alternative to TFF's result in terms of total distance. The difference between the results in total distance is 38363.6 km and approximately % 13.1 . It is considered that this improvement may enable serious benefits in economic, health and environment issues. Group based distributions of teams acoording to the TFF are shown in Turkish Map in Figure 3. Group based distributions of teams acoording to GA are shown in Turkish Map in Figure 4.

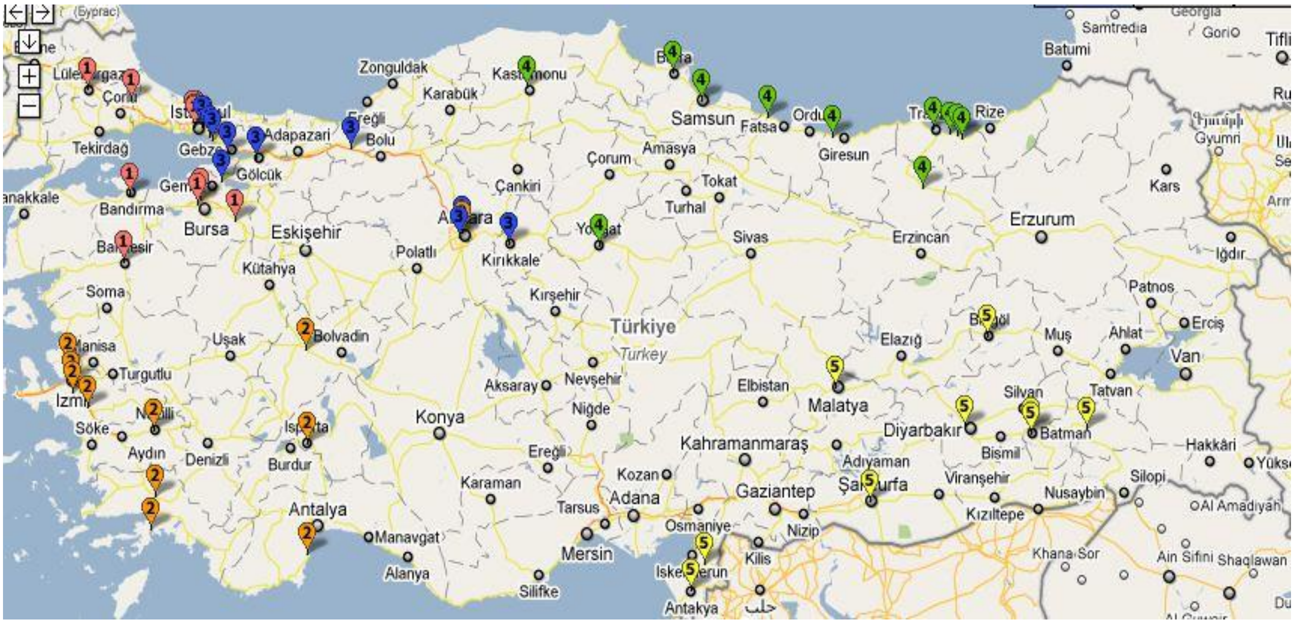

FIGURE 13
TFF's Current Group Distribution on Turkish Map

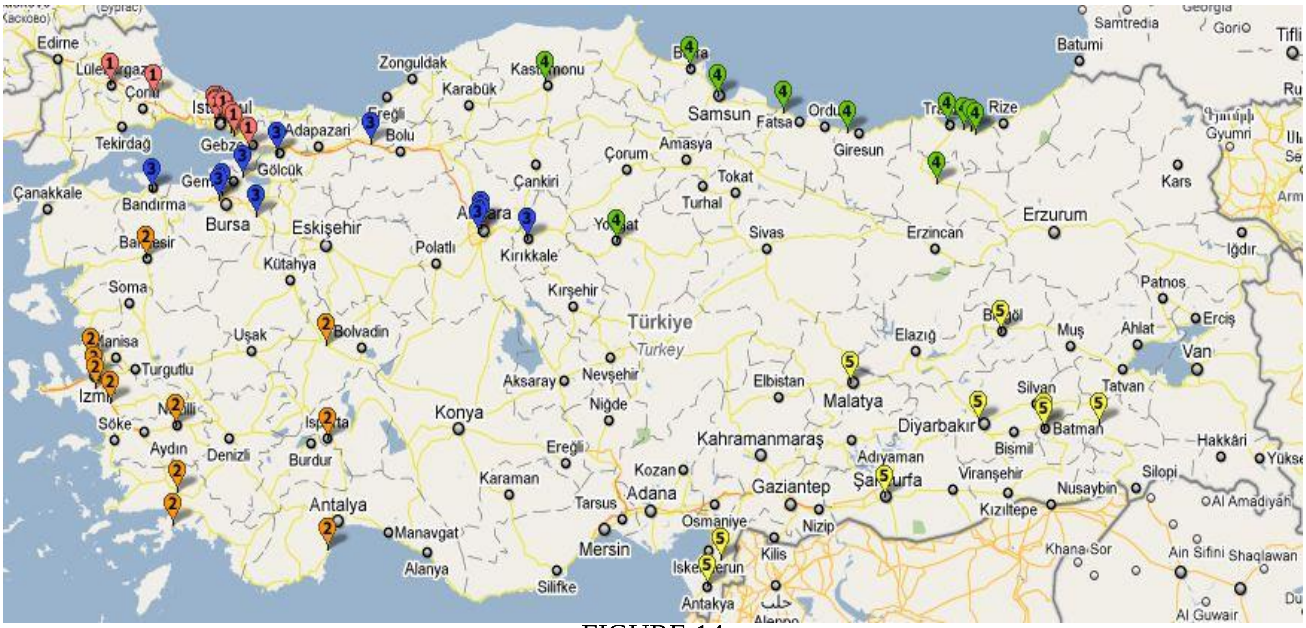

FIGURE 14
Proposed GAs Group Distribution on Turkish Map

Examining the figures, it can be seen that Proposed GA forms better groups than TFF's and this enables an improvement in total distance. But there might be imbalances between groups and teams as the objective function is the minimization of the total distance. This imbalance is clearly seen when you look at group's and team's means and deviations in Table 1.

CONCLUSIONS

In this paper, determination of Turkish Football Federation (TFF) 3. League classification groups with Genetic algorithms is presented as a set partitioning problem. The aim of the study is to provide an alternative solution with a scientific approach to TFF's current solution. Objective function is the minimization of the total distance taken by teams between the others in the same group. According to the results, an improvement which is approximately % 13.1 is obtained. This means 38363.6 km in terms of distance. So it can be noted that GA may be a good alternative. But when team's and group's means and deviations are taken into consideration, an increase in the imbalance between the groups and teams is seen ; although there is an improvement in total distance, assignments of teams to groups have more inequity. The competition is not only in the field in football and economic power is also a competition issue so such an assignment may prevent the balance of competition between teams and groups. According to this, it is not enough to determine the objective function that covers only minimization of total distance, it must include also balance of total distance between teams and groups.

As Genetic algorithm presents a good performance about total distance, it is taught to be the same algorithm can be used to balance the distances between teams and groups as well. With further reseach on this subject, transportation costs which are important cost items can be balanced in competitive intense sector like football.

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IMPLEMENTATION PROCESS OF ACQUISITION LOGISTICS FOR THE SYSTEM AND PROJECT MANUFACTURING COMPANIES IN IT SECTOR: A CONCEPTUAL MODEL

Halim YURDAKUL[1] Serhat BURMAOĞLU[2]

Abstract *— In this study, we examine how to implement an acquisition process in a software solution company in IT sector. We assume that the products of such companies are unique systems or projects which are customized for the customer up to her requirement. An acquisition process model is not only for the customer but also for the producer and seller, regarding its complex procedure and mostly its high value. During the whole period of defining, designing, producing, selling/purchasing, supporting and finally disposing the systems, the main factors of acquisition logistics are the human-system integration, principals of integrated logistics system, adaptation of logistics support elements to the current situation, supportability factors, configuration management, the life cycle cost analysis and contract management process. All of these factors must be handled, considered and planned carefully.*

Keywords— Acquisition Logistics, System approach, life cycle cost, supportability, integrated product team, configuration, human-system integration

INTRODUCTION

We know that, it is hard to progress complex software-hardware integrated acquisition projects. In this study we want to find a way to maket his complex process simple by using integrted product teams.

Many of today's software development projects use Integrated Product Teams (IPTs) to develop software products. Such teams are composed of individuals from several organizations.

Traditional methods of system and product design,development, and acquisition have often been described as serial and linear processes where functional groups make contributions sometimes independent of other internal and external elements [1]. As a result of these "throw it over the wall" activities, critical decisions that can significantly impact overall product design, development, and costs are frequently made without regard to the effect on or consequences to others.

One of the basic ideas of concurrent engineering, needed for product design and development, is to assemble a team that is focused on developing or redesigning a product. These teams are usually composed of people from various functional elements, e.g., development, engineering, manufacturing and product management [2].

Concurrent engineering, is not a set of techniques but a conceptual methodology that enables all who are impacted by the product design have early access to design information and have the ability to influence the final design to identify and prevent future problems [3].

Within these cooperative environments it is necessary for individuals to share information and collaborate in the decision making process. Several researchers and authors indicate that collaborative work requires the exchange of information for purposes such as notification and clarification, and the processing of information for monitoring, negotiating, and decision-making [4, 5, 6]. This cooperation ensures that everyone impacted by the design has early access to design information and the ability to influence the final design effectively and efficiently. Collaboration is the key to make this happen.

The remainder of the paper is structured as follows. First, in Section 2 difference between traditional and integrated product team approaches is presented as theoretical framework. In Section 3, proposed model is mentioned. Finally the benefits of the model is discussed.

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DIFFERENCES BETWEEN TRADITIONAL AND INTEGRATED PRODUCT TEAM APPROACHES

In the generic and more traditional project management model, the project office manages funding, development, product integration, transition from R&D to production, and fielding. However, due to limited staff, independent technical organizations such as design engineering, testing, and procurement often provide matrix support to the Project Manager. Unfortunately, along with the technical expertise comes layered functional management. Decision making is slowed by time-consuming meetings, briefings, and staffing requirements. Complicating matters further, each functional organization, working on its piece part, vies for resources provided by the project office. The competition is good, but at a micro level, the result is often over- and under-funding of the differing technical areas. Under-funded areas naturally cause project delay. Redesign, which is costly and generally reserved to solve integration problems, increases program time and money requirements. Thus, the decision making process is further aggravated by management "stovepipes" and inefficient communication.

On the private contractor side, businesses tend to closely mirror the organizational structure and culture of their counterpart government customers. Again, generous project money supported this approach. Many of the same problems associated with powerful functional organizations and layered management also exist with the contractors. Some private companies have embraced acquisition streamlining and Integrated Product Development (IPD) on their own. Others resist change and are waiting for their government customers to take the lead.

Clearly, there are significant efficiencies yet to be realized from both the government and contractors. In contrast to the more traditional approach, IPD is the integration of all needed skills (program management, technical development, producibility, etc.) early in the product's life cycle.

In the language of IPD, the team, the (IPT) implements the IPD philosophy. The core IPT has overall responsibility for managing both the programmatic and technical decisions and looks for means to integrate the product (i.e., tries to understand the mutual impacts of the product's various piece parts) early in the life cycle. The team leader and members are empowered by their respective organizations. Indeed, most decisions can be made within the context of the team.

Consequently, many of the briefings, meetings, and staffing requirements are reduced if not eliminated. Moreover, with the team making resource allocation decisions in one "stovepipe," thereby subordinating functional interests to the goals of the team, program management is optimized to avoid schedule and overall product performance impacts. Equally important is the fact that more informed decisions can be made on the most important cost drivers early, when most of the program cost is determined. Agreed-upon team goals and metrics create pressure to manage within budget and schedule. Ultimately, rapid communication, team empowerment, integration of all relevant skill sets, and team synergy result in a shorter decision cycle and lower development costs.

IPTs are cross-functional teams that are formed for the specific purpose of delivering a product for an external or internal customer. IPT members should have complementary skills and be committed to a common purpose, performance objectives, and approach for which they hold themselves mutually accountable. IPTs are the means through which IPPD is implemented. Members of an IPT represent technical, manufacturing, business, and support functions and organizations that are critical to developing, procuring and supporting the product. Having these functions represented concurrently permits teams to consider more and broader alternatives quickly, and in broader context, enables faster and better decisions. Once on a team, the role of an IPT member changes from that of a member of a particular functional organization, who focuses on a given discipline, to that of a team member who focuses on a product and its associated processes. Each individual should offer his expertise to the team as well as understand and respect the expertise available from other members of the team. Team members work together to achieve the team's objectives. Critical to the formation of a successful IPT are: (1) all functional disciplines influencing the product throughout its lifetime should be represented on the team; (2) a clear understanding of the team's goals, responsibilities, and authority should be established among the business unit manager, program manager and functional managers, as well as the IPT; and (3) identification of resource requirements such as staffing, funding, and facilities.

US Department of Defense(DoD) uses three types of IPTs to accomplish its goals: Overarching IPTs (OIPT), Working-Level IPTs (WIPT), and Program-Level IPTs (PIPT). Figure 1 more clearly defines the hierarchy and relationships among the various types of IPTs in DoD.

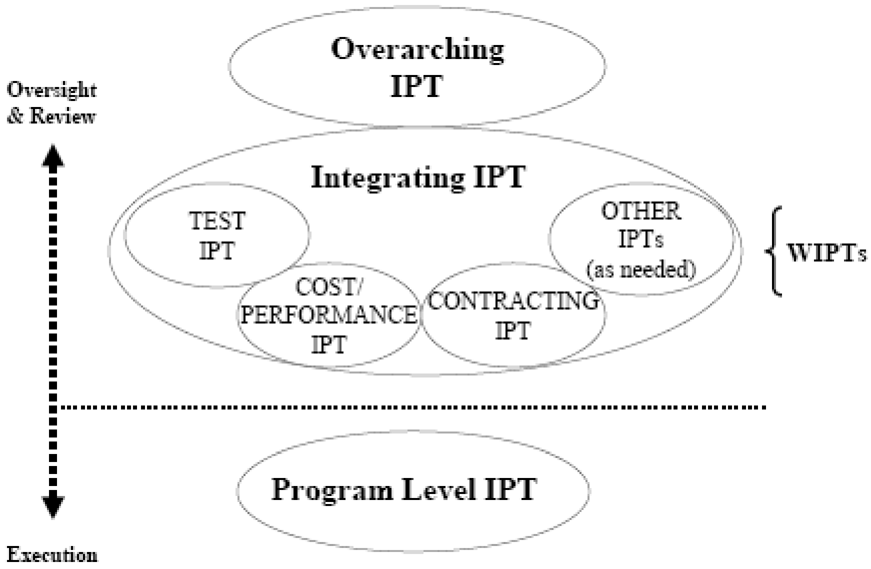

FIGURE 1
IPT Hierarchy, adapted from [7]

PROPOSED MODEL

We develop a model upto the literature reviewed for an IT company (manufacturing customized systems) in telecommunication sector. The model has been demonstrated in Figure 2.

