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DETERMINING SUPPLY CHAIN RISK FACTORS IN FOOD INDUSTRY

SNEZANA JOVIC

MSc. THESIS
DEPARTMENT OF INDUSTRIAL ENGINEERING
PROGRAM OF INDUSTRIAL ENGINEERING

ADVISER
ASST. PROF. TUĞBA EFENDİGİL

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A thesis submitted by Snezana JOVIC in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** is approved by the committee on 04.09.2014 in Department of Industrial Engineering, Industrial Engineering Program.

Thesis Adviser

Asst. Prof. Tuğba EFENDİGİL

Yildiz Technical University ____________________

Approved By the Examining Committee

Asst. Prof. Tuğba EFENDİGİL

Yildiz Technical University ____________________

Asst. Prof. Nezir AYDIN, Member

Yildiz Technical University ____________________

Assc. Prof. Gülfem TUZKAYA, Member

Marmara University ____________________

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LIST OF ABBREVIATIONS

CBR	Case Based Reasoning
DEMATEL	Decision Making Trial and Evaluation Laboratory
DM	Decision Makers
FMEA	Failure Models and Effects Analysis
JIT	Just In Time
MCDM	Multi Criteria Decision Making
RM	Risk Management
SC	Supply Chain
SCOR	Supply Chain Operation Reference Model
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management
WIP	Work In Process

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ABSTRACT

DETERMINING SUPPLY CHAIN RISK FACTORS IN FOOD INDUSTRY

Snezana JOVIC

Department of Industrial Engineering

Ms. Thesis

Adviser: Asst. Prof. Tugba EFENDIGIL

Today organizations are faced with many different types of risks (operational, project, human resource, financial, safety, etc). At all levels of an organization, risk management is an integral component of good management and decision-making because of what a lot of standards and guidance documents are created with the purpose of productive organization managing. In environment where all resources are to be used in most productive way, risk management should be considered as a proactive and systematic process to understand and manage risk from an organization wide perspective.

In this study, to get the better understanding of supply chain risk management, a real world application is investigated. This application is implied to company for food distribution which is located in Istanbul, Turkey. The project has been done in two levels, starting from April 2013.

The first level of project includes data collecting of internal and external risk factors about their effect on both work flow and consequences. In the second level of project; the company's main problems are defined and besides the main risks in supply chain, the utilized technique for eliminating the risk factors and possible solutions are mentioned. As a result, the main problem in supply chain is detected as low capacity at days when customer demand is higher. This is the crucial risk that causes the supply chain fragility and delivery delay.

The best solution is suggested as finding the suitable contractor and collaborating in busy days. However, to find the suitable contractor is up to determining the risk criteria and ranking them properly In this project, determining the risk criteria process is supported by the literature studies and the employees’ of Hedef Gida . For an effective solution, DEMATEL method is decided to be employed to rank the risk criteria

Based on the results of this project; in the future study DEMATEL method can be combined with AHP, ANP, TOPSIS or any other decision making method for ranking the alternatives, in purpose of choosing the best supplier or partner for distribution work.

Key words: Risk management, supply chain management, food distribution, contractor selection, criteria ranking, DEMATEL method.

ÖZET

GIDA SEKTÖRÜNDE TEDARİK ZİNCİRİ RİSK FAKTÖRLERİNİN BELİRLENMESİ

Snezana JOVIC

Endüstri Mühendisliği Anabilim Dalı
Yüksek lisans tezi

Tez danişmanı: Asst. Prof. Tuğba EFENDİGİL

Bugünlerde şirketler pek cok farklı risk sıkıntıları ile karşılaşıyor (opersyon, proje, insan kaynakları, finansal, emniyet vb.). Risk yonetimi her bir yonetim seviyesinde, cok onemli bir nokta olduğundan dolayı bir coğun standar ve rehberliğin amaci verimli bir uretim amacidir. Onun için risk yonetimi proaktif ve sistematik yol olarak kabul edilmektedir.

Tedarik zinciri risk yonetimi daha iyi anlamak için, bu projede gerçek bir örnek araştırıldı. Bu araştırma gıda dağıtım için, Istanbulda bulunduğu şirketinde gerçekleştirdi. Nisan, 2013un yılından beri bu proje üç seviyede gerçekleştiriyor. Gıda dağıtım şirketleri diger şirketlere gore daha fazla riskler ile karşılaşmak nedeniyle bu araştırmada risk ilk adım risk belirlemektir. Bu adım tedarik zinciri risk ile ilgili literatur incelemesi ve Hedef Gıda şirketin raporları desteklenendi. Risk ve risklerin tekilerini toplayınca ılk adım bitmiş oldu. Şirketin en önemli bir problemini belirtmek ikinci adımdı. Bu seviyede en buyuk problem neydi, nasıl çozebilir ve risk azaltmak ve ya elimine etmek için handi metod en uygundur begli oldu. Sonuç olarak yoğun günlerinde tedarik zincirinin duşuk kapasitesini bulunmustur. Bu risk aynızamanda tedarik zinciri kırılganlığı ve teslimat gecikmesinin nedeni oluyormuş. Bahsedilmiş olan risk için anlaşmalı taraf ve kritik günlerde iş paylaşmak en uygun çozum olarak bulunmuş ancak o tarafi seçmek diğer riskler getiriyormus. Dogru kriterler seçip dogru bir sıraya koymak. Kriterleri seçmek için Hedef Gıda şirkette çalişanlar yardimci oldu ve kriterler siraya koymak için DEMATEL kullanildi.

Projenin sonuçlara gore geleceklerde DEMATEL metod AHP, ANP, TOPSIS ya da başka bir metod ile birieştirip alternativleri sıraya koymak için en iyi tedarikçi secmek amaçiyla kullanılır.

Anahtar kelimeler: Risk yonetim, tedarik zinciri yonetimi, gıda industri, kriteria seçmek, kriteria siraya koymak, DEMATEL metod.

CHAPTER 1

INTRODUCTION

1.1 Literature review

A supply chain is the network of all the individuals, organizations, resources, activities and technology involved in the creation and sale of a product. It begins with the delivery of source materials from the supplier to the manufacturer, through to its eventual delivery to the end user. A set of approaches utilized to efficiently integrate all mentioned entities (suppliers, manufactures, warehouses and stores) so that merchandise is produced and distributed at the right quantities, to the right location and at the right time in order to minimize system wide cost is supply chain management (SCM). SCM can also be defined as the coordination of production, inventory, location and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served.

Supply chain management arose in late 1980s and came into widespread use in 1990s. Earlier it was known as "Logistics" and "Operations Management" although there is a difference between the concept of supply chain management and traditional concept of logistic [1]:

- Logistics refers to activities that occur within the boundaries of a single organization whereas supply chain management refers to network of companies that work together and coordinate their action to deliver a product to market.
- Logistics focuses its attention on activities such as procurement, distribution, maintenance and inventory management whereas supply chain management acknowledges all the traditional logistics, and also include activities such as marketing, new product development, finance and customer service.

Effective SCM requires simultaneous improvement in both customer service level and the internal operating efficiencies of the companies in the supply chain. Customer service at its most basic level means consistently high order fill rates, high on-time delivery rates and very low rate of products returned by customers. Internal efficiency in an organization of a supply chain means that these organizations get an attractive rate of return on their investments in inventory and other assets, and also find ways to lower their operating and sales expenses.

A typical supply chain includes the following stages:

1. Customer
2. Retailer
3. Wholesaler/distributor
4. Manufacturer
5. Component/raw material supplier

The main objective of the supply chain is to add value to a product or in other words to increase the throughput while simultaneously reducing both inventory and operating expenses. Throughput refers to the rate at which sales to the end customer occur. SCM is a tool to accomplish following strategic objectives:

- Reducing working capital
- Taking assets of the balance sheet
- Accelerating cash to cash cycles
- Increasing inventory turns

Supply chain profitability is the total profit to be shared across all supply chain stages. The higher the supply chain profitability, the more successful is the supply chain. Supply chain success should be evaluated in terms of supply chain profitability and not in terms of the profits at an individual stage. The next logical step to look for the success of a supply chain in terms of supply chain profitability is revenue and cost. For any supply chain, there is only one source of revenue: the customer. At manufacturer, a customer purchasing an item is the only one providing cash flow for the supply chain. All other cash flow is simply fund exchanges that occur within supply chain given that different stages have different owners. When a manufacturer pays its supplier, it is taking a percentage of the customer provides and passing that money on to supplier. All flow of information, products, or funds generate costs within the supply chain. Thus, the appropriate management of these flows is a key to supply chain success. SCM involves the management of flows between stages in a supply chain to maximize total supply chain profitability.

Although with the same point there are lot of different approaches to defining, managing supply chain, as well as different attitudes about basic elements, scope, characteristics and their purpose.

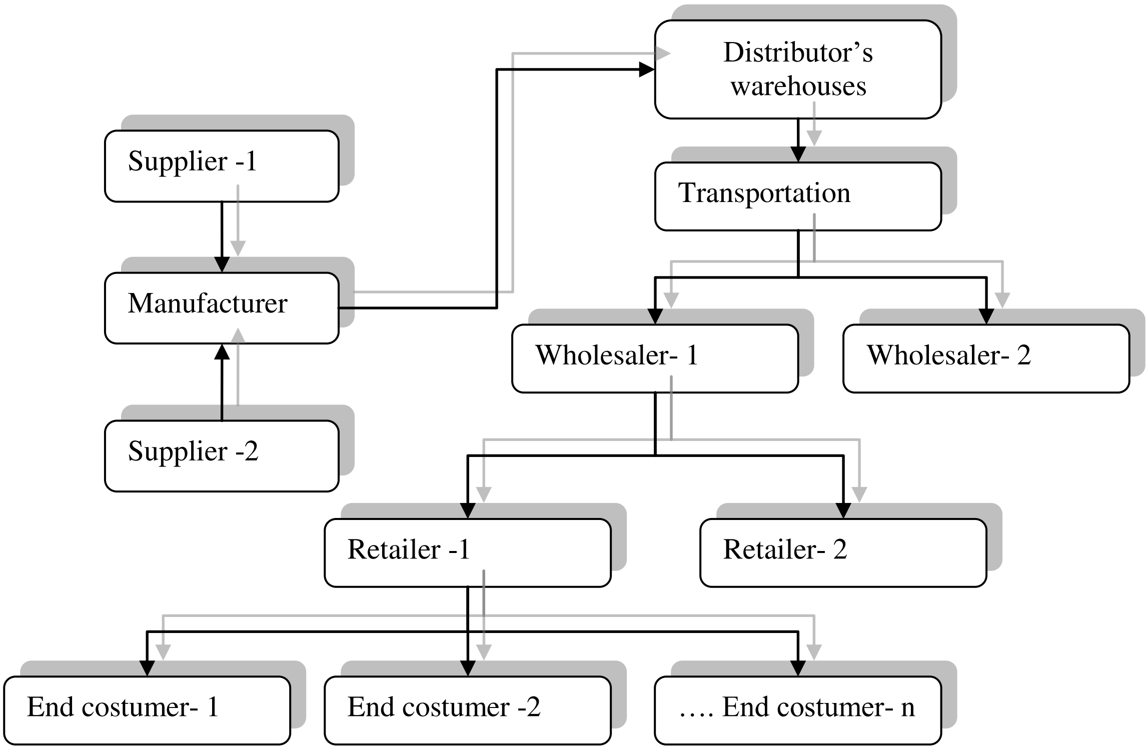

Figure 1.1 Supply chain layout

"SCM is management of material and information flow in a supply chain to provide the highest degree of customer satisfaction at the lowest possible cost" [1]**.** La Londe and Masters proposed that a supply chain is a set of firm that pass materials forward **[**2]. Normally, several independent firms are involved in manufacturing a product and placing it in the hands of the end user in a supply chain raw material and component producers, product assemblers, whole sellers, retailer merchants and transportation companies are all members of a supply chain **[**2].

A primary focus of SCM is the optimization of customer satisfaction, a broad term encompassing the combined efforts of many organizations, organizational functions and processes to meet the needs of customers. Integrating a variety of functions and processes within and between organizations is a pivotal part of SCM [3]. Since its conception in the early 1980s, SCM has undergone significant change and many perceptions of SCM have been offered by scholars conducting research in the field [4].

In the 1950s and 1960s, most manufacturers emphasized mass production to minimize unit production cost as the primary operations strategy. New product development was slow and relied exclusively on house technology and capacity. ‘Bottleneck’ operations were cushioned with inventory to maintain a balanced line how, resulting in huge investment in work in process (WIP) inventory. Sharing technology and expertise with customers or suppliers was considered too risky and unacceptable and little emphasis appears to have been placed on cooperative and strategic buyer supplier partnership. The purchasing function was generally regarded as being a service to production, and managers paid limited attention to issues concerned with purchasing [1].