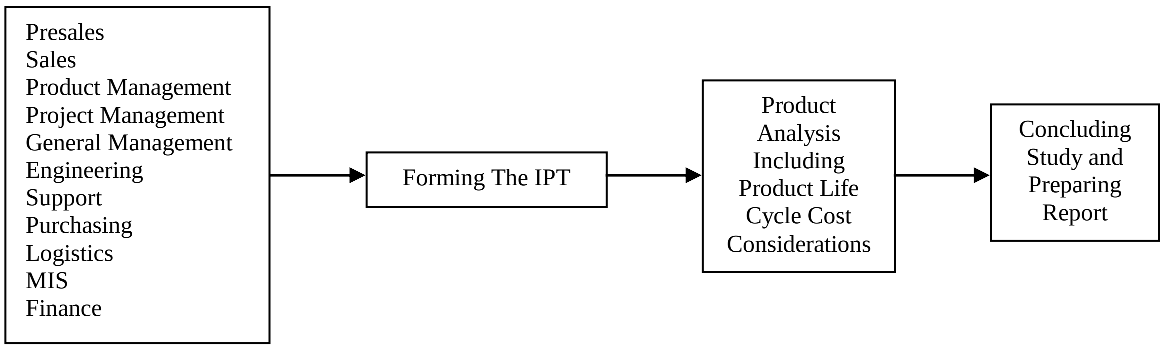

FIGURE 2
Proposed Model for IPT Usage in Telecommunication Sector

In the first stage, the company calls the departments for the "Integrated Product Team" to be gathered and work on the product required by the customer. The team's goal is to find out all the requirements of the product and to gather all the necessary details to make a sound, quotation to the customer and to build a framework to produce, ship and install the system on site. An "Integrated Product Team" in an IT Company in Telecommunication sector may include the representatives from the departments as seen below:

- Presales
- Sales
- Product Management
- Project Management
- General Management
- Engineering

- Support
- Purchasing
- Logistics
- MIS
- Finance

In the second stage, Integrated Product Team analyses the product, required by the customer considering every single logistics support element listed below to get the right product at the right price, right place, right time and with the right personel on site. This analysis also includes the product Life Cycle Cost considerations.

10 Logistics Support Elements

- Design
- Maintenance
- Manpower and Personnel
- Supply Support
- Support Equipment
- Technical Data
- Training and Training Devices
- Computer Resources
- Facilities
- Packaging, Handling Storage&Transportation

In the last stage, Integrated Product Team concludes its study which includes the details to build and fulfill the entire Project.

- Presales build the quotation.
- Sales admit the quotation to the customer.
- Contract Admin leads the contracting process in direction of the results achieved by the team.
- Customer PO arrives.
- Integrated Product Team comes together again to point out the differences between the study made before and the PO, and the tasks for the departments to complete the whole project as required. The team also points out the deadlines and next meetings.
- The departments bring the outcomes together and build the system ready to ship to the customer on site.
- MIS tests the product before shipping.
- Quality Management should be an organizational approach.
- Logistics department ships the product to the site and leads all the related procedures.
- MIS installs the system on site.
- Project Management organizes and monitors whole process and gets the Acceptance from the customer.
- Support provides maintenance and support according to the requirements coordinating with the departments of Purchasing, Logistics and MIS.
- General Management leads Configuration Management tasking the departments.

CONCLUSION

In this study, we examine implementation of acquisition logistics to system producing IT companies in telecommunication sector and we try to develop a model based on acquisition logistics using integrated product team as a matrix organization. With this study, we think that such companies reorganized with this model we propose will get the benefits listed below:

- This model provides a high level customer satisfaction by way of the study and workmanship to produce the right product to match all customer requirements considering the products life cycle cost and support.
- It provides a maximum level coordination among the departments and the problems will be reduced to a minimum level.
- The detailed studies of the team will be recorded and the records light up next projects.

- The records mentioned above will be a road map for the departments.
- It develops a unique workflow and background in the company. The lessons learned will lead to a perfect flow.
- It develops a team spirit inside the company.
- It develops a harmony and consistency among the departments.
- It leads the departments to understand each other.
- Total quality decreases.
- It provides shorter and healthier process.

As a concluding word, acquisition logistics is not a process which is planned and implemented solely by the logisticians. It also should be assumed a managerial and organizational approach. Otherwise, it shall be far from a cost effective and optimum process.

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THE CONCEPT OF NATIONAL LOGISTICS COMPETENCE: IS IT TRUE OR FALSE?

Danuta Kisperska-Moron[1]

Abstract *– International comparisons of logistics performance were always difficult, mainly due to unclear concepts of what to measure, full set of data hard to be obtained and methodological problems of data aggregation. Often all kinds of surveys were used to collect information on companies' performance and the cost of logistics operations. In order to highlight national logistics competence a concept of the Logistics Performance Index was created with the purpose to illustrate differences of logistics operations in various countries. The paper questions the general concept of national logistics competencies in the light of significant differences of logistics performance in various regions of the same country. It also indicates that using international surveys based on examination of perceptions for a professional benchmarking system like LPI seems to be somewhat problematic. The paper suggests the use of more "objective" methods of measuring logistics efficiency in different regions of various countries.*

Keywords – national logistics competence, Logistics Performance Index, interregional logistics performance comparisons

INTRODUCTION

Logistics competence might be expressed by proper definition and measurement of logistics and supply chain processes. Direct measurement of the activities associated with supply chain and/or logistics is often not possible nor desirable. Very often measurement of these activities may be more accurate through measuring the result of the activity, i.e. logistics or supply chain performance. There are several different opinions on that subject focusing around two main problems: what exact aspects of logistics performance should and could be measured and how to create a system of integrated measures that can be used throughout whole supply chain [18], [22]. Operational practices in supply chain measurement demonstrate that despite of all those efforts the state of art is still not satisfactory.

Some researchers focused on constructing different performance typologies and performance measurement systems [2], [5], [6], [8], [9], [12], [13], [14]. Other research concentrates on measurement procedures within the framework of benchmarking concept [3], [4], [7], [26].

Taking to account the dynamic character of supply chains their driving forces for performance measurement represent than three basic dimensions of the business [20], [27].

- Effectiveness, connected to the extent to which the company is able to realise its goals and to what extent are customer needs met;
- Efficiency, understood as the relation between resources engaged in realisation of a certain set of effects, i.e. company's goals, showing how economically are the resources of the company utilised;
- Changeability - to what extent are the companies prepared for future changes, addressing the responsiveness of the operating system.

Consequently researchers proposed the following dimensions to be measured in logistics systems:

- Logistics costs and service quality [21],
- Customers service or satisfaction associated with flexibility and time-based measures [2], [14],
- Financial reports based figures [5], [25].

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Global competition and actual market conditions force to create complex multidimensional concepts consisting of measurement of several items at the same time [22]. Translating the triad of business driving forces (customer satisfaction, productivity, flexibility) into operating performance criteria one should mention the following factors:

- Quality – having at present far broader meaning than conformance to specifications and including such aspects like features, performance, durability, reliability, aesthetics, etc.;
- Delivery terms – resulting in positive evaluation when performance equals expectations from the point of view of two main aspects: quantity and timeliness;
- Cycle time – being the sum of ordering time, manufacturing lead time, process time, move time, queue time, set-up time, etc. and usually requiring lots improvements and reductions;
- Waste – representing the non-value-added activities and resources in the process of meeting customers requirements.

These aspects became the basis for the most popular measurement system incorporated In the SCOR model which currently seems to be the main paradigm of logistics and supply chain performance measurement.

Much of the criticism of the traditional measurement systems in the field of logistics depends also on accounting practices that often do not provide relevant feedback for operational control and generate misleading logistics costs data. Logistics costs and other financial measures cause doubts concerning the precision of their calculation [23].

THE CONCEPT OF NATIONAL LOGISTICS COMPETENCE

The main concept of national logistics competence implies that there are some general and specific factors which bring about different logistics performance in various regions of the world and in particular countries. Many researchers attempted to identify those national logistics competence using some main types of national or international logistics studies and surveys such as [17]:

- Statistics-based studies applying models:
  - Econometric
  - Other modeling approaches
- Case study-based approaches by country
- Survey-based studies using questionnaires:
  - Comprehensive themes
  - Single-theme surveys.

Differences in logistics competence in various world regions result in different level of logistics costs. The example of a model aiming at identification of an aggregated national logistics costs is presented in Figure 1.

As a result of collection of data in different world regions the actual levels of logistics costs in several world regions were estimated. They demonstrate that in various areas of the world logistics costs constitute a different portion of the GDP (Table 1). Those differences clearly show diversified efficiency of logistics operations across the world.

The concept of illustrating the gaps in logistics competence through estimation of national logistics cost has some serious limitations [16]. First of all that estimation depends on the width of boundaries of firms (business units) included in that calculation, which heavily affects the concept of costs. Particularly in a manufacturing sector the intra-firm trade is quite substantial but not always easy to measure on the basis of national statistic data. In the case of self-reported costs by companies their declared level might be often subjective and, when they get aggregated they demonstrate the effect of ‘double-counting’. Therefore the researchers must face the dilemma whether to rely on firm level costs or macro level logistics costs. It is closely connected to the choice of the exact definition of logistics costs as well, and the national statistics data often might be not precise enough.

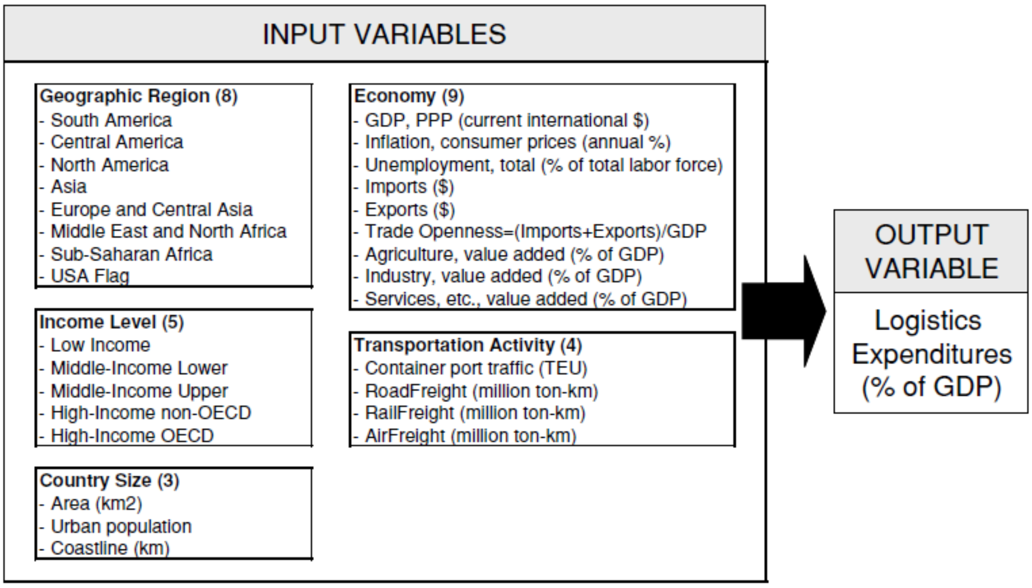


FIGURE 1
Rodrigues, Bowersox and Calantone econometric model in 2005 [19]

TABLE 1
Global logistics costs by World regions in 1997, 2000 and 2002 [19]

Region	1997 Log. costs US$ bill.	1997 % GDP	2000 Log. costs US$ bill.	2000 % GDP	2002 Log. costs US$ bill.	2002 % GDP
Europe	884	12.2 %	1,100	12.8 %	1,229	13.3 %
N. America	1,035	11.0 %	1,240	10.6 %	1,203	9.9 %
Pacific region	1,459	14.5 %	1,989	15.3 %	2,127	15.7 %
S. America	225	14.3 %	280	14.4 %	272	14.3 %
Other areas	1,492	15.4 %	1,778	15.7 %	1,902	16.0 %
Whole world	5,095	13.4 %	6,387	13.7 %	6,732	13.8 %

Secondly, it is usually difficult to draw a clear border line between domestic and international logistics costs. Moreover, SME data becomes very important to get a balanced picture of logistics costs, and that data is not always easy to be obtained. On the other hand, in many international surveys with one respondent from a very large conglomerate, calculation of aggregated logistics costs often could be misleading. Generally, access to reliable and comparable cost data is quite difficult.

Finally, the severe limitation for international logistics costs comparison results from the fact that middle income countries are difficult to be covered in costs estimation, and, it might be extremely difficult to get data from low income countries [15]. In short: severe knowledge gaps exist specially as the concept of logistics costs is concerned.

Logistics surveys seem to be the most popular research instrument. Besides logistics costs and different features of logistics competence they often examine the following aggregate themes:

- Key logistics indicators,
- Outsourcing of logistics activities,
- Logistics information systems,
- Logistics operating environment.

However, international logistics surveys are associated with several methodological and conceptual issues that reduce their reliability as a tool for producing the precise image of national logistics competence. The most important problems for international logistics surveys are as follows [16]:

- Logistics concepts might be elusive and often unfamiliar in some world regions,

- Semantics vary by language and simple translations of terminology may not be adequate to the real meaning of specific expressions,
- Surveys using small sample sizes might be problematic for their representativeness of national logistics competence,
- Cross-country comparisons might be difficult due to specific cultural differences,
- Other factors may apply such as respondents' readiness to respond to surveys, resulting from certain attitudes, for example such as suspicion to surveys and/or survey fatigue.

CONCEPT OF LOGISTICS PERFORMANCE INDEX

One of the recent concepts of logistics performance measurement was proposed as the interactive benchmarking tool for international comparisons of different countries in order to asses the logistics gaps between them. This new formula for measuring the outcome of supply chain management was organised within the Framework of the Logistics Performance Index (LPI) claimed to provide a comprehensive picture of supply chain performance [1].

Initially the logistics performance index consisted of seven indicators:

- efficiency of the clearance process by customers and other border agencies,
- quality of transport and the information technology infrastructure for logistics,
- ease and affordability of arranging international shipments,
- competence of the local logistics industry,
- ability to track and trace international shipments,
- domestic logistics costs,
- timeliness of shipments in reaching destination within the scheduled and expected delivery time.

There were several main obstacles in data collection used later for calculation of LPI on international basis and particularly [16]:

- Differences in the understanding the exact terminology in various countries,
- Lack of appropriate concepts and business solutions in developing countries,
- Reluctance to answer 'sensitive' questions, perceived from the point of business sensitivity to competition; often such questions are not answered at all,
- Company surveys might be a new phenomenon, for example in developing market economies and not quite well understood and appreciated,
- Frequent surveys could cause great annoyance to firms, especially in some regions popular for the excellence of logistics operations (eg. large ports, special economic zones, etc.),
- Web-based surveys are not feasible in all countries, usually they can be administered only in well developed market economies.

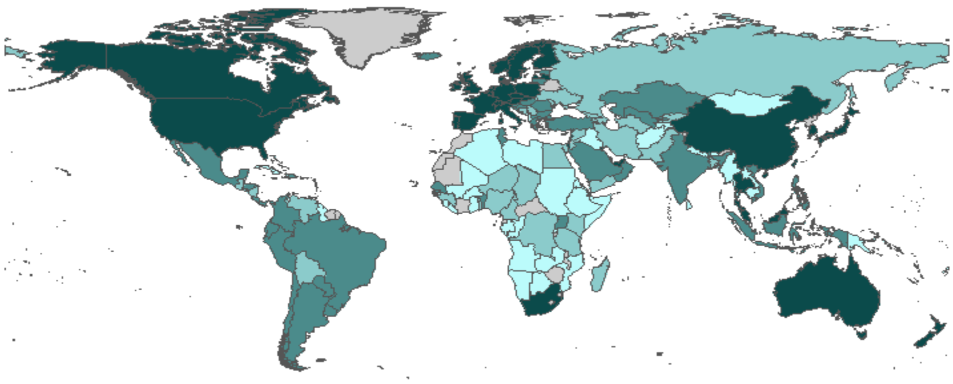
In 2010, due to the limitations of that data collection and as the result of general improvement process the Logistics Performance Index ($LPI) is the weighted average of the country scores on the six dimensions:

- Efficiency of the clearance process (i.e. speed, simplicity and predictability of formalities) by border control agencies, including Customs;
- Quality of trade and transport related infrastructure (e.g. ports, railroads, roads, information technology);
- Ease of arranging competitively priced shipments;
- Competence and quality of logistics services (e.g., transport operators, customs brokers);
- Ability to track and trace consignments;
- Timeliness of shipments in reaching destination within the scheduled or expected delivery time.