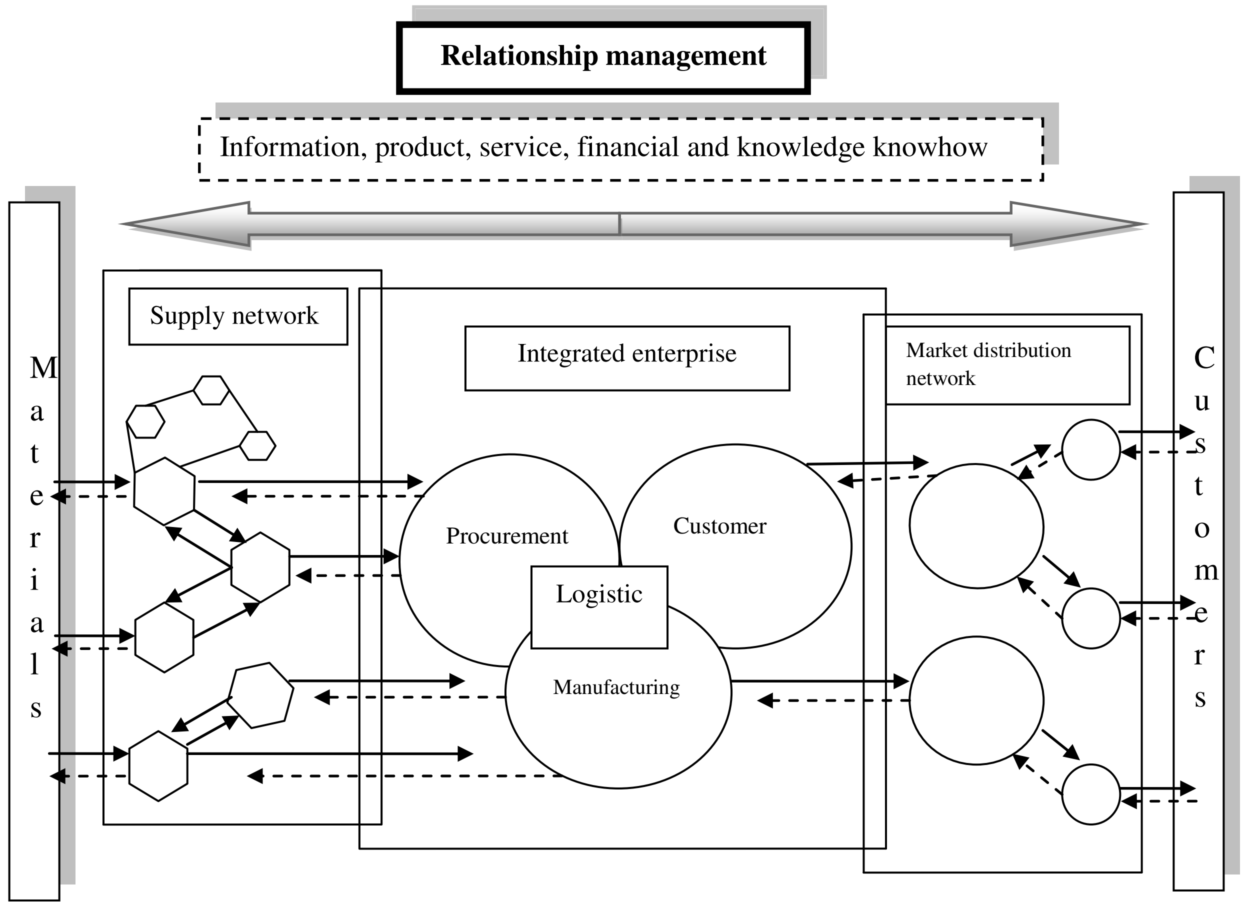

Figure 1.1 Supply chain management layout

In the 1970s, Manufacturing Resource Planning was introduced and managers realized the impact of huge WIP on manufacturing cost, quality, new product development and delivery lead-time. Manufacturers resorted to new materials management concepts to improve performance within the company. The intense global competition in the 1980s forced worldclass organizations to over low cost, high quality and reliable products with greater design flexibility. To improve manufacturing efficiency and cycle time, manufacturers were utilizing just-in-time (JIT) and other management initiatives. In JIT manufacturing environment with little inventory to cushion production or scheduling problems, manufacturers began to realize the potential benefit and importance of strategic and cooperative buyer-supplier relationship. The concept of SCM emerged as manufacturers experimented with strategic partnerships with their immediate suppliers. In addition to the procurement professionals, experts in transportation and logistics carried the concept of materials management a step further to incorporate the physical distribution and transportation functions, resulting in the integrated logistics concept, also known as SCM. The evolution of SCM continued into the 1990s as organizations further extended best practice in managing corporate resources to include strategic suppliers and the logistics function in the value chain. Supplier efficiency was broadened to include more sophisticated reconciliation of cost and quality considerations. Instead of duplicating non-value-adding activities, such as receiving inspection, manufacturers trusted suppliers' quality control by purchasing only from a handful of qualified or certified suppliers [2]. More recently, many manufacturers and retailers have embraced the concept of SCM to improve efficiency across the value chain. Manufacturers now commonly exploit supplier strengths and technology in support of new product development, and retailers seamlessly integrate their physical distribution function with transportation partners to achieve direct store delivery or cross docking without the need for receiving inspection [4]. A key facilitating mechanism in the evolution of SCM is a customer-focus corporate vision, which drives change throughout a firm's internal and external linkages.

Effective SCM becomes an essential task in all areas of business. Nowadays, SCM is defined as a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right location, and at the right time, in order to minimize systems costs while satisfying service level requirements. In recent years, increased attention has been paid to the performance, design, and analysis of supply chain.

In recent years the number of modeling approaches to SCM has grown considerably. The experience of successful application of different modeling approaches is presented in a variety of scientific papers, however understanding precognitions of applying particular modeling algorithm to certain problem solving is within the competencies of its users. Among the models presented in scientific publications related to SCM, ones of the most famous ones are belonging to mathematical modeling.

Mathematical models focus on solving one certain task in SCM; therefore they belong to the object oriented approach. Beside mathematical models, there are also descriptive models aimed at analysis of supply chain process and their interrelations thus implementing the process-oriented modeling approach. In the most of the papers it is assumed that mathematical models are aimed at obtaining any numerical results while descriptive models serve for describing the supply chain performance. In a traditional perspective, some models (for example, simulation models) can be referred to as both mathematical and descriptive models. Descriptive models can be applicable to situations where the problems are not known exactly for identifying critical points in supply chain performance. They are commonly used also in information system engineering; therefore they are useful to be elaborated before implementing new information systems. In the context of supply chain hierarchical planning, descriptive models provide advantages at the strategic planning level.

- *Supply Chain Operation Reference model*

The supply chain operations reference (SCOR) model is a process reference model that the supply chain council developed and endorsed as the cross-industry standard for supply chain management. According to SCORs own definition, the SCOR model integrates the well-known concepts measurement into a cross-functional framework (SCOR overview 2006).

Among descriptive models SCOR is the most popular supply chain operation reference model. Was developed to assist firms in increasing the effectiveness of their supply chains, and to provide a process-based approach to SCM [5]**.** SCOR is based on five distinct management processes: Plan, Source, Make, Deliver, and Return. The benefit of SCOR is a performance metrics which allow evaluating the process efficiency in supply chain. Since the SCOR model is the main framework used in the organization of this study, a short explanation is required. In each decision area there are three levels of process detail.

In level 1, for the above-mentioned decision areas the scope and content of the core management has been processed. For example, the SCOR Plan process was defined as those processes that balance aggregate demand and supply for developing actions which best meet sourcing, production, and delivery requirements.

Level 2 describes the characteristics associated with the following process types deployed within the core processes: planning, execution and enable. For example, supply chain partners require processes for planning the overall supply chain, as well as planning processes for supporting source, make, deliver, and return decisions. Characteristics associated with effective planning processes include a balance between demand and supply and a consistent planning horizon. The SCOR model also contains Level 2 process categories defined by the relationship between a core management process and process type.

Level 3 provides detailed process element information for each Level 2 process category. Inputs, outputs, description and the basic flow of process are captured at this level of the SCOR model.