The most important change in calculation of the LPI was the exclusion of logistics cost element as quite difficult to be objectively estimate for that purpose.

Data required to calculate the LPI are being collected by means of a world survey of global freight forwarders. Results of the survey are supported with objective data on the performance of the most important components of operating logistics chains in each country.

On the basis of that data countries were initially ranked from 1 – 150 in 7 groups of that rank. In 2010 the scorecards demonstrate *comparative performance* - the dimensions show on a scale from 1 to 5 relevant to the possible comparison groups – all countries (World), region and income groups.Figure 1 presents the idea of evaluation where different colour shades indicate different rank groups. Darker shades indicate more advanced logistics background and lighter colour shades mark countries with less developed logistics systems. The exact values of ranks are available at the www.worldbank.org.



1 <= LPI <= 2.48	2.48 <= LPI <= 2.75
2.75 <= LPI <= 3.23	3.23 <= LPI <= 5
No data	1 is the lowest score and 5 is the maximum score.

FIGURE 1
Logistics Performance Index countries ranking [28]

The main research questions were:

RQ1: Is the level of national logistics competencies a valid concept and how precisely the Logistics Performance Index represents those national logistics competencies?

RQ2: To what extent decision makers may draw general conclusions on the basis of the aggregated value of LPI for the country (national economy) as they are quoted on the webpage of the World Bank?

The main hypothesis was that some large differences occur in the area of the above mentioned three dimensions of LPI which probably may distort the picture of homogeneous evaluation of countries assessed through the value of the LPI.

In this research out of all dimensions of the LPI three of them were subject to more profound analysis:

- Domestic logistics costs,
- Competence of the local logistics industry,
- Quality of infrastructure (transport and information technology).

RESEARCH DESIGN AND METHODOLOGY

Research process depended on the availability of comparable data that could illustrate properly the issues addressed in the main research question and the hypothesis. Therefore several sources of information were used:

- Reports of the LogOn Baltic project analyzing the results of international surveys conveyed in the countries of Baltic region;
- Results of the original survey including identical questions to the LogOn Baltic survey completed by

companies in the south of Poland in 2007.

In the original LogOn Baltic project one country was represented by two different regions: it was Germany with data available for the Hamburg region and Mecklemburg-Vorpommern region. The LogOn Baltic reports clearly indicated that responses to the survey question for these two regions are quite different.

As a counter-part of these two German regions my research included two sets of data from Poland:

- One set of data collected for the Pomerania region and reported in the Logon Baltic research;
- Second set of data resulting from the survey completed by the author In the southern part of Poland in the region of Upper Silesia.

Samples characterizing Germany were described in details in the LogOn Baltic research reports [10], [11], [16], [24]. The author's sample consisted of 46 manufacturing companies, 26 trade companies and 40 companies of logistics providers in Poland. The majority of companies in the sample belonged to the sector of SMEs.

Scope of that comparison was limited by the availability of exactly corresponding data for each of examined regions. Hence this research did not include many variables that should be taken to account as characteristics of such dimensions as logistics costs, logistics competencies of industries and quality of logistics infrastructure. However even in case of such limited data set of benchmarks some interesting results were obtained.

DISCUSSION

The overall score of the LPI officially reported at www.worldbank.org is 3 ranking points for Germany and 40 ranking points for Poland in 2007 and respectively 1 and 30 in 2010. According to those ranks Poland offers much worse logistics environment than Germany. Germany and Poland are quite large countries and the results of research conducted by the author of this paper demonstrated significant differences within each of those countries. Some of them will be discussed in the forthcoming part of the paper.

Domestic Logistics Costs

Logistics costs as % of companies' turnover calculated for manufacturing and trading companies were quite different in each of examined regions ranging from 14,5% in Pomerania and 12% in Hamburg region(manufacturers) to 35% (traders) and 46% (manufacturers) in Silesia. The only similarity has been detected for these costs in Germany where for both regions trading companies reported around 15% of logistics costs as % of companies' turnover. The details of costs evaluation are presented in table 2.

Similar situation occurred with respects to transportation costs as % of logistics costs. Average share of these costs was about 34 – 37% in most of the regions but in Mecklemburg-Vorpommern region it reached almost 50% for trading companies, comparing to only 19% in Pomerania. It clearly indicates that logistics cost diversification when considered as % of companies turnover is extremely large. Probably the indicator of the share of transport costs in the total logistics costs has been more stable.

Competence of the Local Logistics Industry

Logistics as the key factor when compared with their main competitors has been evaluated by around 62-67% in both German regions and only 39-44% of two Polish regions. However, companies in each of these regions differently evaluated their environment when comparing it with that of their main competitors. In Germany 44% from Hamburg region and only 15% of respondents from Mecklemburg-Vorpommern region evaluated it as good. In two Polish regions the level of satisfaction was slightly higher ranging from 43% in Pomerania to even 63% in Silesia.

TABLE 2
Logistics costs in examined regions

Types of costs	Germany		Poland	
	Mecklemburg-Vorpommern	Hamburg	Pomerania	Silesia
MANUFACTURERS				
Logistics costs as % of companies' turnover	20%	12%	14,5%	46%
Transportation costs as % of logistics costs	35%	40%	34%	20%
TRADING COMPANIES				
Logistics costs as % of companies' turnover	15%	15,5%	23%	35%
Transportation costs as % of logistics costs	50%	35%	19%	37%

Regional review of the overall logistics efficiency is very homogeneous in Germany. On average that efficiency is being perceived as good. It is an interesting issue since other specific elements of the evaluation of logistics systems demonstrates large difference between two German regions. In Poland evaluation of these elements is much higher in Silesia when compared with Pomerania region. Detailed aspects of that evaluation are shown in Table 3.

TABLE 3
Regional review of logistics efficiency (all industries)

Evaluation	Germany		Poland	
	Mecklemburg-Vorpommern	Hamburg	Pomerania	Silesia
Poor	6%	5%	33%	8%
Neutral	46%	46%	22%	29%
Good	48%	49%	45%	63%

Personnel logistics competencies and their development needs seem to be quite different in surveyed regions. Some similarities have been discovered for logistics providers, such as requirements of extending the knowledge of strategic issues in Poland (21-23%) and Germany (30%) and language proficiency seeming to be much better in both of German regions (2%) than in Polish regions (around 15%). Significant differences between regions in each country have been observed in basic logistic skills, operations management skills and strategic skills in manufacturing and trading companies.

Considerations regarding logistics development needs have been examined through such factors as (Table 4):

- For manufacturers and trading companies: cutting logistics costs, visibility of supply chains and IT systems, growing scope of logistics networking, development og logistics operations and improved customers service;
- For logistics providers: extending range of services, service quality, service capacity, cutting service provision costs, developing the competence of personnel and IT applications.

Documented differences in that area indicated major differences between regions within of each of the countries. It seems that each of examined regions plans to follow different pattern of development of logistics chains, probably according to local requirements.

TABLE 4. Logistics development needs in examined regions

Share of specific development needs	Germany		Poland	
	Mecklemburg-Vorpomen	Hamburg	Pomerania	Silesia
MANUFACTURERS				
Cutting logistics costs	8%	25%	26%	11%
IT-systems and Supply Chain Visibility	60%	16%	16%	29%
Network functionality / development	9%	15%	11%	7%
Developing logistics competence of personnel	3%	3%	27%	30%
Improving customer service	20%	41%	20%	23%
TRADING COMPANIES				
Cutting logistics costs	14%	42%	12%	11%
IT-systems and Supply Chain Visibility	41%	18%	46%	45%
Network functionality / development	18%	15%	21%	7%
Developing logistics competence of personnel	5%	-	7%	17%
Improving customer service	22%	25%	14%	20%
LOGISTICS SERVICE PROVIDERS				
Extending range of services	39%	22%	40%	28%
Service quality	12%	24%	20%	27%
Service capacity	29%	22%	22%	28%
Cutting service provision costs	-	1%	2%	3%
Developing logistics competence of personnel	12%	11%	3%	6%
IT applications	8%	20%	3%	8%

Quality of transport and information infrastructure

Regional review of the status-quo of domestic transport infrastructure for all industries is very homogeneous in Germany. On average that efficiency is being perceived as good. The details of that evaluation are presented in Table 5.

TABLE 5. Views regarding the domestic transport infrastructure (all industries)

Evaluation	Germany		Poland	
	Mecklemburg-Vorpommern	Hamburg	Pomerania	Silesia
Poor	9%	18%	52%	16%
Neutral	22%	17%	23%	17%
Good	69%	65%	25%	67%

The level of information infrastructure has been evaluated by two indicators: 1) the percentage of employees having access to e-mail and Internet and 2) estimated share of e-commerce. In this field the results are less diversified showing average better access to the Internet in German companies. However in the group of respondents claiming that more than 75% of their personnel has access to e-mail and Internet the share of answers for Hamburg region was 67-69% and only 31-34% for Mecklemburg-Vorpommern region. Differences between Polish regions were not so large. The scope of e-commerce is somewhat larger in both German regions than in Poland, where diversification between regions seems to be slightly more significant.

CONCLUSIONS

Logistics and supply chain performance once again has been perceived as an extremely difficult field for measurement, much more complicated than e.g. production or trade. The research proved that the hypothesis about distinctive differences between regions has been correct. Therefore one may question the general concept of national logistics competencies in the light of significant differences of logistics performance in various regions of the same country and national economy. It would provide the answer to the RQ1.

There is a limitation of conducted research resulting from unknown credibility of the answers provided by the respondents of all surveys included in this research. Determined differences in logistic performance may occur due to unintended error resulting from subjective factor of respondents perception of the reality. Therefore using such perceptions for a professional benchmarking system like LPI seems to be somewhat problematic, since the influence of less objective factors onto the value of the Logistics Performance Index is quite large. It answers the RQ2, indicating that there should be some other more “objective” methods of measuring logistics efficiency in different economies of various countries. Perhaps researchers might go back to more classical techniques based on reported statistical data (e.g. the relation of value added to the level inventories in the economy, regression analysis between different measurements of logistics operations and some macroeconomic indicators, etc.) and use “subjective” data obtained via surveys only as closer interpretation of hard economic facts.

At the same time research reported in this paper demonstrated that also the level of logistics costs is not a comprehensive figure for the whole country. Logistics costs may substantially differ from region to region and taking to account serious methodological problems connected to their estimation suggests that excluding them from the concept of LPI was right decision.

Future research in the field of measurement of global aspects of logistics competence should be directed not to countries but large economic regions and specific areas in those countries. The focus of that research ideally should be based more on the approach adequate to supply chain management dealing more with processes than single activities. The identification of processes and their activities creates “the business map” which can indicate what kind of metrics and indicators are important for achievement of the best strategic balance between service quality, product quality, and profitability. The main challenge is to create a system of integrated measures that can be used throughout whole supply chain, even if its elements (i.e. companies and institutions) are located across country borders. That integrated perspective must be comparable and consistent across all functions and channel institutions. Without such an integration of measures, for example manufacturer’s perception of adequate customer service may be quite different from that of the wholesaler. That difference of opinion might be a severe limitation to the measurement of logistics competence on global basis.

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ADOPTION OF ONLINE RECRUITMENT METHOD IN TRANSPORT AND LOGISTICS INDUSTRY

M. Serdar Ayan[1], Özlem Otuzlu[2]

Abstract — *Different types of recruitment methods are used by human resources professionals. Technological developments have significantly directed employee recruitment and selection practices to online recruitment as the use of internet increases. The use of online recruitment by recruiters and job seekers has been on the rise throughout the past decade. However, little research exists regarding the use of internet in organizational recruitment. Higher applicant yields and cost savings are the major factors for choosing online recruitment method. Logistics industry, under the influence of micro and macro environmental factors which continues to strengthen and grow will be expected to increase its employment rates in the following years. Due to this reasons it is important to investigate recruitment methods in logistics industry. In this paper the factors that affect the adoption of online recruitment in transport and logistics industry will be explored.*

Keywords — *Human resources management, Internet recruitment, Logistics industry, Online recruitment*

INTRODUCTION

Technological developments have significantly changed employee recruitment and selection practices. The rising usage of World Wide Web directs the recruiters to online recruitment methods throughout the last decade [1]. There has recently been a ''headlong rush" to use the Internet for recruitment, with some reports indicating that as many as 90% of large US companies are now recruiting via the web [3].

Recruiting is defined as "activities or practices that define the characteristics of applicants to whom selection procedures are ultimately applied." Today, recruiting is sometimes referred to as *talent acquisition* to reflect the importance of the human factor in the organization's success [2].

According to another definition, recruitment is the set of activities used to obtain a sufficient number of the right people at the right time; its purpose is to select those who best meet the needs of the organization [4].

Today, much recruiting is done via the Internet. E-cruiting, or recruiting job applicants online, dramatically extend the organization's recruiting reach, offering access to a wider pool of applicants and saving time and money. Besides posting job openings on company Web sites, many organizations use commercial recruiting sites where job seekers can post their résumés and companies can search for qualified applicants. In addition, in industries where competition for highly skilled employees is stiff, new online services emerge to help managers search for "passive candidates," people who aren't looking for jobs but might be the best fit for a company's opening [2].

The objectives of our study are to define online recruitment method and to make literature review about this subject and finally to analyze the adoption of online recruitment method in transport and logistics industry in Turkey.

LITERATURE REVIEW

There is a growing awareness that attracting and retaining talented employees can provide organizations with a sustained competitive advantage. The importance of attracting superior employees, together with low unemployment rates has led to intense competition for the best applicants in a wide variety of occupations [5]. In addition, a successful recruitment function is also critical for a nation's economic growth due to the labor shortage in many countries [6].

Traditionally, individuals in the field of HRM have obtained information about innovations from sources such as newspapers, books, professional publications or conferences. Today, a powerful new channel of information in the form of the internet has been added to the traditional ones. A study conducted by the

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Gartner Group suggests that companies that use technology effectively to manage the HR function will have a tremendous advantage over those that do not [7]. Statistics also support the expansion of online recruitment that with some reports indicating that as many as 90% of large US companies are now recruiting via the web [8]. In the USA, Cober and Brown found that over 50 per cent of new hires were sourced from the internet and that this was expected to increase [9].

The internet first emerged as a recruiting tool in the mid-1990s and was hailed by the popular media as the driver behind a "recruiting revolution" due to the benefits it could bring to recruiters [10]. Online recruitment is defined as the use of the internet to identify and attract potential employees by Breaugh and Starke [11]. By using internet in recruitment processes organizations gain some advantages. In the literature these advantages are listed differently. According to Schreyer and McCarter "software for recruiting purposes has become more readily available and cost-effective."[12]. Millman, similarly argued that Internet-based recruitment offers an efficient and inexpensive way to identify and classify a virtually unlimited number of job seekers [13]. As cited by Chapman and Webster searching the international marketplace for talent is an expensive enterprise. Many organizations are discouraged by the costs involved and others are forced to pay rather than risk losing business as a result of a shortage of skilled workers. The use of IT in screening and selecting applicants has the potential to significantly reduce costs while simultaneously expanding applicant pools [14]. To sum up for employers, online recruitment delivers a convenient, low cost, and efficient solution by providing direct access to a continuously expanding database of resumes [16].

Online recruitment as described before has two different sources. Organization's commercial web sites are the first way to take the attention of job seekers. Internet job boards or commercial job boards (kariyer.net, secretcv, yenibiriş etc.) are the second source for posting job advertisements. Organizations' web pages can provide candidates with the opportunity to learn about the institution (e.g., corporate values, benefits, and the like), search for and preview job ads, submit resumes, and/or fill out application forms [15]. Internet job boards (online recruitment websites) are designed as a powerful medium that brings employers and job seekers together and allows them to interact in a fast, efficient, and effective way. For job seekers, an online recruitment website provides a unique opportunity to explore constantly updated employment opportunities through an extensive database of jobs. Job seekers can then post their resumes online and announce their availability to potential employers [16].

As our research comprises the logistics and transport industry, we just investigate the internet job boards due to logistics organizations own characteristic in Turkey. Logistics is one of the most important industry in business. It is the part of supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customers' requirements [17]. Logistics industry is surrounded by highly competitive environment and high customer demands. This highly competitive environment leads the employers to work with qualified employees as the customer demands are unpredictable and various. Logistics which is a derived demand industry is easily affected by global economic crisis and political events. Hence, individuals in the field of logistics HRM need to select the right people at the right time in order to increase the service quality and competitive advantage of their organization. Thus, our study is important for industry to understand the importance and adoption of online recruitment method.

RESEARCH METHODOLOGY AND DATA ANALSIS

In this study, the factors that affect online recruitment in transport and logistics organizations were explored. The data for this research study were compiled from the human resources specialists of logistics companies in Turkey where these specialists were taken as decision makers in human resources practices and recruitment methods. Logistics organizations data were gathered from the online databases of the Freight Forwarders and Logistics Service Providers Association in Turkey (UTİKAD), Istanbul Chamber of Commerce and Izmir Chamber of Commerce. Companies which are listed twice were taken into account and sent the survey just one time. Of the 789 surveys sent to different regions of Turkey, 128 was responded.

The survey instrument has been used with the permission of Emma Parry, the first author of the cited article. The survey instrument was developed to organise those items identified during the interviews into factors and to investigate the relationship between these factors and the adoption of online recruitment [9]. Parry's framework is constructed with theory of planned behaviour. This model proposed that the intention to perform a particular behaviour is based upon attitudes and beliefs about that behaviour. TPB has been used as a framework for the examination of the adoption of a number of technological advances, including internet technology [9]. Parry also defined online adoption as innovation. Rogers framework for explaining the adoption of innovations by organisations was conducted by Parry. Parry's study examined the factors affecting the adoption of online recruitment within both of these frameworks in order to analyse the efficacy of each model to explain organisational adoption of online recruitment. In Parry and Wilson's survey there were 2 separate sets of qquestionnaires including items for corporate web sites and commercial job boards. Due to logistics industry conditions in Turkey corporate web sites items were eliminated.

Besides, minor changes in wording were used to adapt the instrument in logistics industry. A pilot survey through 8 specialists who would be in a good position to judge the difficulty in understanding or answering the questions, was carried out to assess the clarity thus to increase the validity. The respondents were asked to give comments and opinions on the questions. Thereby, necessary modifications were made.

The respondents answered their agreements with each statement using a five-point Likert scale. "Strongly agree" was represented by "5" while strongly disagree was represented by "1". Respondents were asked to check the scale that best matched with their opinions.

The questionnaires were delivered to respondents by e-mail. This method was chosen in order to reach the companies in different regions of Turkey and to increase speed of response rate. The individuals contacted were asked to pass the survey onto a more appropriate person if they did not indeed have this responsibility. Unfortunately the response rates were disappointing. We assessed the low response rate to confidentiality as the questionnaires were delivered and taken back by e-mail.

RESULTS AND ANALYSIS

Data obtained from the surveys were analyzed by using SPSS Windows Software. The procedures involved in developing this survey instrument to measure online recruitment adoption is reliable. However, the instruments used in the present study were modified for logistics industry context, it was necessary to retest the reliability.

The Cronbach's Alpha Reliability Coefficients present a good consistency (,781) that the reliability of items are high since the score 0,60 is sufficient [18]. As you can see in Table 1 Kaiser-Meyer-Olkin Measure of Sampling Adequacy is ,696 since ,696>,50 our data set is suitable for factor analysis.

TABLE 1

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,696
Bartlett's Test of Sphericity	Approx. Chi-Square	1004,826
	df	45,000
	Sig.	,000

For commercial jobs boards, a two-factor structure was produced in Parry's study.These two factors explained 51.1 per cent of the variance in the sample. In our study, a four-factor structure was produced. And these four factors explained 80,4 per cent of the variance in the sample.

TABLE 2

Factors loading results

Factor	Item	Factor loading
1	Commercial job boards makes it easier to sift out the right candidates.	0,957
1	It speeds up the recruitment process.	0,894
1	Online recruitment process is faster than other recruitment methods.	0,853
1	Speed to hire is one of the big attractions of using them.	0,726
1	It allows you to build up a database of candidates for talent searching.	0,681
2	Online recruitment is cost effective than other recruitment methods.	0,884
2	It helps promote the image of being a leading edge organisation.	0,719
2	Their use extends the reach of our advertising.	0,525
3	Our company welcomes the use of new technology.	0,894
3	Most of our employees applied us via commercial job boards.	0,891
4	Our potential employees tend to look for work on corporate web sites.	0,929
4	Our organisation needs to use online recruitment to move with the times.	0,905
4	Most of our competitors use commercial job boards for recruitment.	0,612

According to Table 2 first factor was named “convenience”. Commercial job boards give the HR specialists convenience that they can easily sift out the right candidates from the database. Hence, online recruitment method speeds up the selection process. Second factor was named “cost-effectiveness”. Commercial job boards provide cost savings to logistics companies. Millman’s, Schereyer and McCarter’, Chapman and Webster’s suggestions supported with our study. Logistics organizations choose commercial job boards for searching and classifying a virtually unlimited number of job seekers while reducing the recruitment costs. By online recruitment, companies can reduce the stationery costs and access to a continuously expanding database of resumes. On the other hand, giving job advertisements to commercial job boards logistics organizations can extend the reach of their advertisements and improve their image. Third factor was named “compatibility”. Logistics organizations in Turkey welcome the use of new technology. Thus this factor supports Parry’s study and almost gave same results by loading same items in the same factor. Fourth factor was named “potential employees”. Potential employees factor is important because we can understand that logistics industry give importance to talents in applicant pools.

CONCLUSION AND RECOMENDATIONS

The results of this study, which is carried out with logistics organizations in Turkey to determine the adoption of online recruitment method can be summarized as follows: First of all it is established that online recruitment is affected significantly by four factors. Convenience appears to be the most important factor. In fact, this outcome is not surprising and expected. Convenience can be considered as the speed, availability of the target employees. Surprisingly cost advantage is not loaded in first factor. Thereby, cost effectiveness of this method is loaded to second factor and gave different result to Parry’s study. This may be because of different culture of two different countries or the logistics industry’s own structure. Further research is needed to establish whether one or both of these comments are correct. Third factor is compatibility which showed same results with the previous study. This factor therefore demonstrates some consistency with both Rogers’ factor of compatibility and Ajzen’s subjective norms [9]. And finally potential employees factor was determined however further research is needed because the impact must be investigated wheather blue collar worker or white collar worker or both of these worker types are affected.

Finally, our study results show that logistics organizations select online recruitment methods based upon the benefits that are most convenient, cost effective and efficient.

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DETERMINATION OF OPTIMUM AIRLINE USING FUZZY TOPSIS METHOD

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Abstract — Due to *globalization, the use of air cargo shipping in transportation system has been increased rapidly. In this process, relative to increasing customer demands and competition, there had been a need for reliability improvement, service quality, and creating different values for customers. The aim of this study is to introduce Fuzzy TOPSIS method and to show how to benefit it for the preference of air cargo shipping companies. Fuzzy TOPSIS method is one of the Fuzzy Multiple Criteria Decision Making (FMCDM) methods and helps group decision-making in fuzzy environments. According to fuzzy TOPSIS method, a closeness coefficient is evaluated to determine the ranking order. A closeness coefficient is calculated by means of Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS). According to the calculated closeness coefficients alternatives are ranked. Five airlines companies, that does mostly Far & Middle East cargo shipping has been evaluated for the selection of airline company problem. A questionnaire survey with freight forwarder firms had been done. Using this survey results most preferred airline company has been chosen. The importance of the study is that this is an unique application in air cargo industry. Furthermore, there have not been any studies focused on airline company selection using Fuzzy TOPSIS. The study also showed that Fuzzy TOPSIS method could be used in airline company selection*

Keywords — Air Cargo, Airline, Freight Forwarder, Multi-Criteria Decision Making, Fuzzy TOPSIS.

INTRODUCTION

The importance of the role of the air cargo industry is increasing day by day in world trade. The air cargo market has doubled in volume every 10 years since 1970, and this trend is expected to continue over the next 20 years with an annual average growth rate of over 6%, according to Boeing's World Air Cargo Forecast. This growth trend is substantially sustained by the emergence of globally integrated just-in-time production and logistics networks and the rapid development of E-commerce [1].

According to Airport Council International data in 2007 the amount shipped by air cargo in world has been increased to 48.3 million tones by 3.6%. In Turkey the amount shipped is approximately 310000 tones according to State Airports Administration data. By air, Turkey imported $18 billion and exported $8 billion of merchandise in 2007. When compared to last year, the value of merchandise imported had been increased by 17% while the value of merchandise exported had increased by 44% [2].

The liberalization of international air transport services has been the subject of numerous papers. Most of the studies have focused on the air passenger market. However, there have been growing interests in the subject of liberalization of air cargo services for the last few years. The interests arise in part due to the fast growth of the sector, and in part to the push by shippers and traders and by major freighter carriers especially air express operators. For the last decade or so, streamlining business supply chains has made air cargo in general, and air express in particular, the fastest-growth area in the dynamic cargo sector [3].

Decisions can be made under certanity or uncertainty. Decision making under certanity is more easier since there has been so many methods enhanced. On the contrary, decision making under uncertanity is much more difficult. The environments where decisions are made under uncertanity and at the same time with

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recessive objection and constraints are known as fuzzy environments [4]. The mathematical formulation of fuzzy set theory was firstly introduced by Zadeh [5]. In that study, Zadeh improved a mathematical method which models uncertain conditions.

Fuzzy TOPSIS is the fuzzy extension of TOPSIS to efficiently handle the fuzziness of the data involved in the decision making. It is easy to understand and it can effectively handle both qualitative and quantitative data in the multiattribute decision making (MADM) problems. Decision makers, decision criteria and alternatives are needed for the model. In Fuzzy TOPSIS, decision makers firstly evaluates the importance level of each criterion subjectively. After that, alternatives are evaluated with respect to each criterion. Decision makers does the evaluation of both alternatives and decision criteria by linguistic variables. Desired calculations are made by transforming linguistic variables into triangular or trapeziodal numbers.

In this study, we use fuzzy TOPSIS to solve a multiple criteria decision making problem. The problem is a selection of the best airline company between five competitive airlines. The remainder of this paper is organized as follows: Next section presents the literature available in logistics sector using fuzzy TOPSIS methodology. Section III briefly discusses the methodology of fuzzy TOPSIS. In Section IV we applied the fuzzy TOPSIS method to the selection of the airline company. Conclusions are drawn in the last Section.

LITERATURE REVIEW

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), firstly introduced by Hwang and Yoon, is a multi-criteria decision making (MCDM) methodology based on the assumption that the best alternative should be as close as possible to the ideal solution and the farthest from the negative-ideal solution [6, 7].

In the last years, TOPSIS has been widely applied in literature. Since there are so many studies been made we limited our research to logistics sector. Qian and Huang [8] had applied TOPSIS to evaluate the performance of third party logistics enterprises (3PLs) and to make decision of outsourcing the logistics services. Feng and Wang [9] constructed a performance evaluation process for airlines with financial ratios taken into consideration. Their study uses TOPSIS method for the outranking of airlines. Tsaur et al. [10] applied fuzzy set theory to evaluate the service quality of airline.

Furthermore, TOPSIS can be integrated with different methods. Bottani and Rizzi [11] had applied a fuzzy TOPSIS methodology in order to support outsourcing of logistics services. Kahraman *et al*. [12], in their study had presented a hierarchical fuzzy TOPSIS method to solve the complex selection problem with vague and linguistic data. Büyüközkan *et al.* [13], models the strategic alliance partner problem as an MCDM problem, and solves it by using fuzzy AHP and fuzzy TOPSIS models. Çelik *et al.* [14], used a hybrid approach on ensuring the competitiveness requirements for major Turkish container ports by utilizing fuzzy axiomatic design (FAD) and fuzzy TOPSIS methodologies to manage strategic decision-making with incomplete information. Wang and Chang [15] in their study, develops an evaluation approach based on TOPSIS to help the Air Force Academy in Taiwan choose optimal initial training aircraft in a fuzzy environment where the vagueness and subjectivity are handled with linguistic terms parameterised by triangular fuzzy number. There can be find many applications of fuzzy TOPSIS in various research areas in the literature [16, 17, 18, 19].

FUZZY TOPSIS METHODOLOGY

A TOPSIS solution is defined as the alternative which is simultaneously farthest from the negative-ideal and closest to the positive-ideal alternative. In the classical TOPSIS method, the weights of the criteria and the ratings of alternatives are known precisely and crisp values are used in the evaluation process. However, under many conditions crisp data are inadequate to model real-life decision problems. Therefore, the fuzzy TOPSIS method is proposed where the weights of criteria and ratings of alternatives are evaluated by linguistic variables represented by fuzzy numbers to deal with the deficiency in the traditional TOPSIS.

In this paper, the extension of TOPSIS method is considered which was proposed by Chen [20] and Chen et al.[21] The algorithm of this method can be described as follows:

Step 1: First of all a committee of decision-makers is formed. In a decision committee that has K decision-makers; fuzzy rating of each decisionmaker $D_k = (k = 1,2,..., K)$ can be represented as triangular fuzzy number $\tilde{R}_k = (k = 1,2,..., K)$ with membership function $\mu_{\tilde{R}_k}(x)$.

Step 2: Then evaluation criteria are determined.

Step 3: After that, appropriate linguistic variables are chosen for evaluating criteria and alternatives.

Step 4: Then the weight of criteria are aggregated [21].

If the fuzzy ratings of all decision-makers are described as triangular fuzzy numbers $\tilde{R}_k = (a_k, b_k, c_k)$, $k = 1,2,..., K$ then the aggregated fuzzy rating can be determined as:

$$\tilde{R} = (a,b,c),\ k = 1,2,..., K \tag{1}$$

Here;

$$a = \min_k \{a_k\},\ b = \frac{1}{K}\sum_{k=1}^{K} b_k\ ,\ c = \max_k \{c_k\}$$

If the fuzzy rating and importance weight of the *k*th decision-maker are $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ and $\tilde{w}_{jk} = (w_{jk1}, w_{jk2}, w_{jk3})$, $i = 1,2,..., m$, $j = 1,2,..., n$ respectively, then the aggregated fuzzy ratings $(\tilde{x}_{ij})$ of alternatives with respect to each criterion can be found as $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ (2)

where,

$$a_{ij} = \min_k \{a_{ijk}\},\ b_{ij} = \frac{1}{K}\sum_{k=1}^{K} b_{ijk}\ ,\ c_{ij} = \max_k \{c_{ijk}\}$$

Then the aggregated fuzzy weights $(\tilde{w}_{ij})$ of each criterion are calculated as:

$$(\tilde{w}_{ij}) = (w_{j1}, w_{j2}, w_{j3}) \tag{3}$$

where,

$$w_{j1} = \min_k \{w_{jk1}\}, w_{j2} = \frac{1}{K}\sum_{k=1}^{K} w_{jk2}\ ,\ w_{j3} = \max_k \{w_{jk3}\}$$

Step 5: Then the fuzzy decision matrix is constructed as:

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix}$$

$$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n]$$

where

$(\tilde{x}_{ij}) = (a_{ij}, b_{ij}, c_{ij})$ and $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$; $i = 1, 2, \ldots, m$ $j = 1,2,..., n$ can be approximated by positive triangular fuzzy numbers.