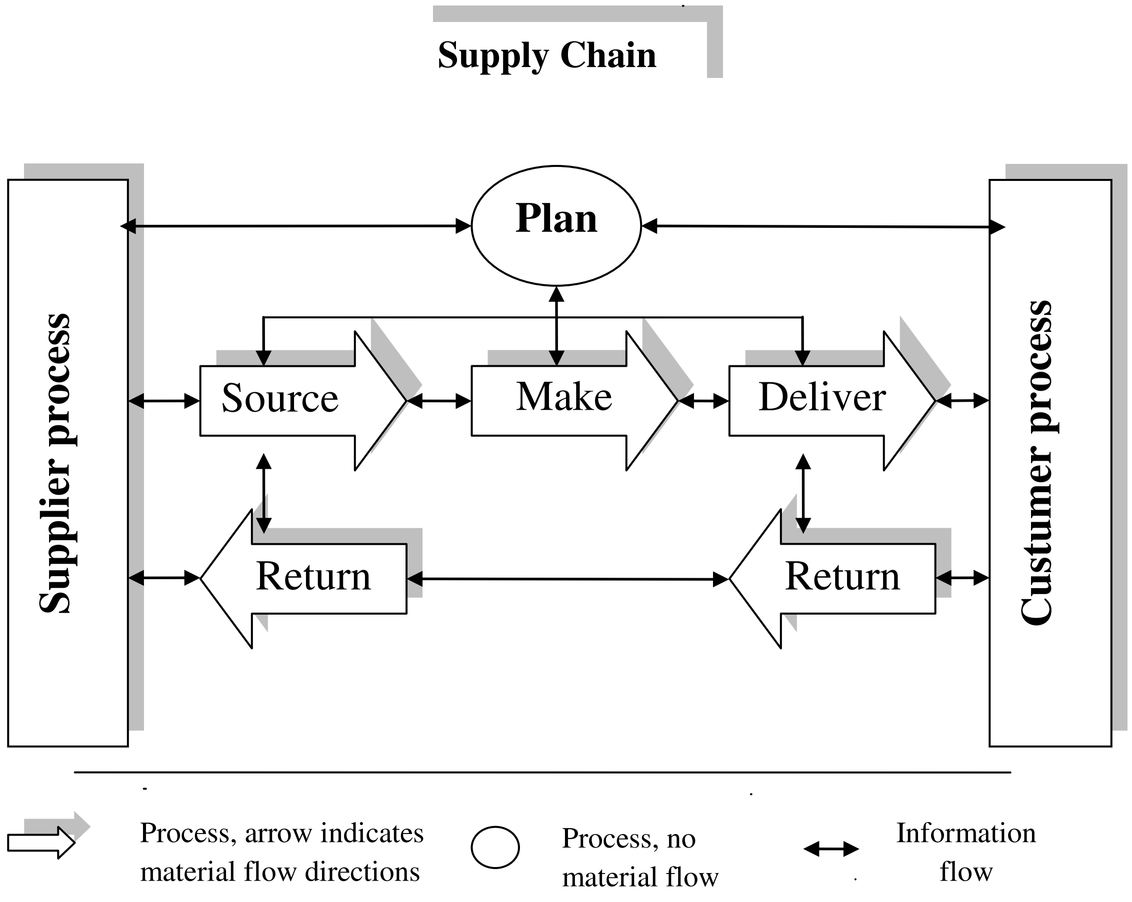

Figure 1.2 SCOR model

There are plenty of modeling approaches which could be successfully applied to support decision making in supply chain management. Some of them, such as linear programming, mixed linear programming, dynamic programming, as well as analytic models belonging to operation research models are traditional tools focused on supply chain management and descriptions. Most often, challenging is

(1) What kind of models to apply,

(2) When it is necessary to use the appropriate model for solving particular task in supply chain management.

1.2 Objectives of thesis

In spite of numerous research papers presenting mathematical methods, algorithms and models to support decision making in logistics and SCM, risk in SCM and it's decreasing are still considered to be a big challenge in many companies.

Although the risk thematic is not new in management, in SCM it is a recent and growing subject. Supply Chain Risk Management (SCRM) plays a major role in successfully managing business processes in a proactive manner. Supply chain risk has multiple sources including process, control, demand, supply and environment. SCM, faced with these risks, requires specific and adequate responses such as techniques, attitude and strategies for management of risk.

A great popularity of SCM as well as fields that are covered by supply chain exists not only in scientific and professional community, but also in practical domains as well. Applying even the best methods and techniques cannot give good results if the supply chain itself has not been defined at the very beginning (i.e. what participants, which resources, how big their potentials are, their locations, process types, the way in which goods, information and financial flows are realized etc). Having in mind a great number of published scientific papers that is covering this subject, the importance of questions mentioned so far is obvious.

This research is based on an empirical study of logistics and SCM in food distribution company in Istanbul. We will identify the biggest risk in SCM of Hedef Gida company and offer the solution for decreasing or eliminating it. The research is organized in followed order;

- Section 1 gives the definition of Supply Chain (SC), Supply Chain Management (SCM),
- Section 2 includes the definition of risk in SC and literature review,
- Section 3 presents the food distribution service and risks in SC,
- Section 4 presents the DEMATEL methodology and implementation in two different ways,
- In section 5 are presented the results and conclusions regarding DEMATEL implementation.

1.3 Hypothesis

After researching a number of various papers and studies related with SCRM, my conclusion is that for risk controlling and/or eliminating, authors were concentrated mostly on malty-criteria decision analyses techniques such as AHP, ANP, TOPSIS, ELECTREE, PROMETHE etc. Very recently, in ranking the alternatives/criteria DEMATEL method started being in use. This method not only evaluates the importance of perspectives/criteria but also depicts the causal relations among those perspectives/criteria without requiring the assumption that the criteria are mutually independent.

A case study applies DEMATEL method not only to evaluate the importance of perspectives/criteria but also to describe the contextual relationships among those perspectives/criteria.

CHAPTER 2

SUPPLY CHAIN RİSK MANAGEMENT

2.1 Literature review of SCRM

The ultimate importance and challenges of dealing with uncertainty, risk, and vulnerability in supply chains have made these issues one of the focal points of interest for both SCM researchers and practitioners over the recent years, and are the main focus of research in the context of SCRM. Specifically, SCRM research is aimed at developing approaches for identification, assessment, analysis and treatment of areas of vulnerability and risk in supply chains. In order to achieve this aim, SCRM research addresses the problems of coherent representation of the supply chain structure, the way risks are related to the components of this structure, the nature of risk and the major criteria to identify and assess those risks [6].

The risk of disruptions caused by both factors within SC and outside environmental forces is one of the main concerns of both practitioners and researchers. SCRM is therefore a field of escalating importance and is aimed at developing approaches to the identification, assessment, analysis and treatment of areas of vulnerability and risk in SCs [7]. Various trends that enhance exposure to risks, such as the increased use of outsourcing, globalization, reduction of the supplier base; reduced buffers, increased demand for on time deliveries or shorter product life cycles are ratcheting up the importance of SCRM [8]. This is highlighted by several practical examples of the high cost of improper preparation for and response to various events. Currently, SCRM approaches seek to measure either supplier attributes or the SC structure, use the findings to compare suppliers and predict disruption. The results are then used to prepare proper mitigation and response strategies associated with these suppliers. SCRM is most often a formal process that involves identifying potential losses, understanding the likelihood of potential losses, and assigning significance to these losses [9]. A typical example of such an approach is the Probabilistic Risk Assessment Methodology (PRAM) developed by the Dow Chemical Company to measure SC risk and its impacts. This approach examines the following factors of a SC: supply market risk, supplier risk, organization risk and supply strategy risk [10] **.** Due to the relative newness of the SCRM field it is currently chaotic and somewhat disorganized. There are several different classifications of risks and methodologies and often they focus only on the prediction of disruptive events instead of the root causes of uncertainties. Frequently, only disruptive events (such as bankruptcy, natural disaster or the possibility of a terrorist attack) are included, whereas continuous changes due to a turbulent environment (e.g. a change in customer tastes, technology shifts or supplier priorities) are ignored.

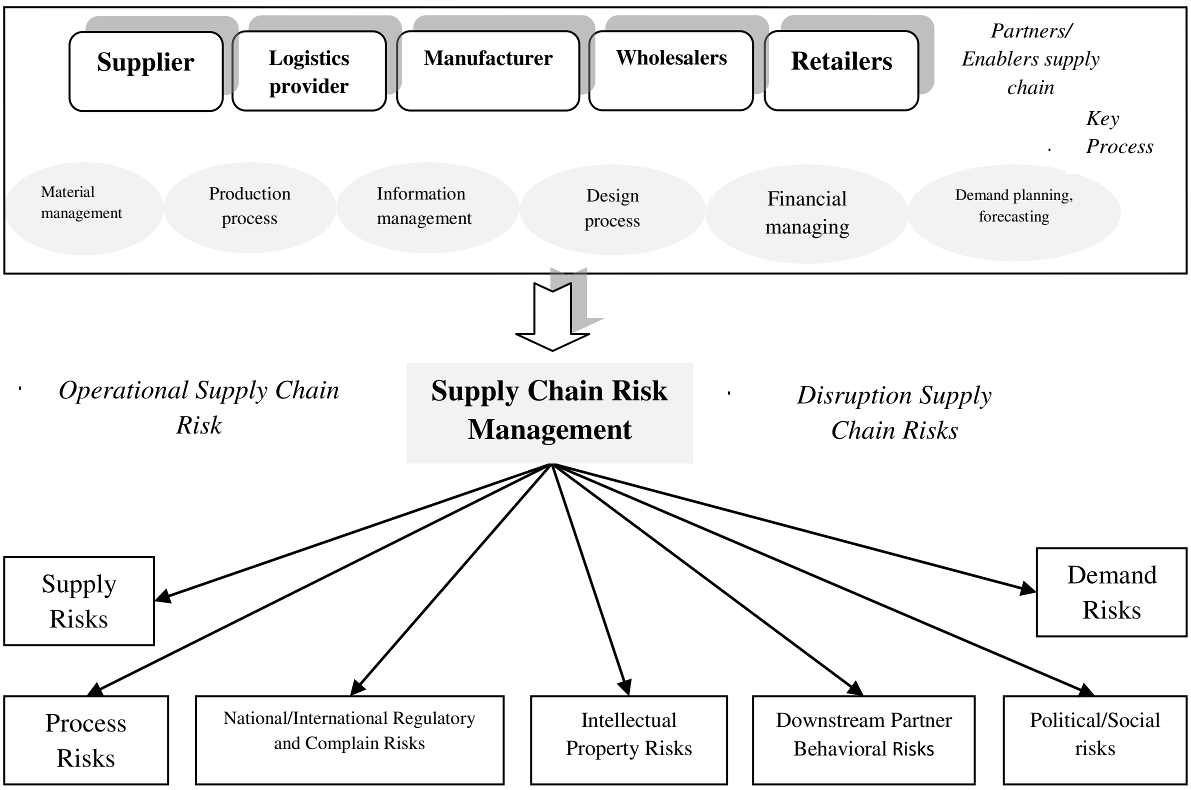

Figure 2.1 Supply chain risk management layout

Production in the early years was simple, with single flow of products moving from raw material suppliers, to manufacturers and then to markets. Nowadays, shorter product life cycle and increasing demand among all have led to a complicated supply chain. Due to cost pressure and competitive advantages, companies are adopting globalization and outsourcing strategies. This also requires an extended supply chain network, hence increases the nodes in the system. In addition, many companies have introduced lean production concepts, which intend to remove ‘‘wastes’’ from a supply chain, for instance, by reducing the number of suppliers. This helps in smoothing the operations but it would also create problems if unexpected events happen in a supply chain. The rising use of internet helps supply network in sharing information visibility [11]. It is indubitable that the emerging uses of enterprisers our preplanning (ERP) solutions such as Oracle and SAP have cut down the information transaction time and reduced the incidents of inaccuracy and redundancy. Vast assistance from these systems has, however, exposed to another consequence, namely information disruption. All the above changes have in evitable increased the importance of supply chain risk management (SCRM). One typical example is Ericsson's crisis in 2000. Since a single-source policy was used, afire accident in its chips' supplier immediately disrupted the material supply. Ericsson's loss was estimated to reach USD 400 million in the T28 model [12] **.** In June 2008, Volvo Cars reported 28% reduction of sales compared with the same period in previous year, with the biggest loss in its SUVs for about 50%. Another example is the Taiwan earth quake in December 2006 which caused break age in undersea cables and slowed down internet. One immediate effects prolonged wait in a time of containers in the Shanghais exporting China, since all claim procedures rely on information systems. Nature disaster, terrorist attack, labor strike, accidents can all be the causes for supply chain disruption and delay [13].

The above examples show that any material, financial or information risk could create problems in a supply chain. Any disorder transpired within the supply chain will cause delay and even disruption. Disruption does not only halt the supply chain operations but without preparation and precaution, it takes time for the affected system to recover. The above background provides the motivation to investigate the current trend and issues in SCRM.

The purposes of this study are to:

(i) Define the risk factors in food distribution companies and mitigation techniques and methods for risk identification in SC;

(ii) Identify the biggest risk in Hedef Gida company;

(iii) Identify and implementing the technique for risk decreasing or eliminating.

2.2 Definition of risk in SC

Risk is a probability or threat of damage, injury, liability, loss, or another negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action.

In the following, risks driving the vulnerability of supply chains are discussed based on an approach by [14] who distinguishes between external and internal SCR. In terms of internal SCR, cross-company-based risks and internal company risks can be differentiated. Internal company risks deal with disruptions caused by problems within the organizational boundaries of the company such as machine breakdowns or IT problems. These risks can be influenced by a company directly [15]. In the context of cross-company-based SCR it can be distinguished between purchasing risks and demand risks.

Purchasing risks are concerned with activities which are making the results opposite form the target of the supply chain. Companies are faced with the risks related to suppliers, e.g. quality problems of delivered material. Furthermore, the financial instability of supplier can lead to its insolvency and therefore can result in the total loss of a supplier. Technological changes or innovation in terms of product/service design might overstrain a supplier’s capabilities and therefore lead to disturbances at the supply site. Demand risks are based on ‘‘downstream’’ activities in the supply chain. These risks can be related to the distribution of products or can be based on uncertainties in terms of demand forecasts which might result in delivery bottlenecks, high inventories, or inefficient capacity utilization [16].