Step 6: After constructing the fuzzy decision matrix, it is normalized. Instead of using complicated normalization formula of classical TOPSIS, the linear scale transformation can be used to transform the various criteria scales into a comparable scale.

Therefore, we can obtain the normalized fuzzy decision matrix $\tilde{R}$ [20].

$$\tilde{R} = [\tilde{r}_{ij}]_{m*n} \qquad i = 1,\ 2,\ ....,m;\ j = 1,\ 2,\ ...,\ n \tag{4}$$

where:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right),$$

$$c_j^* = \max_i c_{ij}$$

Step 7: Considering the different weight of each criterion, the weighted normalized decision matrix is computed by multiplying the importance weights of evaluation criteria and the values in the normalized fuzzy decision matrix. The weighted normalized decision matrix $\tilde{V}$ is defined as:

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m*n} \qquad i = 1, 2, ..., m \,;\, j = 1, 2, ..., n \tag{5}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij}(\cdot)\tilde{w}_j$$

here $\tilde{w}_j$ represents the importance weight of criterion C_j .

According to the weighted normalized fuzzy decision matrix, normalized positive triangular fuzzy numbers can also approximate the elements $\tilde{v}_{ij}$, .

Step 8: Then, the fuzzy positive ideal solution $(FPIS, A^*)$ and fuzzy negative ideal solution $(FNIS, A^-)$ are determined as [21]:

$$A^* = \left(\tilde{v}_1^*, \tilde{v}_2^*, ..., \tilde{v}_n^*\right), \tag{6}$$

$$A^- = \left(\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_n^-\right), \tag{7}$$

where

$\tilde{v}_j^* = \max_i \{v_{ij3}\}$ and $\tilde{v}_j^- = \min_i \{v_{ij1}\}$

$i = 1,2,..., m$, $j = 1,2,..., n$.

Step 9: Then the distance of each alternative from FPIS and FNIS are calculated as:

$$d_i^* = \sum_{j=1}^{n} d_v\left(\tilde{v}_{ij}, \tilde{v}_j^*\right),\; i = 1,2,..., m \tag{8}$$

$$d_i^- = \sum_{j=1}^{n} d_v\left(\tilde{v}_{ij}, \tilde{v}_j^-\right),\; i = 1,2,..., m \tag{9}$$

where $d_v(.,.)$ is the distance measurement between two fuzzy numbers.

Step 10: A closeness coefficient is defined to determine the ranking order of all possible alternatives. The closeness coefficient represents the distances to the fuzzy positive ideal solution (A^*) and fuzzy negative ideal solution (A^-) simultaneously. The closeness coefficient (CC_i) of each alternative is calculated as [20]:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-},\; i = 1,2,..., m \tag{10}$$

Step 11: According to the closeness coefficient, the ranking of the alternatives can be determined. Obviously, according to (10) an alternative A_i would be closer to FPIS and farther from FNIS as CC_i approaches to 1.

NUMERICAL EXAMPLE

The evaluation process is valid for the five competitive firms which does far & Middle East cargo shipping intensively. Far & middle east cargo shipping includes either imported or exported cargos from /to Turkey. A freight forwarder is an international trade specialist who can provide a variety of functions to facilitate the movement of cross-border shipments. These functions include, but are not limited to, booking vessel, air space, preparing relevant documentation, paying freight charges, and arranging inland transport services [22]. In air cargo transportation price criteria will change due to the different routes or company relations. Because of these reason price criteria is not taken in this study.

In our study, we take five criteria into consideration. These are Reliability (C_1), Number of Locations (C_2), Frequency (C_3), Service Quality (C_4) and Customer Satisfaction (C_5).

Firstly, four decision-makers evaluated the importance of criteria by using the linguistic variables in Table 1. The importance weights of the criteria determined by these four decision-makers are shown in Table 2.

TABLE 1
Linguistic Variables for Importance Weight of Each Criterion

Linguistic variables	Triangular fuzzy numbers		
Very high(VH)	0,9	1	1
High (H)	0,7	0,9	1
Medium high (MH)	0,5	0,7	0,9
Medium (M)	0,3	0,5	0,7
Medium low (ML)	0,1	0,3	0,5
Low (L)	0	0,1	0,3
Very low (VL)	0	0	0,1

TABLE 2
Importance Weight of Criteria from Four Decision-makers

	DM_1	DM_2	DM_3	DM_4
C_1	VH	MH	H	VH
C_2	H	VH	M	M
C_3	VH	H	H	M
C_4	MH	VH	M	H
C_5	MH	H	MH	VH

Four decision-makers use the linguistic variables shown in Table 3 to evaluate the ratings of alternatives with respect to each criterion. The ratings of five alternatives under five criteria are shown in Table 4.

TABLE 3
Linguistic Variables for Ratings

Linguistic variables	Triangular fuzzy numbers		
Very good (VG)	9	10	10
Good (G)	7	9	10
Medium good (MG)	5	7	9
Fair (F)	3	5	7
Medium poor (MP)	1	3	5
Poor (P)	0	1	3
Very poor (VP)	0	0	1

TABLE 4
Ratings of the Five Alternatives by Decision- makers Under Each Criterion

	C_1				C_2				C_3				C_4				C_5			
	DM1	DM2	DM3	DM4	DM1	DM2	DM3	DM4	DM1	DM2	DM3	DM4	DM1	DM2	DM3	DM4	DM1	DM2	DM3	DM4
A	MG	VG	G	MG	MG	G	MG	G	VG	G	G	VG	VG	VG	VG	VG	G	MG	G	VG
B	VG	VG	F	VG	G	MG	G	MG	G	VG	VG	VG	MG	G	G	F	VG	VG	VG	MG
C	F	G	MG	G	P	P	P	P	MG	MG	MG	G	G	G	G	G	F	F	F	F
D	P	F	MG	P	F	MG	F	F	G	F	F	F	F	P	P	P	P	VP	P	P
E	MP	F	MG	MP	VG	VG	VG	VG	F	F	G	G	MG	MG	P	P	MP	F	MP	MP

Then linguistic variables that are presented in Tables 2 and 4 are converted into triangular fuzzy numbers to form fuzzy decision matrix as shown in Table 5.

The normalized fuzzy decision matrix is formed as in Table 6. Then weighted normalized fuzzy decision matrix is formed as in Table 7.

After a weighted normalized fuzzy decision matrix is formed, fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) are determined as

$$A^* = [(0{,}98\,,0{,}98,\,0{,}98),(0{,}85,\,0{,}85,\,0{,}85),(0{,}93,\,0{,}93,0{,}93),(0{,}90,\,0{,}90,\,0{,}90),(0{,}95,\,0{,}95,\,0{,}95)]$$

$$A^- = [(0{,}16\,,0{,}16,\,0{,}16),(0,\,0,\,0),(0{,}26,\,0{,}26,0{,}26),(0{,}06,\,0{,}06,\,0{,}06),(0,\,0,\,0)]$$

Then the distance of each alternative from FPIS and FNIS with respect to each criterion are calculated by using vertex method [20].

TABLE 5
Fuzzy Decision Matrix and Fuzzy Weights of Five Alternatives

	C_1			C_2			C_3			C_4			C_5		
A	6,50	8,25	9,50	6,00	8,00	9,50	8,00	9,50	10,00	9,00	10,00	10,00	7,00	8,75	9,75
B	7,50	8,75	9,25	6,00	8,00	9,50	8,50	9,75	10,00	5,50	7,50	9,00	8,00	9,25	9,75
C	5,50	7,50	9,00	0,00	1,00	3,00	5,50	7,50	9,25	7,00	9,00	10,00	3,00	5,00	7,00
D	2,00	3,50	5,50	3,50	5,50	7,50	4,00	6,00	7,75	1,00	2,50	4,50	0,00	0,75	2,50
E	2,50	4,50	6,50	9,00	10,00	10,00	5,00	7,00	8,50	2,50	4,00	6,00	1,50	3,50	5,50
Weights	0,75	0,90	0,98	0,55	0,73	0,85	0,65	0,83	0,93	0,60	0,78	0,90	0,65	0,83	0,95

TABLE 6
Normalized Fuzzy Decision Matrix

	C_1			C_2			C_3			C_4			C_5		
A	0,68	0,87	1,00	0,60	0,80	0,95	0,80	0,95	1,00	0,90	1,00	1,00	0,72	0,90	1,00
B	0,79	0,92	0,97	0,60	0,80	0,95	0,85	0,98	1,00	0,55	0,75	0,90	0,82	0,95	1,00
C	0,58	0,79	0,95	0,00	0,10	0,30	0,55	0,75	0,93	0,70	0,90	1,00	0,31	0,51	0,72
D	0,21	0,37	0,58	0,35	0,55	0,75	0,40	0,60	0,78	0,10	0,25	0,45	0,00	0,08	0,26
E	0,26	0,47	0,68	0,90	1,00	1,00	0,50	0,70	0,85	0,25	0,40	0,60	0,15	0,36	0,56

TABLE 7
Weighted Normalized Fuzzy Decision Matrix

	C_1			C_2			C_3			C_4			C_5		
A	0,51	0,78	0,98	0,33	0,58	0,81	0,52	0,78	0,93	0,54	0,78	0,90	0,47	0,74	0,95
B	0,59	0,83	0,95	0,33	0,58	0,81	0,55	0,80	0,93	0,33	0,58	0,81	0,53	0,78	0,95
C	0,43	0,71	0,92	0,00	0,07	0,26	0,36	0,62	0,86	0,42	0,70	0,90	0,20	0,42	0,68
D	0,16	0,33	0,56	0,19	0,40	0,64	0,26	0,50	0,72	0,06	0,19	0,41	0,00	0,06	0,24
E	0,20	0,43	0,67	0,50	0,73	0,85	0,33	0,58	0,79	0,15	0,31	0,54	0,10	0,30	0,54

The results of all alternatives' distances from FPIS and FNIS are shown in Table 8. The table summarizes the results. The higher the closeness means the beter the rank. Therefore, alternative A is defined as the best alternative for air cargo shipping in this study.

TABLE 8
Distances from FPIS and FNIS

	d_i^*	d_i^-	CC_i	Rank
A	**1,41**	**3,18**	**0,69**	**1**
B	1,45	3,10	0,68	2
C	2,33	2,25	0,49	3
D	3,15	1,36	0,30	5
E	2,46	2,07	0,46	4

CONCLUSION

In this study, our aim was to make a selection between five competitive airline companies using fuzzy TOPSIS method. The airline companies mentioned here does mostly Far & Middle East cargo shipping. Fuzzy TOPSIS method had been applied for solving airline company selection problem. The result indicates that Fuzzy TOPSIS method seems to be promising. Fuzzy TOPSIS method can also be used for airline company selection problem.

A questionnaire survey with freight forwarder firms had been done at the beginning of the study to choose the attributes which will be used in TOPSIS method and also due to the questionnaire the weights of each attribute are calculated. As a result, based on the descending order of closeness coefficient, the preference order of the companies is found as Firm A, B, C, E and D, respectively.

This research can also be extended by incorporating additional selection criteria such as risk factors and environmental concerns. Different alternative methodologies such as fuzzy analytic network process and fuzzy ELECTRE can also be implemented to solve the problem.

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LESSONS FROM EUROPEAN UNION FUTURE TRANSPORT POLICIES

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Abstract - *European Union (EU) committees had been prepared policy programs for the competitiveness and sustainability of European transport system. By means of these policies, EU has safer skies, seas, railways, waterways and roads. Besides, transport services are cheaper and more efficient, passenger rights have been strengthened and transport workers enjoy a higher level of social protection. But recently transport is at a transition point. EU is facing new and formidable challenges like as reducing the greenhouse gas emissions, growing demand and declining production of oil etc. On the other hand, Turkey's national transport policy has its own agenda: Improving safety and security, financial sustainability etc. This paper aims to evaluate European Union's policy programme and Turkey's national agenda together and composed of two main parts. First part consists of the survey regarding with the EU transportation policies. Second part focuses on national transport policies of Turkey.*

Key words- European Union, transport policies, Turkey

INTRODUCTION

Transport is a complex system that depends on multiple factors, including the pattern of human settlements and consumption, the organization of production and the availability of infrastructure. Owing to this complexity, any intervention in the transport sector must be based on a long-term vision for the sustainable mobility of people and goods, not least because policies of a structural character take a long time to implement and must be planned well in advance. That is why transport policies for the next ten years must be based on a reflection on the future of the transport system that embraces also the following decades.

The present communication summarizes the results of this wide reflection. In the following section, recent developments of the European Transport Policy (ETP) and outstanding issues have been mentioned. While looking at future, identifying trends in transport drivers and the likely challenges they could pose to society. Some current intermediate policy objectives, which could be pursued to address the emerging challenges in the transport sector, had been assessed. In order to accommodate Turkey's National Transportation Policy to EU Transportation Policies, all in 9th Development Plan, Medium Term Programme and Transport Master Plan Strategy the basic principles of EU and global transportation priorities had been mentioned.

EUROPEAN TRANSPORT POLICY IN THE RECENT PAST

Before looking at the future, it is useful to take stock of developments in the recent past. While it is too early to fully assess the impact of a number of policy measures taken since 2000, a few indications can nevertheless be distilled from market trends and data. (4). The following section shows that the European Transport Policy (ETP) has largely achieved the objectives set out in the above mentioned strategic documents, by substantially contributing to the development of the European economy and its competitiveness, by facilitating market opening and integration, by establishing high quality standards for safety, security and passenger rights and by improving working conditions.

Transport is an essential component of the European economy. The transport industry at large accounts for about 7 % of GDP and for over 5 % of total employment in the EU. The ETP has contributed to a mobility system that compares well in terms of efficiency and effectiveness with that of the economically most advanced regions of the world. The ETP has assisted social and economic cohesion and promoted the competitiveness of the European industry [1] thereby contributing significantly to the Lisbon agenda for growth and jobs.

Market opening has generally led to more efficiency and lower costs. This can be seen in air transport, where the process is more advanced. The EU is on its way to create a level playing field in the increasingly integrated transport market, but issues such as differences in taxation and subsidies still need to be addressed.

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Trans-European transport networks (TEN-T) policy has much increased the coordination in the planning of infrastructure projects by the Member States. Progress in implementation has been substantial and about one third of the necessary investments (EUR 400 billion) in the TEN-T has been made. The extension of the TENs to cover the new Member States, building on the investment already made prior to enlargement. Much remains to be done, but the TENs have already gone a long way in linking EU markets and peoples [2].

Progress has been achieved in reducing air pollution and road accidents. Air quality in European cities has significantly improved through the application of ever-stricter Euro emission standards, but more needs to be done. In the maritime sector, marine pollution and maritime accidents were considerably reduced and the EU has established one of the most advanced regulatory frameworks for safety and for pollution prevention (most recently with the third maritime safety package). In aviation, it has adopted a comprehensive set of common, uniform and mandatory legislation covering all the key elements affecting safety.

Quality services for transport users have been promoted by strengthening passenger rights. Legislation on aviation passengers' rights has been adopted and is now in force. On the other hand, public transport (bus and rail) has been identified as one of the sectors where consumer satisfaction is the lowest [3].

The social dimension of transport policy was strengthened also with respect to transport workers. Legislation on working time, the minimum level of training and mutual recognition of diplomas and qualifications was introduced — in collaboration with the social partners — to improve working conditions in road, rail and maritime transport.

The energy efficiency of transport is increasing, but the gains in efficiency have not been entirely devoted to reducing overall fuel consumption and have not been enough to outweigh the larger transport volumes. There has also been limited progress in shifting transport to more efficient modes, including through the development of short sea shipping, although a certain rebalancing has taken place and the relative decline of rail transport appears to have stopped.

Transport did not reduce significantly its GHG intensity by switching to cleaner energy sources and is still 97 % dependent on fossil fuels, which has negative implications also for the security of energy supply. Measures to improve fuel quality and a binding target of a 10 % share of renewable energy sources in transport by 2020 have been adopted recently as part of the climate and energy package [2].

EUROPEAN TRANSPORT POLICY TRENDS AND CHALLENGES

This section describes trends in the main transport drivers up to the middle of the century and the related challenges. It is difficult to anticipate which of them will have the greatest influence in shaping the future of transport.

Ageing: By 2060, the median age of the European population is projected to be more than 7 years higher than today and the number of people aged 65 or more is expected to represent 30 % of the population (now 17 %). Although above a certain age people generally travel less than when they were younger, aged people of today tend to travel more than their parents did. This tendency is expected to continue and is reinforced by improved health, more travelling options. An ageing society will pay more emphasis on the provision of public transport services involving a high level of perceived security and reliability, and which feature appropriate solutions for users with reduced mobility. A society with a higher ratio of older people will need to devote more public resources to pension payments, health care and nursing.

Migration and internal mobility: Net migration to the EU might add 56 million people to the EU's population in the next five decades [4]. Migration could play an important role in mitigating the effect of ageing on the labour market. Migrants, generally young and mainly living in urban areas, will further intensify Europe's ties with neighbouring regions, by creating cultural and economic links with their country of origin. These links will entail more movement of people and goods. Mobility of workers is also expected to increase with the gradual removal of administrative and legal barriers and further deepening of the internal market.

Environmental challenges: There is growing urgency for the transport sector to mitigate its negative impact on the environment. The EU has recently adopted a climate and energy package that sets a target of reducing GHG emission in the EU by 20 % with respect to 1990. Transport has a key role to play in achieving this goal. European Environment Agency shows that many Europeans still remain exposed to dangerously high levels of air and noise pollution. Transport itself will suffer from the effects of climate change and will necessitate adaptation measures. Global warming resulting in a rising sea level will amplify the vulnerability of coastal infrastructures, including ports. Extreme weather events would affect the safety of all modes. Droughts and floods will pose problems for inland waterways.

Increasing scarcity of fossil fuels: In the coming decades, oil and other fossil fuels are expected to become more expensive as demand increases and low cost sources dry up. The negative impact on the environment will be greater, as conventional sources are replaced by more polluting supplies. At the same time, the need to move to a low-carbon economy and the growing concerns about energy security will bring about a greater supply of renewable energy, made much cheaper by technological progress and mass production.

The shift in relative prices will make investments in alternative energy sources more attractive, in spite of the high variability of those prices. The immediate consequence of such transformation will be the reduction in the need to transport fossil fuels [2].

Urbanisation: Urbanisation has been a clear trend in the past decades and is expected to continue, with the proportion of the European population residing in urban areas increasing from 72 % in 2007 to 84 % in 2050 . The proximity of people and activities is a major source of advantages that drive urbanisation. However, in the past 50 years, the growth of urban areas across Europe was even larger than that of the resident population. This urban sprawl is the main challenge for urban transport, as it brings about a greater need for individual transport modes, thereby generating congestion and environmental problems. Urban transport accounts for 40 % of CO2 emissions and 70 % of emissions of other pollutants arising from road transport [5] .

Congestion that is prevalent in agglomerations and in their access routes is the source of large costs in terms of delays and higher fuel consumption. As most freight and passenger transport starts or ends in urban areas, urban congestion also negatively impacts on inter-urban travel. While denser cities are better served by collective modes of transport, the availability of land and public acceptability to construct new infrastructures for public or alternative means of transport will remain a great challenge.

Global trends affecting European transport policy: Together with further deepening of the single market, integration of the EU with neighbouring regions (eastern Europe, North Africa) and into the world economy is likely to continue. Globalisation, enabled by trade liberalisation agreements and by revolutionary developments in transport and communication technologies that have reduced distance and time barriers. Although it may be temporarily halted by economic crises and geopolitical instability, the strong economic growth of many developing countries implies further globalisation. Transport outside Europe will increase much more than inside Europe and EU external trade. The world population is expected to exceed 9 billion by 2050. More people and greater economic affluence mean more mobility and more transport. It is expected that the number of cars in the world will increase from around 700 million today to more than 3 billion in 2050, creating serious sustainability problems unless there is a transition towards lower and zero-emission vehicles and a different concept of mobility is introduced.

EUROPEAN UNION POLICIES FOR SUSTAINABLE TRANSPORT

The goal of the ETP is to establish a sustainable transport system that meets society's economic, social and environmental needs and is conducive to an inclusive society and a fully integrated and competitive Europe [2]. The most immediate priorities appear to be the better integration of the different modes of transport as a way to improve the overall efficiency of the system and the acceleration of the development of innovative technologies — within an approach that always keeps the transport users and workers, with their needs and rights, at the centre of policymaking. Here are the policy objectives for sustainable transport:

- Quality transport that is safe and secure
- A well-maintained and fully integrated network
- More environmentally sustainable transport
- Keeping the EU at the forefront of transport services and technologies
- Protecting and developing the human capital
- Smart prices as traffic signals
- Improving accessibility

Whereas the previous section proposes the broad objectives for future transport policy, this section puts forward some suggestions on how the available policy instruments could be activated to reach those goals and respond to the sustainability challenge.

Infrastructure: maintenance, development and integration of modal networks: The optimal functioning of the transport system requires full integration and interoperability of the individual parts of the network, as well as interconnection between different (modal) networks. Crucial in achieving this result are the nodes, which are the logistics centers of the network and offer connectivity and choice for both freight and passenger transport. Intermodal and transhipment platforms should be promoted and developed where there is a potential for consolidation and optimization of passenger and freight flows.

Well-focused infrastructure expansion will help in avoiding congestion and time losses. In this respect, infrastructure needs to be carefully planned and prioritized with a view to optimize transport chains and the overall transport network. In addition to the removal of bottlenecks, it will be essential to identify green corridors in order to reduce congestion and environmental pollution.

New infrastructure is costly and making the optimal use of existing facilities can already achieve a lot with more limited resources. This requires proper management, maintenance, upgrading and repair of the large infrastructure network that has so far given Europe a competitive advantage.

Due to Europe’s long coastline and large number of ports, the maritime sector is a valuable alternative to land transport. The full implementation of the European maritime space without barriers and the maritime transport strategy for 2018 can make the ‘motorways of the sea’ a reality and exploit the potential of intra-European short sea shipping.

Funding: finding the resources for sustainable transport: The transition towards a low-carbon economy will impose a substantial overhaul of the transport system. This will require considerable and well-coordinated funding, but the necessary resources will be difficult to find: the current economic crisis is putting public finances under pressure and is likely to be followed by a phase of budgetary consolidation.

Investment in transport infrastructure is mainly financed with public funds, which often also cover around 50 % of operating costs of public transport services. The use of public funding in addition to ‘user-pays’ sources is justified on the basis of wider socioeconomic benefits. These benefits should be assessed through project appraisal methods progressively harmonized at EU level. Total infrastructure costs in road transport — that is fixed cost plus maintenance — are estimated at about 1.5 % of GDP.

The Commission proposed last year a stepwise strategy for the internalization of external costs in all transport modes, which contemplates, among other measures, the inclusion of aviation in the EU emission trading scheme from 2012 and the introduction of internalization charges for heavy goods vehicles. The development of technology will facilitate the future implementation of this strategy. Internalization charges to complement revenues from energy taxation are likely to be necessary in any event, since excise duties on oil derivatives will presumably decline with wider diffusion of vehicles running on alternative sources of energy.

Technology: how to accelerate the transition to a low-carbon society and lead global innovation: Science and industry are already very active in searching out solutions for transport safety, fuel dependency, vehicle emissions and network congestion. In view of the abovementioned trends in world population and global car ownership, there is a compelling need for a technological shift towards lower and zero-emission vehicles and for the development of alternative solutions for sustainable transport. Europe must pave the way to sustainable mobility, where possible providing solutions that are valid on a global scale and that can be exported to other regions of the world.

The most important policy instrument will probably be standard setting. The transition to a new and integrated transport system will only be quick and successful if open standards and norms for new infrastructure and vehicles and other necessary devices and equipment are introduced. The standard setting should aim at interoperable, safe and user-friendly equipment. This is not only important for the internal market, but also to foster European standards on an international scale.

Another policy instrument is to foster research & development expenditures towards sustainable mobility, for example through the European green cars initiative and joint technology initiatives. New transport systems and vehicle technologies will have to be first implemented as demonstration projects, to assess their feasibility and economic viability. Public intervention would also be needed at various stages of the development of the infrastructure that supports new vehicles for electric transport or hydrogen distribution networks. Finally, state aid rules will also be an important policy instrument to favour the development of new technologies and of alternative modes of transport.

The legislative framework: further promoting market opening and fostering competition: The EU has embarked on a market opening process which has already proved successful where more advanced. As a result, a growing number of firms are active across national markets and different modes, which benefits overall economic performance and employment in the EU. Partially open markets, however, carry the risk that operators acting in protected environments subsidise their operations in liberalized markets.

The completion of the internal market with a strong enforcement of competition rules is essential. It should also include administrative simplification aiming at reducing unnecessary burdens on transport companies. On the basis of the achievements in the fields of air and road transport, new rules for opening up the markets coupled with effective enforcement of existing legislation will be particularly important in the rail sector. At the same time, the regulatory framework needs to evolve towards harmonized environmental obligations, effective supervision, uniform protection of workers conditions and users' rights. The legislative framework will need to make sure that competition not only takes place on a level playing field, but also does not sacrifice safety and security standards, working conditions and the rights of customers.

Behaviour: educate, inform and involve: Transport policies have a very direct impact on people's lives and tend to be highly controversial: citizens should be given better information on the reasoning behind policy decisions and on the available alternatives. A better understanding of the challenges ahead is a precondition for public acceptance of the solutions. Greater public involvement in transport planning can be ensured by recourse to participatory instruments, namely open consultations, surveys and stakeholders' representation in decision processes. Transport workers and the sectoral social partners should be informed and consulted on the development, application and monitoring of transport policy and related measures, both at sectoral and at enterprise level.

Governance: effective and coordinated action: The transport system involves complex interactions among political, economic, social and technical factors. The sector can only thrive if policymakers are capable of providing sound planning, adequate funding and a proper regulatory framework for market operators.

This is a challenging task since it requires policy coordination between different bodies and at different levels. The ETP is a particular case in point, its success depending to a large extent on how it is implemented and complemented by measures decided at other levels of government. There are at least two areas in which the benefits of effective coordinated action, beyond what is currently done at EU level, are worth emphasizing.

• Standards and interoperability. Many new technologies and regulatory practices will develop in the next few years to address transport challenges. Coordination will be needed to ensure equipments' interoperability and to avoid the proliferation of different systems at national level, for example rules and standards for tolling, for ITS or for access to congested areas.

• The urban challenge. For subsidiarity reasons, the EU role in regulating urban transport is limited. On the other hand, most transport starts and ends in cities and interconnection-standardisation issues do not stop at cities. Cooperation at EU level can help urban authorities in making their transport systems more sustain able.

The external dimension: the need for Europe to speak with one voice: The transport sector is increasingly international. The ETP needs therefore to project itself internationally so to ensure further integration with the neighboring countries and advance Europe's economic and environmental interests in the global context. Closer economic integration and migration flows from neighbouring countries and the African continent will be one of the key challenges that Europe will have to face in the future. International transport cooperation aiming at establishing the necessary interconnection of the major transport axes of these regions should be further promoted, helping in ensuring sustainable development.

Indeed, the development of the south east Europe core regional network as a precursor of the TEN-T is crucial for the stability and economic prosperity of south east Europe and will strengthen also the links with the candidate and potential candidate countries from the region.

TURKEY'S NATIONAL POLICY FRAMEWORK ON TRANSPORT POLICY

In order to accommodate Turkey's National Transportation Policy to EU Transportation Policies, all in 9th Development Plan, Medium Term Programme and Transport Master Plan Strategy the basic principles of EU and global transportation priorities had been mentioned. Following is respectively Turkey's National framework [6]:

The 9th Development Plan (9th DP):

The 9th Development Plan which covers the period of 2007-2013, is the major policy document of Turkey which sets down the priorities of the Country in economic, social and cultural fields. While former Development Plans covered a period of 5 years, the 9th DP Development Plan (published on 1 July 2006 in Official Gazette) was elaborated for 7 years in the interests of consistency with the timeframe of EU budgeting and IPA programming. The 9th DP sets out five development axes:

- Increasing the competitiveness,
- Increasing employment,
- Empowering human capital and social solidarity,
- Ensuring regional development, and
- Increasing quality and efficiency of public services.

Among these axes which support the strategic aim of achieving economic growth and social development in a sustainable way, transport is assessed under the development axis 'Increasing Competitive Power'. The strategic goal for transport sector is defined as: '*Establishment of rapid and safe transport infrastructure that will increase the competitive power of the country*'. In line with this strategic goal, 9th DP puts forward four thematic subjects for transport policy:

- Establishment of an Efficient Transport System
- Improved Safety and Security
- Integration with Europe and Neighbouring Economies
- Environmental and Financial Sustainability

Also, sectoral priorities are identified under each thematic subject. In summary, content of the sectoral priorities; 9th DP mainly focuses on the imbalance among transport modes, the insufficiency of physical infrastructure in rail and maritime transportation and the lack of safety in road transport, partly, because of low physical standards.

Medium Term Programme 2007 – 2009

The Medium Term Programme covering the period of 2007-2009 has been formulated for the purpose of incorporating public policies and directing associated resource allocation according to this frame. With its statement of coherent objectives, policies and priorities in various domains, the Medium Term Programme contains major development axes and sectors alled with macro policies. The main aims of the Medium Term Programme 2007-2009 are:

- Ensuring sustainable growth
- Enhancement of competitiveness of Enterprises
- Regional Development and Reducing Regional Disparities
- Improvement of physical infrastructure

The Medium Term Programme determines the main objective to be endorsed in transport policies as a transport system that ensures a healthy balance among transport modes in line with the needs of the economy and social life and the timely development of a transport infrastructure on which economic, safe and speed transportation is realised in accordance with modern technology and international regulation. The Programme specifies the transport priorities as the connection of the transport network of Turkey with the TEN-T, focus on the railways and maritime transport modes in freight transport, introducing high-speed railway transportation, improvement of ports as logistics centres that can realise combined transportation; enhancement of standards of highways and augmenting the traffic safety on all transportation modes, especially on the roads.

Transport Master Plan Strategy

This plan was commissioned by the Ministry of Transport as an all-encompassing policy document that would facilitate decisions on sound of future investment in the transport sector, better identify priorities and re-organise legal and institutional structures in the sector, . The document was produced by distinguished academicians, in consultation with all relevant stakeholders and was completed by end 2005. The goal of Turkish transport policy is set out in the Transport Master Plan Strategy as the provision of an interrupted, safe and environmentally and user friendly transport service with quality standards having regard to the economic and social development of the State and to the needs of national security, and utilising modern technologies.