External SCR deal with environmental causes that can barely be influenced and lead directly or indirectly to disturbances within the supply chain. They can be caused by sociopolitical, economical, technological or geographical reasons. Examples are earthquakes or hurricanes as well as terrorist attacks or political instabilities. Subsequent to risk identification, an assessment of the risks concerning their probability of occurrence and the extent of the adverse effect on the entire supply chain should be carried out. Although the exact quantification of these values is often difficult since a precise assessment of the probability of occurrence and their effect is hardly possible it is advisable to evaluate the identified risk at least in a qualitative way.

It is presumed that internal SCR have a higher likelihood to occur than external SCR since the majority of the latter are predominantly exceptional (e.g. war or terrorist attacks), whereas internal SCR such as supplier problems or a change in customer demand cannot be regarded as uncommon incidents. Hence, these supply chain risks are expected to have a higher probability. Furthermore, it is expected that external SCR such as natural disasters will show a higher impact since their occurrence is normally accompanied by grave consequences.

The risks can be depicted in a portfolio regarding the dimensions ‘‘probability’’ and ‘‘impact’’ based on a Likert-scale [17]**.** Fig. 2.2. shows the probability-impact-matrix.

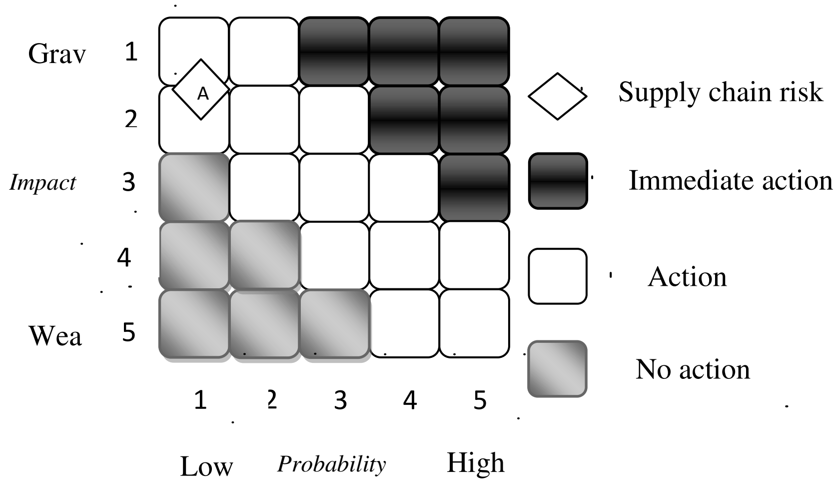

Figure 2.2 Assessment of risk level

Internal SCR have a higher likelihood to occur than external SCR.

External SCR have a greater impaction the supply chain than internal SCR.

In recent years, the composition of the risk portfolio changed for most companies due to new market conditions. Besides usual risks that arise from the business activity of each company, new risks emerge from sources that are often related to close cooperation. The Canfield School of Management identified the following drivers as causes for the emergence of these new risks:

- Globalization of supply chains
- Reduction of inventory holding
- Centralized distribution
- Reduction of the supplier base
- Outsourcing
- Centralized production

The combination of this risk drivers leads to an increasing vulnerability of the supply chains and, hence, to an increasing risk portfolio of each company within the supply chain. Globalization leads to an increased geographical complexity in supply chains, while outsourcing and centralized distribution result in organizational and logistical complexity. Simultaneously, companies in a supply chain become more and more dependent on each other when they outsource functions and reduce their supplier base.

Particularly the concentration on a small number of suppliers or single sourcing in the extreme case may result in a significant increase of supply risks. The breakdown of one supplier may then lead to serious disruptions of the production process of a company. In addition the ability to compensate disruptions through buffers decreases e.g. because of the reduced inventory. Companies which are initial disruption on to the next company in the production chain, because these companies reduced their risk buffers as well disruptions can lead to significant damages. This effect can proceed through the entire supply chain and the breakdown of one company may lead to a damage of partners much further down the supply chain although they are geographically widely dispersed.

If companies pass their own mostly internal risks on to their partners, this leads to a larger risk portfolio for all companies of this supply chain. However, companies are often unable to react to this part of their risk portfolio, because the respective risk sources are out of their range and in many cases also out of their visibility. Consequently these risks can only be integrated into risk management indirectly as and demand risks.

The level of the vulnerability of a supply chain and the extent of the described effect is proportional to the level of the temporal, functional dependencies within that a supply chain. Since the mutual dependency of companies within a supply chain is closely linked to their cooperation and since the importance of this cooperation for the company performance is growing continuously, the vulnerability of the whole supply chain and individual companies will increase further. In addition the growing intra-organizational complexity, e.g. caused by high variety of variants, causes a higher complexity within the whole supply chain. This complexity, introduced to the supply chain by its members, is an additional risk driver in the supply chain context.

Hence, due to measures of single company, the risk portfolio changes and risk might increase for all companies in the supply chain. The risk that arises internally is more effectively. At the same time, there is another problem, how to divide risks among the partners. In analogy to the concept of profit sharing, risk sharing becomes an issue in SCRM.

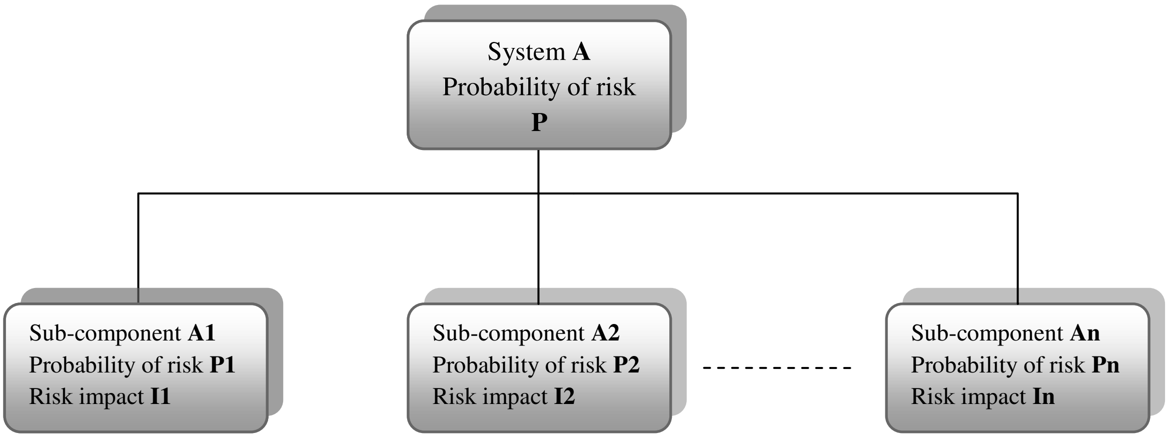

Figure 2.3 Probability of risk in supply chain

2.3 Elements and types of risk analyses

The first core element of risk analysis is risk assessment – the process through which the probability or frequency of a loss by or to an engineering system is estimated and the magnitude of the loss (consequence) is also measured or estimated. Risk management is the process through which the potential (likelihood or frequency) of magnitude and contributors to risk are estimated, evaluated, minimized, and controlled. Risk communication is the process through which information about the nature of risk (expected loss) and consequences, risk assessment approach and risk management options are exchanged, shared, and discussed between the decision markets and other markets and other stakeholders. Elements of risk analyses are shown in figure 2.4.