A primary objective of the project was to identify a strategy for the transport sector and to develop concrete and realisable proposals for the provision of a more balanced structure for the transport sector in which serious imbalances existed among the transport modes. The strategy observed that the road transport markedly stood out in both freight and passenger transport resulting not only in increased transport costs, but also roads congestion and increases in road traffic accidents causing serious life and property losses. Policies developed as a result of these analyses were as follows: focusing on combined transport, improving port capacity with its hinterland; revitalising the railways through restructuring the railway system, construction of new railway lines, maintenance and renewal works, provision of new rolling stock, improvement in the existing and future road accident black points. In this context, five strategies were presented as follows :

- Establishment of an administrative structure that would secure the coordination of relevant institutions in each mode of transport from one centre
- Preparation, implementation and updating of national strategic transport plan
- Collection and update of transport data
- Addressing the problems on the financing of transport projects
- Increase the efficiency of training activities in the field of transport

Strategic Coherence Framework (SCF)

Strategic Coherence Framework (SCF) which is elaborated under the coordination of the Strategic Coordinator, SPO and the contribution of all relevant Turkish authorities in conjunction with the guiding documents and the proposals of the Commission, is the major umbrella document for the Operational Programmes of the components of Regional Development and Human Resources Development. As the major strategic document of Turkey in the IPA process, SCF is designed in accordance with the priorities of Turkey consistent with the priorities of the EU.

The overall objective of SCF is "*To contribute both to the Turkey's approximation to the EU, and to the economic and social development of Turkey by reducing regional disparities and improving the human resources"* SCF puts forward three priority axes dealing with the problems of the transport sector which also embodies the main frame of the TOP:

- Rehabilitation and/or new construction of future TEN-T railway network and improvement/construction of ports as nodal and transit points in the TEN-T network
- Construction and improvement of highway network in conformity with TEN-T
- Technical Assistance for effective preparation, implementation, monitoring and evaluation of the operational *programme and for enhancement promotion and visibility of the activities.*

The TOP Transport fully endorses the priorities of SCF in its own priority axes through the adoption of special measures for the railways and ports, and establishment of their links with the TEN-T. At the same time, due to the extent of the financial resources allocated to the TOP, a measure for *construction and improvement of highway network in conformity with TEN-T* could not be covered under the current TOP Transport under 2007 -2009 programming.

CONCLUSION

As found in the sectoral assessments in Turkey, the imbalance among transport modes causes many disadvantages both in social life and in the economy. Railways have low standards and travelling time by rail is long, whereas air transport still tends to be expensive and airport access being troublesome. For these reasons, road transport is perceived by the public to be the most convenient. The dominance of road in the modal split and accessibility of the road network influences public investment to focus on roads.

One of the measure of Strategic Coherence Framework is "to improve the transportation infrastructure considering safety and intermodality on future TEN-T Network, while maintaining an efficient and a balanced transportation system."

In line with the overall objective and taking into account the shortcomings and the needs of the transport sector in Turkey, priorities have been set as follows: Improvement of railway infrastructure, improvement of port infrastructure and technical assistance.

In this context, again in line with the needs of the sector, the major policies of Turkey and the results of TINA Turkey Study with a prioritised project pipeline (and availability of IPA funds), two measures are submitted under two priorities:

- New construction and/or rehabilitation of railway lines on future TEN-T railway network or in connection with existing TEN-T
- New construction of ports on future TEN-T with necessary multimodal hinterland connections. In this way, it would be possible to realise and expedite needed investments in both rail and maritime infrastructure, and also reinforce the impact of the TOP by concentrated selection of measures and projects.

Achievement of these priorities, will directly lead to ensure a sustainable supply chain for the trade exchange between Turkey and Europe by means of the two modes of transport (railway and maritime), both environmentally positive. Secondly, ensure the integration of Turkey as a key element into the multi-modal supply chains of the region – the link between the Near East, Middle East, Caucasian region and Europe. And lastly, transform Turkey into a logistics node or hub for the multi-modal supply chains between Asia and Europe as well as Asia and the Black Sea region.

For freight transport, because of missing lines and inefficient railway infrastructure, highways are currently much preferable, although railways are more economic and more environmental friendly. Construction of missing lines will result in a strong and common freight transport system. Construction/improvement of ports as nodal and transit points will also a considerable effect on decreasing the imbalance among modes and on increasing the economic competitiveness. Intermodal transport will improve significantly with port hinterland connections. The priorities in the TOPwill upgrade maritime transport infrastructure, enhance existing port capacities and/or lead to the development of new hubs and large-scale ports in Mediterranean, Aegean and Black Sea regions with their hinterland connections within the context of Motorways of the Sea concept.

For all these reasons, strong railway infrastructure and port capacity are the prerequisites of a modern and developed Turkey and a productive Asia-Europe connection. Integration of the Turkish railway infrastructure with the TEN-T network and main corridors is of crucial importance for increasing Turkey's trade volume with Europe (and vice versa) and for passenger transport in Turkey, which would also benefit Turkey's competitiveness.

The coherence of TOP with other major policy documents is assured through the strategic priorities being defined in line with both Community policies and national policies as expressed in the major strategy documents - MIPD, White Paper, CSG and the 9th NDP, Transport Master Plan Strategy and SCF.

The overall objective of SCF is "*To contribute to the economic and social development of Turkey both at national and regional level by diminishing regional disparities and improving the human resources".* The overall objective of the Regional Development component, in which TOP is sited, is *"to boost Regional Development of Turkey by reducing regional disparities, improving competitiveness and promoting environmental actions and transportation infrastructure"*. More specifically, the main objective of the transportation sector in Turkey is to improve transport infrastructure considering safety and intermodality on future TEN-T Network of Turkey. The priorities of the transport sector in SCF, designed for 7 years, to achieve the above objective are : the rehabilitation and/or new construction of future TEN-T railway network and improvement of ports as nodal and transit points in TEN-T network, construction and improvement of highway network in conformity with TEN-T and Technical Assistance.

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MEDIATED EFFECT OF TRANSPORTATION ON COMPETITIVENES

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Abstract *—Transportation as a driver of national competitiveness has increased considerably over recent decades, due mostly to the increasingly complex demands by the international economy. As the nature of transport demand has become more complex, processes required to complete trade transactions, involving multiple steps, numerous actors and a range of legal and regulatory frameworks have also become more complex. With costs added at each step of the process, the quality, cost and efficiency of transport and logistics services have considerable effect on the value of goods at their final destination, and consequently, on overall national competitiveness on a global scale. This study aims to find the effect of transportation data on countries' values of competitiveness which are determined in world competitivenes yearbook and extract the mediated effect of transportation on competitiveness.*

Keywords— transportation, competitiveness, mediated effect

INTRODUCTION

Since logistics advanced from 1950s, there were numerous researches focused on this area in different applications. Due to the trend of nationalization and globalization in recent decades, the importance of logistics management has been growing in various areas. For industries, logistics helps to optimize the existing production and distribution processes based on the same resources through management techniques for promoting the efficiency and competitiveness of enterprises. The key element in a logistics chain is transportation system, which joints the separated activities. Transportation occupies one-third of the amount in the logistics costs and transportation systems influence the performance of logistics system hugely. Transporting is required in the whole production procedures, from manufacturing to delivery to the final consumers and returns. Only a good coordination between each component would bring the benefits to a maximum.

Because of the importance of transportation and logistics, this study aims to find mediated effect of logistics on competitiveness. Other headings of the article are as follows: in strategic management and competitiveness section logistics and competitiveness subjects are mentioned in the view of strategic aspect. In analysis section hierarchical regression method is performed to selected variables for finding the mediated effect. Finally concluding remarks are provided in conclusion section.

STRATEGIC MANAGEMENT AND COMPETITIVENESS

The field of Strategic Management has considerably advanced in both theoretical domain and empirical research over the last decades. While the roots of the Strategic Management can be traced in military doctrines especially drawn by Sun Tzu (1851), the progress and the evolution in few decades were striking.

In this manner, in this study we will divide the Strategic Management's advancement into three phases: strategic planning, competitive strategy, and the resource-based strategy. In fact, the progress of the Logistics Strategy is very parallel with the field of the Strategic Management. Thus, we will look over the two fields, Strategic Management and Logistics Strategy, all together as shown in the Figure 1.

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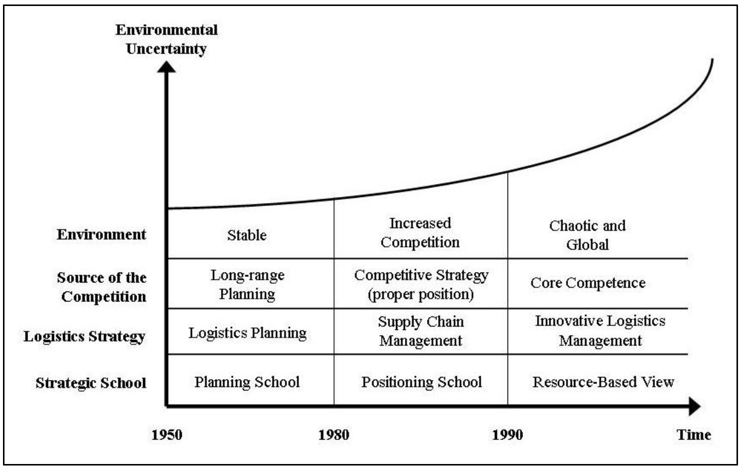

FIGURE 1
Co-evolution of Strategic Management and Logistics Strategy

The emergence of modern strategic thinking can be dated back to 1950s when the managers were faced with the problems of controlling and coordinating the large and complex corporations. The development of financial budgeting provided basic rules for coordination but this coordination required longer planning horizon than the annual planning method. Hence, that need triggered the long-range planning or the strategic planning era.

Planning School of strategy can be dated to Ansoff's pioneer book "Corporate Strategy" in 1965. According to Ansoff , strategy is a long-range planning process. So, the strategy making is a rational and mechanical model that must depend on significant objectives in the future [1]. The main contribution of Planning School to Strategic Management is the declaration of strategy making as a rational effort and rationalization of that effort with analytical tools [2] such as BCG matrixes and SWOT analysis. In strategic planning, every phase is described in detail and with the combination of the phases, corporate strategy emerges.

During the era of strategic planning, logistics strategy was basically a matter of system planning that correspond the stable environment. This view of logistics strategy fitted well with the strategic planning since the main focus was just to forecast the future and to make long-range plans in conforming to pre-designed objectives.

The development and expansion of global competition began in the 1970s and accelerated in 1990s. Firms have increasingly become more international, as evidenced by the growth in foreign sourcing of raw materials, component parts, sub-assemblies, and labor. Companies have penetrated new markets throughout the world. With rising interest rates and increasing energy costs during the 1970s logistics received attention as a major cost driver. In addition logistics costs become a more critical issue for many organizations due to globalization of industry. During the 1990s, market changes accelerated, resulting in further recognition that logistics could help to create sustainable competitive advantages for organizations [3].

In an environment characterized by strong and sophisticated competitors, each trying to develop sustainable competitive advantage, many organizations have recognized that logistics competency holds the key to developing or maintaining continued business success. As international competitive pressures continued and along with advances in the field of strategic management, attention shifted to logistics management as a competitive weapon and as an important dimension of competitive strategy. In the last years an additional shift in orientation has taken place. No longer is it enough to think about logistics management at the business firm level, but rather attention has been shifted to the industry level, partly as a consequence of Michael Porter's theoretical framework concerning the value chain. This has resulted in the newest orientation: Supply Chain Management, which positions logistics management in considerable overlap with the field of Strategic Management [4,5].

ANALYSIS

There are two different datasets used in the analysis. One of them is global competitiveness data and the other is logistics performance index data. Global competitiveness data is gathered from World Economic

Forum and logistics performance data is gathered from Worldbank's published reports.

World Economic Forum (WEF) making this competitiveness index study since 1989. WEF's research field is the competitiveness of nations. According to WEF competitiveness of nations is,

"a field of Economic theory, which analyses the facts and policies that shape the ability of a nation to create and maintain an environment that sustains more value creation for its enterprises and more prosperity for its people."

WEF has been measuring competitiveness of nations with twelve pillars. These pillars are demonstrated in Table 1. In WEF internet website, researchers can find detailed information on competitiveness measurement [6].

TABLE 1
World Competitiveness Measurement Pillars

PILLARS	*SUBINDEX GROUPS*
First pillar: Institutions Second pillar: Infrastructure Third pillar: Macroeconomic stability Fourth pillar: Health and primary education	Basic Requirements
Fifth pillar: Higher education and training Sixth pillar: Goods market efficiency Seventh pillar: Labor market efficiency Eighth pillar: Financial market sophistication Ninth pillar: Technological readiness Tenth pillar: Market size	Efficiency Enhancers
Eleventh pillar: Business sophistication **Twelfth pillar: Innovation**	Innovation And Sophistication Factors

According to WEF the *basic requirements subindex* groups those pillars most critical for countries in the factor-driven stage. The *efficiency enhancers subindex* includes those pillars critical for countries in the efficiency-driven stage. And the *innovation and sophistication factors subindex* includes the pillars critical to countries in the innovation-driven stage (Global Competitiveness Report, 2009).

For the logistics data Worldbank's Logistics Performance Index (LPI) is used in the analysis. Based on a worldwide survey of global freight forwarders and express carriers, the Logistics Performance Index is a benchmarking tool developed by the World Bank that measures performance along the logistics supply chain within a country. Allowing for comparisons across 155 countries, the index can help countries identify challenges and opportunities and improve their logistics performance. The World Bank conducts the survey every two years. With the LPI, the World Bank aims to focus attention on an issue of global importance and provide a platform for dialogue among government, business, and civil society. The Logistics Performance Index (LPI) survey contains detailed information on countries' logistics environments, core logistics processes and institutions, and performance time and cost data. Researchers can find additional information on methodology and variables in Worldbank's official website (Connecting to Compete 2010). The competitiveness dataset and logistics data set are presented in Appendix A.

Two huge datasets are gathered and merged in one table for analysis. After merging datasets, some of the countries excluded because of missing variables. In the analysis, SPSS 10.0 package program is used.

In hierarchical regression Competitiveness Index is used as dependent variable. Sub-indexes of competitiveness are used predictors in the first model and logistics performance variables are added to the model as predictors in the second model. Model summary is shown in Table 2.

TABLE 2
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	,981	,962	,961	,1300	,962	977,817	3	117	,000	1,940
2	,983	,967	,964	,1242	**,005**	2,877	6	111	,012	

As can be seen, first model's predictors can explain competitiveness with 0.981 values and this value is statistically significant. By adding logistics variables R Square changed with 0.005 points. This means that logistics variables have significant effect on competitiveness. In table 3 models statistically significance is tested by ANOVA.

TABLE 3
ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	49,566	3	16,522		
1	Residual	1,977	117	1,690E-02	977,817	,000
	Total	51,543	120			
	Regression	49,832	9	5,537		
2	Residual	1,711	111	1,541E-02	359,229	,000
	Total	51,543	120			

Up to the results of ANOVA two models are statistically significant (F=977.817, $p<0.05$; F=359.229, $p<0.05$). In Table 4 we can see the coefficients of variables which have mediated effect on competitiveness.

TABLE 4
Coefficients

Model		Unstandardized Coefficients B	Standardized Coefficients Beta	t	Sig.
1	(Constant)	,496		6,418	,000
	Institutions	,144	,204	6,472	,000
	Innovation and Sophistication Factors	,154	,180	3,411	,001
	Efficiency Enhancers	,614	,637	12,284	,000
2	(Constant)	,472		4,039	,000
	Institutions	,164	,232	6,650	,000
	Innovation and Sophistication Factors	,132	,154	2,801	,006
	Efficiency Enhancers	,553	,573	9,776	,000
	Customs	-,171	-,159	-2,534	**,013**
	Logistics Infrastructure	,120	,131	1,613	,110
	International shipments	1,232E-02	,008	,285	,776
	Logistics competence	,125	,117	1,474	,143
	Tracking & tracing	-,113	-,106	-2,058	**,042**
	Timeliness	,100	,082	2,207	**,029**

As can be seen in Table 4, first model has three predictors and all of them is statistically significant. By adding logistics variables we know that exploratory effect has increased 0.005 points. By examining coefficients of logistics variables which of them have statistically significant contribution can be determined. Customs (-0.171, $p<0.05$), tracking&tracing (-0.113, $p<0.05$) and timeliness (0.100, $p<0.05$) has statistically significant effect on competitiveness.