Risk analyses are about estimating the potential and magnitude to any loss and ways to control it from or to a system. If there are adequate historical data on such losses, then the risk can be directly estimated from the statistics of the annual loss. The approach is often used for cases where data on such losses are readily available such as a car accidents, cancer risks, and frequency of some certain natural events such as storms and floods. The other option is for cases where there is not enough data on the actual losses. In this case, the loss is “modeled” in the risk analysis. Therefore the potential loss is estimated. In most cases, data on losses are small or even unavailable, especially for the complex engineering systems. Therefore, the analyst should model and predict the risk. The risk analysis attempts to measure the magnitude of a loss (consequences) associated with complex systems, including evaluation, risk reduction and control policies. Generally, three types of risk analysis are: quantitative, qualitative and mix of the two. All these methods are widely used each with different purposes, strengths, and weaknesses.

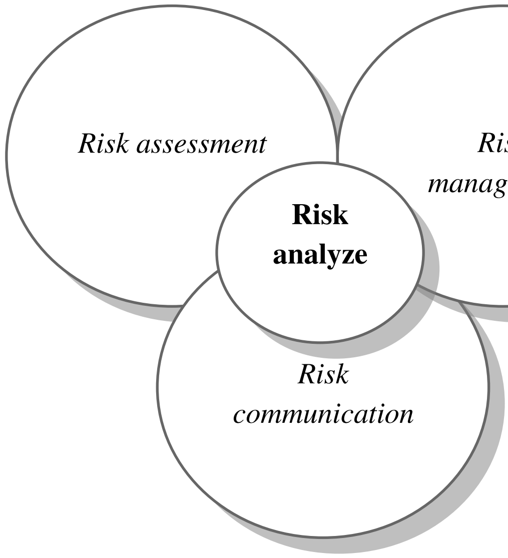

Figure 2.4 Elements of risk analyze

2.3.1 Quantitative risk analysis

The quantitative risk analyses attempts to estimate the risk in form the probability of a loss and evaluates such probabilities to make decision and communicate the results. In this context, the "uncertainty" associated with the estimation of the frequency (or probability) of the occurrence of the undesirable events and the magnitude of losses are characterized by using the probability concepts. When evidences and data are scarce, uncertainties with the quantitative results play a decisive role in the use of the results.

Quantitative risk analysis is clearly preferred approach when adequate field data, test data, and other evidences exist to estimate the probability (or frequency) and magnitude of losses. The use of quantitative risk analysis has been steadily rising in the recent years, primarily due to availability of quantitative estimation of adverse events and scenarios in complex systems from limited data. However, the use of quantitative risk analyses has been restricted to large scope risk analyses, because quantitative risk analyses are complicated, time-consuming, and expensive.

2.3.2 Qualitative risk analysis

This type of risk analyses is perhaps the most widely used one, just because it is simple and quick to perform. In this type, the potential loss is qualitative estimated using linguistic scale such as low, medium, and high. In this type of analyses a matrix is formed which characterizes risk in form of the frequency (or likelihood) of the loss versus potential magnitudes (amount) of the loss in quantitative scales. The matrix is then used to make policy and risk management decisions. Because this type of analysis does not need to rely on actual data and probabilistic treatment of such data, the analysis is far simpler and easier to use and understand, but is extremely subjective.

Qualitative risk analysis is the method of choice for very simple systems such as a single product safety, simple physical security, and straight forward processes.

2.3.3 Mixed qualitative-quantitative analysis

Risk analysis may use a mix of qualitative and quantitative analysis. This mix can happen in two ways: the frequency or potential for loss is measured qualitatively, but the magnitude of the loss (consequence) is measured quantitatively. Further, it is possible that both the frequency and magnitude of the loss are measured quantitatively, but the policy setting and decision making part of the analysis relying on qualitative methods, for example, using qualitative policy setting and decision making part of the analysis relying on qualitative methods, for example, using qualitative policy measures for quantitative range of loss. Also quantitative risk values may be augmented by other quantitative or qualitative risk information to arrive at a decision.

2.4 Techniques of risk identification

Risk identification is the first step in the process of RM, where a list of risk factors has to be clearly recognized. The risk factors, also called risk ownership, are the sources which cause risks and bring about potential failures of enterprise collaboration. Risks are likely to occur at any collaboration phase in the whole process of enterprise collaboration, from the start, through its maturity with productivity, to its end. A risk factor may have various probabilities of risk occurrence, and impose various severities of impacts on the enterprise collaboration along the evolution of collaboration.

Considering that there are various classifications of risks, three wide categories of risks in a SC were identified including:

(1) Internal risks,

(2) Network related risks,

(3) External risks [18].

Relations among SC members and partners were different, and, consequently, the relevant sources of risks might be different. In the study of Zsidisin, Ritchie [18] four more specific SC risk categories were proposed as follows:

(1) Disruptions to the supply of goods or services which cause a risk of failing to satisfy customer demand,

(2) Volatility of prices that causes a risk of losing a customer and/or profit,

(3) Poor quality of products or services which may cause a poor customer satisfaction,

(4) Reputation of a member firm, which is not directly related to a SC, but may impose a risk to it [18].

Suggested different risk categories based on five sub-chains:

(1) Physical sub-chain and corresponding risks related to movements across SC members and storage of products,

(2) Financial sub-chain and risks referring to cash flows between SC members,

(3) Informational sub-chain and risks regarding usage of electronic systems,

(4) Relational sub-chain and risks inherent in SC coordination mechanisms and relationships among SC members, and

(5) Innovational sub-chain and risks that involve processes of product marketing or discovering business opportunities [19].

Many approaches have been provided to assess or evaluate risk. The most frequently used analytical method for identification of possible failure and estimation of the related risks is *Failure Mode Effect Analysis (FMEA).*

Failure Modes and Effects Analysis (FMEA) is a systematic, proactive method for evaluating a process to identify where and how it might fail and to assess the relative impact of different failures, in order to identify the parts of the process that are most in need of change. FMEA includes review of the following:

- Failure modes (What could go wrong?)
- Failure causes (Why would the failure happen?)
- Failure effects (What would be the consequences of each failure?)

Teams use FMEA to evaluate processes for possible failures and to prevent them by correcting the processes proactively rather than reacting to adverse events after failures have occurred. This emphasis on prevention may reduce risk of harm to both patients and staff. FMEA is particularly useful in evaluating a new process prior to implementation and in assessing the impact of a proposed change to an existing process.

This technique was one of the first systematic techniques for failure analysis. It was developed by reliability engineers in the 1950s to study problems that might arise from malfunctions of military systems. An FMEA is often the first step of a system reliability study. It involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects. For each component, the failure modes and their resulting effects on the rest of the system are recorded in a specific FMEA worksheet. There are numerous variations of such worksheets. A FMEA is mainly a qualitative analysis. A few different types of FMEA analysis exist, like Functional, Design and Process FMEA. Sometimes the FMEA is called FMECA to indicate that Criticality analysis is performed also.