CONCLUSIONS

We know that countries have connected each other with the link of globalization. So when the results of the analysis are examined, it is observed that movement of goods from the gate to customer is determining competitiveness. This means that when customs are well-organized, goods are tracked online and delivered on time, firms in micro level and nations in macro level will gain the competitive advantage. The importance of operations management in customs is clearly stated by this study.

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COMPETITIVENESS AND LOGISTICS VARIABLES **APPENDIX A**

COUNTRIES	GCI 2009-2010	BASIC REQUIREMENTS	INNOVATION AND SOPHISTICATION FACTORS	EFFICIENCY ENHANCERS	CUSTOMS	LOGISTICS INFRASTRUCTURE	INTERNATIONAL SHIPMENTS	LOGISTICS COMPETENCE	TRACKING AND TRACING	TIMELINESS
Albania	3,72	4,04	2,9	3,63	2,07	2,14	2,64	2,39	2,39	3,01
Algeria	3,95	4,44	2,88	3,29	1,97	2,06	2,7	2,24	2,26	2,81
Argentina	3,91	4,11	3,44	3,84	2,63	2,75	3,15	3,03	3,15	3,82
Armenia	3,71	4,13	3,03	3,51	2,1	2,32	2,43	2,59	2,26	3,4
Australia	5,15	5,63	4,61	5,29	3,68	3,78	3,78	3,77	3,87	4,16
Austria	5,13	5,7	5	4,98	3,49	3,68	3,78	3,7	3,83	4,08
Azerbaijan	4,3	4,63	3,71	4,03	2,14	2,23	3,05	2,48	2,65	3,15
Bahrain	4,54	5,41	3,69	4,39	3,05	3,36	3,05	3,36	3,63	3,85
Bangladesh	3,55	3,6	3	3,54	2,33	2,49	2,99	2,44	2,64	3,46
Barbados	4,35	5,16	3,81	4,11	.	.	.	.	.	.
Belgium	5,09	5,43	4,95	5,04	3,83	4,01	3,31	4,13	4,22	4,29
Benin	3,56	3,78	3,12	3,25	2,38	2,48	2,65	2,64	3,07	3,49
Bolivia	3,42	3,68	2,63	3,08	2,26	2,24	2,53	2,38	2,38	3,2
Bosnia and Herze	3,53	3,74	2,8	3,5	2,33	2,22	3,1	2,3	2,68	3,18
Botswana	4,08	4,43	3,25	3,77	2,09	2,09	1,91	2,29	2,59	2,99
Brazil	4,23	4,04	4,08	4,41	2,37	3,1	2,91	3,3	3,42	4,14
Brunei Darussala	4,64	5,44	3,42	3,94	.	.	.	.	.	.
Bulgaria	4,02	4,13	3,29	4,08	2,5	2,3	3,07	2,85	2,96	3,18
Burkina Faso	3,23	3,25	3,12	3,22	2,22	1,89	1,73	2,02	2,77	2,77
Burundi	2,58	2,49	2,94	2,68	.	.	.	.	.	.
Cambodia	3,51	3,55	3,08	3,49	2,28	2,12	2,19	2,29	2,5	2,84
Cameroon	3,5	3,68	3,11	3,27	2,11	2,1	2,69	2,53	2,6	3,16
Canada	5,33	5,74	4,96	5,39	3,71	4,03	3,24	3,99	4,01	4,41
Chad	2,87	2,92	2,81	2,81	2,27	2	2,75	2,04	2,62	3,14
Chile	4,7	5,14	3,96	4,55	2,93	2,86	2,74	2,94	3,33	3,8
China	4,74	5,09	4,23	4,56	3,16	3,54	3,31	3,49	3,55	3,91
Colombia	4,05	4,12	3,67	4,07	2,5	2,59	2,54	2,75	2,75	3,52
Costa Rica	4,25	4,44	4,08	4,13	2,61	2,56	2,64	2,8	3,13	3,71
Côte d'Ivoire	3,43	3,49	3,2	3,38	2,16	2,37	2,44	2,57	2,95	2,73
Croatia	4,03	4,62	3,49	4,05	2,62	2,36	2,97	2,53	2,82	3,22
Cyprus	4,57	5,43	4,18	4,45	2,92	2,94	3,13	2,82	3,51	3,44
Czech Republic	4,67	4,78	4,4	4,78	3,31	3,25	3,42	3,27	3,6	4,16
Denmark	5,46	5,98	5,28	5,36	3,58	3,99	3,46	3,83	3,94	4,38

Dominican Republ	3,75	3,82	3,41	3,77	2,51	2,34	2,59	2,42	3,17	3,85
Ecuador	3,56	4	2,88	3,34	2,32	2,38	2,86	2,6	2,84	3,55
Egypt	4,04	4,21	3,51	3,87	2,11	2,22	2,56	2,87	2,56	3,31
El Salvador	4,02	4,39	3,36	3,85	2,48	2,44	2,18	2,66	2,68	3,63
Estonia	4,56	5,1	3,98	4,69	3,14	2,75	3,17	3,17	2,95	3,68
Ethiopia	3,43	3,56	2,98	3,26	2,13	1,77	2,76	2,14	2,89	2,65
Finland	5,43	6,04	5,47	5,17	3,86	4,08	3,41	3,92	4,09	4,08
France	5,13	5,6	4,9	5,08	3,63	4	3,3	3,87	4,01	4,37
Gambia, The	3,96	4,26	3,55	3,49	2,38	2,17	2,54	2,37	2,27	3,15
Georgia	3,81	4,1	2,94	3,73	2,37	2,17	2,73	2,57	2,67	3,08
Germany	5,37	5,85	5,47	5,12	4	4,34	3,66	4,14	4,18	4,48
Ghana	3,45	3,4	3,08	3,58	2,35	2,52	2,38	2,42	2,51	2,67
Greece	4,04	4,49	3,59	4,13	2,48	2,94	2,85	2,69	3,31	3,49
Guatemala	3,96	4,13	3,66	3,86	2,33	2,37	2,16	2,74	2,71	3,52
Guyana	3,56	3,69	3,06	3,4	2,02	1,99	2,31	2,25	2,28	2,7
Honduras	3,86	4,1	3,21	3,54	2,39	2,31	2,67	2,57	2,83	3,83
Hong Kong SAR	5,22	5,9	4,53	5,37	3,83	4	3,67	3,83	3,94	4,04
Hungary	4,22	4,48	3,67	4,38	2,83	3,08	2,78	2,87	2,87	3,52
Iceland	4,8	5,36	4,7	4,64	3,22	3,33	3,1	3,14	3,14	3,27
India	4,3	4,18	4,24	4,52	2,7	2,91	3,13	3,16	3,14	3,61
Indonesia	4,26	4,3	4,03	4,24	2,43	2,54	2,82	2,47	2,77	3,46
Ireland	4,84	5,06	4,63	4,87	3,6	3,76	3,7	3,82	4,02	4,47
Israel	4,8	4,88	4,87	4,72	3,12	3,6	3,17	3,5	3,39	3,77
Italy	4,31	4,38	4,15	4,37	3,38	3,72	3,21	3,74	3,83	4,08
Jamaica	3,81	3,74	3,39	3,95	2	2,07	2,82	2,32	3,07	2,82
Japan	5,37	5,27	5,7	5,21	3,79	4,19	3,55	4	4,13	4,26
Jordan	4,3	4,74	3,79	4,06	2,31	2,69	3,11	2,49	2,33	3,39
Kazakhstan	4,08	4,27	3,43	4,04	2,38	2,66	3,29	2,6	2,7	3,25
Kenya	3,67	3,49	3,8	3,94	2,23	2,14	2,84	2,28	2,89	3,06
Korea, Rep.	5	5,4	4,88	4,92	3,33	3,62	3,47	3,64	3,83	3,97
Kuwait	4,53	5,02	3,62	4,08	3,03	3,33	3,12	3,11	3,44	3,7
Kyrgyz Republic	3,36	3,4	2,8	3,36	2,44	2,09	3,18	2,37	2,33	3,1
Latvia	4,06	4,45	3,36	4,21	2,94	2,88	3,38	2,96	3,55	3,72
Lesotho	3,54	3,71	3,16	3,31	.	.	.	.	.	.
Libya	3,9	4,38	3,04	3,36	2,15	2,18	2,28	2,28	2,08	2,98
Lithuania	4,3	4,68	3,75	4,33	2,79	2,72	3,19	2,85	3,27	3,92
Luxembourg	4,96	5,85	4,58	4,84	4,04	4,06	3,67	3,67	3,92	4,58
Macedonia, FYR	3,95	4,27	3,23	3,83	2,55	2,55	2,83	2,76	2,82	3,1
Madagascar	3,42	3,52	3,2	3,28	2,35	2,63	3,06	2,4	2,51	2,9

Malawi	3,42	3,43	3,21	3,43	.	.	.	.	.	.
Malaysia	4,87	5,12	4,43	4,76	3,11	3,5	3,5	3,34	3,32	3,86
Mali	3,22	3,3	3,14	3,09	2,08	2	2,17	2,13	2,31	2,9
Malta	4,3	4,97	3,83	4,31	2,65	2,89	2,91	2,89	2,56	3,02
Mauritania	3,25	3,43	2,83	3,01	.	.	.	.	.	.
Mauritius	4,22	4,63	3,59	4,01	2,71	2,29	3,24	2,43	2,57	2,91
Mexico	4,19	4,47	3,57	4,15	2,55	2,95	2,83	3,04	3,28	3,66
Mongolia	3,43	3,48	2,93	3,42	1,81	1,94	2,46	2,24	2,42	2,55
Montenegro	4,16	4,43	3,56	4,06	2,17	2,45	2,54	2,32	2,44	2,65
Morocco	4,03	4,49	3,35	3,71	.	.	.	.	.	.
Mozambique	3,22	3,26	3	3,19	1,95	2,04	2,77	2,2	2,28	2,4
Namibia	4,03	4,61	3,26	3,72	1,68	1,71	2,2	2,04	2,04	2,38
Nepal	3,34	3,5	2,77	3,15	2,07	1,8	2,21	2,07	2,26	2,74
Netherlands	5,32	5,71	5,17	5,26	3,98	4,25	3,61	4,15	4,12	4,41
New Zealand	4,98	5,58	4,37	5,11	3,64	3,54	3,36	3,54	3,67	4,17
Nicaragua	3,44	3,54	2,96	3,32	2,24	2,23	2,63	2,31	2,51	3,21
Nigeria	3,65	3,51	3,53	3,91	2,17	2,43	2,84	2,45	2,45	3,1
Norway	5,17	5,73	4,83	5,14	3,86	4,22	3,35	3,85	4,1	4,35
Oman	4,49	5,3	3,75	4,18	3,38	3,06	2,31	2,37	2,04	3,94
Pakistan	3,58	3,53	3,39	3,69	2,05	2,08	2,91	2,28	2,64	3,08
Panama	4,21	4,54	3,73	4,04	2,76	2,63	2,87	2,83	3,26	3,76
Paraguay	3,35	3,49	2,7	3,32	2,37	2,44	2,87	2,59	2,72	3,46
Peru	4,01	4,06	3,37	4,11	2,5	2,66	2,75	2,61	2,89	3,38
Philippines	3,9	3,94	3,45	3,91	2,67	2,57	3,4	2,95	3,29	3,83
Poland	4,33	4,3	3,84	4,56	3,12	2,98	3,22	3,26	3,45	4,52
Portugal	4,4	5,05	3,98	4,4	3,31	3,17	3,02	3,31	3,38	3,84
Puerto Rico	4,48	4,84	4,21	4,5	.	.	.	.	.	.
Qatar	4,95	5,57	4,1	4,67	2,25	2,75	2,92	2,57	3,09	4,09
Romania	4,11	4,1	3,44	4,25	2,36	2,25	3,24	2,68	2,9	3,45
Russian Federati	4,15	4,43	3,47	4,2	2,15	2,38	2,72	2,51	2,6	3,23
Saudi Arabia	4,75	5,17	4,15	4,49	2,91	3,27	2,8	3,33	3,32	3,78
Senegal	3,78	3,93	3,69	3,54	2,45	2,64	2,75	2,73	3,08	3,52
Serbia	3,77	3,9	3,21	3,77	2,19	2,3	3,41	2,55	2,67	2,8
Singapore	5,55	5,99	5,15	5,61	4,02	4,22	3,86	4,12	4,15	4,23
Slovak Republic	4,31	4,61	3,71	4,55	2,79	3	3,05	3,15	3,54	3,92
Slovenia	4,55	5,18	4,23	4,49	2,59	2,65	2,84	2,9	3,16	3,1
South Africa	4,34	4,26	4,05	4,47	3,22	3,42	3,26	3,59	3,73	3,57
Spain	4,59	5,06	4,14	4,66	3,47	3,58	3,11	3,62	3,96	4,12
Sri Lanka	4,01	4,05	3,95	3,95	1,96	1,88	2,48	2,09	2,23	2,98

Suriname	3,57	4,26	2,94	3,14	.	.	.	.	.	.
Sweden	5,51	5,96	5,53	5,31	3,88	4,03	3,83	4,22	4,22	4,32
Switzerland	5,6	5,98	5,68	5,39	3,73	4,17	3,32	4,32	4,27	4,2
Syria	3,76	4,3	3,17	3,35	2,37	2,45	2,87	2,59	2,63	3,45
Taiwan, China	5,2	5,47	5,25	5,06	3,35	3,62	3,64	3,65	4,04	3,95
Tajikistan	3,38	3,51	3,06	3,22	1,9	2	2,42	2,25	2,25	3,16
Tanzania	3,59	3,71	3,21	3,45	2,42	2	2,78	2,38	2,56	3,33
Thailand	4,56	4,86	3,83	4,46	3,02	3,16	3,27	3,16	3,41	3,73
Timor-Leste	3,26	3,6	2,68	2,78	.	.	.	.	.	.
Trinidad and Tob	3,91	4,67	3,42	3,9	.	.	.	.	.	.
Tunisia	4,5	5,09	3,94	4,14	2,43	2,56	3,36	2,36	2,56	3,57
Turkey	4,16	4,34	3,7	4,16	2,82	3,08	3,15	3,23	3,09	3,94
Uganda	3,53	3,58	3,14	3,49	2,84	2,35	3,02	2,59	2,45	3,52
Ukraine	3,95	3,96	3,42	4,05	2,02	2,44	2,79	2,59	2,49	3,06
United Arab Emir	4,92	5,75	4,41	4,89	3,49	3,81	3,48	3,53	3,58	3,94
United Kingdom	5,19	5,29	4,92	5,31	3,74	3,95	3,66	3,92	4,13	4,37
United States	5,59	5,23	5,71	5,66	3,68	4,15	3,21	3,92	4,17	4,19
Uruguay	4,1	4,64	3,44	3,86	2,71	2,58	2,77	2,59	2,78	3,06
Venezuela	3,48	3,7	2,76	3,38	2,06	2,44	3,05	2,53	2,84	3,05
Vietnam	4,03	4,02	3,72	4,08	2,68	2,56	3,04	2,89	3,1	3,44
Zambia	3,5	3,51	3,26	3,52	.	.	.	.	.	.
Zimbabwe	2,77	2,71	2,86	2,87	2,17	1,83	2,41	2,01	2,35	2,85

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