Case-based reasoning (CBR) is a method which considers cases which took place in the past and infers their applications to a new situation by comparing the similarity of the features of a new case to the ones in the case-base. The principles of CBR in being able to solve new problems based on historical cases make it applicable to RM. In recent years, to analyze uncertainty have been used Bayesian networks. The networks were employed to analyze a supplier's external, operational and network risk probabilities, and the associated revenue impact on the organization**.** It is noticeable that these approaches adopted similar expressions for risk assessment as in the formula below, which involved assessing the probability of loss P(n) and the significance of loss L(n) for the event n [20]**:**

$$Risk(n) = P(n) \times L(n)$$

In practice, it is often difficult to specify precise probabilities and measure an impact of risk. Furthermore, companies may not have historical data available for risk analysis and assessment. Therefore, instead of using probability theory, CBR and data mining technology, in the areas of SCs is more useful using benefits of applying *fuzzy logic based estimations of risk* factors. These assess probabilities of risks and their impacts, and aggregate them in different ways.

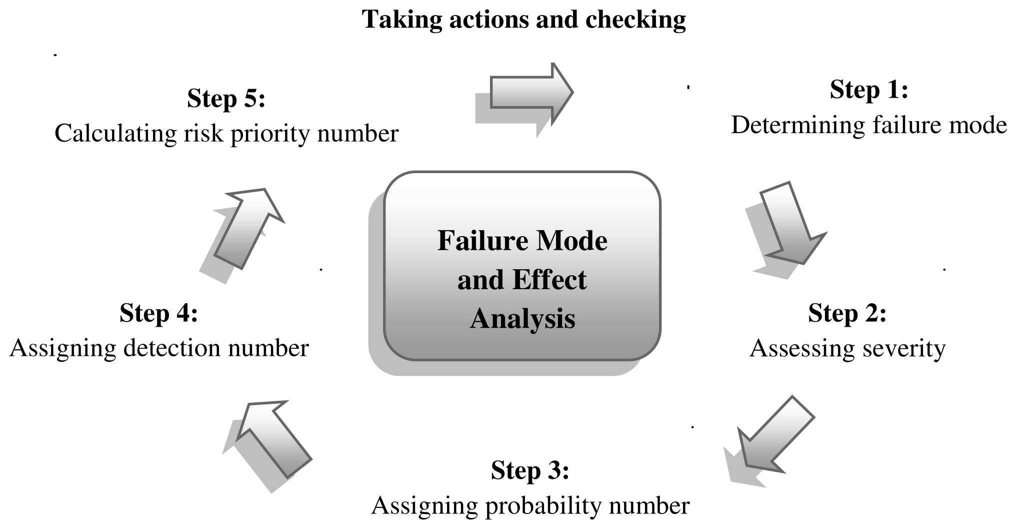

Figure 2.5 Evaluation the process by Failure Models and Effects Analysis

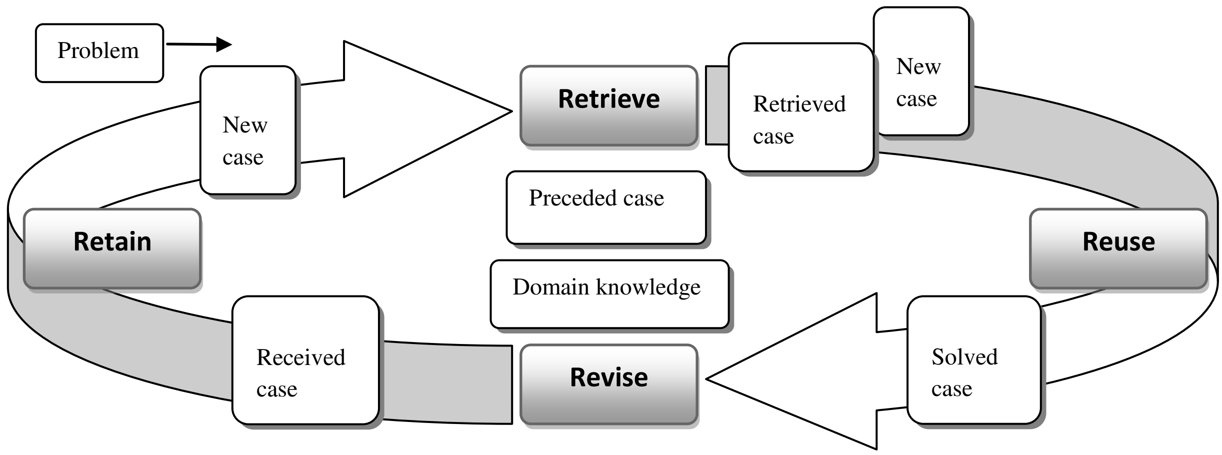

Figure 2.6 Case based reasoning

A generic fuzzy comprehensive evaluation method is very often used method for risk assessment of a company. Risk probability and its consequence are assessed using a set of possible linguistic values, {low, middle, high, extra high} which are simply mapped into corresponding scalar values. The risk factor is calculated for each stage of a company life cycle based on the assessed risk probabilities, their consequences and weights. Finally, these risk factors are combined into one overall risk factor. Its interpretation is based on a simple rule; if the risk factor is less (greater) than 0.3 (0.7), it is considered to be low (high). So the risks relating to system interoperability, which is the key element to enterprise's sustainability, were not taken into accounted.

Therefore, the risk evaluation for enterprise collaboration, when the assessment is carried out by a single evaluator, is as follows:

Step 1: Identify relevant risk factors in specific enterprise collaboration. Let the number of identified risk factors be n.

Step 2: Estimate the probability of risk P_i and risk impact I_i of each identified risk factor i $(i = 1, 2, \ldots, n)$. Express both by linguistic terms using the set of nine linguistic terms in Table 2.1.

Table 2.1 Sample risk assessment matrix

	Frequent	**Likely**	**Occasional**	**Seldom**	**Unlikely**
Catastrophic	EH	EH	H	H	M
Critical	EH	H	H	M	L
Moderate	H	M	M	L	L
Negligible	M	L	L	L	L

EH – Extra High; H – High; M – Medium; L – Low

Step 3: Assess the risk factor i $(i = 1, 2, \ldots, n)$ as risk assessment $(i) = P_i \times I_i$

Step 4: Calculate the total probability of risk of the enterprise collaboration, represented as an aggregation of the risk assessments of all risk factors using the fuzzy weighted mean method. Risk assessment

$$P = \frac{\sum_{i=1}^{n} Risk\ assessment(i)}{\sum_{i=1}^{n} Ii}$$

Step 5: Apply the similarity measure, and find a fuzzy linguistic value from the set of four, which is the most similar to the total collaboration risk – the probability of risk P [21].

2.5 Risk and turbulent environments

Researches often neglect an important division of risks, namely the origin of risks, which can either be within a chain or from the outside environment. In order to distinguish between the different kinds of risks, the sources of uncertainty need to be separated into two different constructs:

- Endogenous uncertainty
- Exogenous uncertainty

2.5.1 Endogenous uncertainty

Turbulent conditions are mostly characterized by frequented unpredictable market and/or technological changes within an industry which accentuate risk and creation inability to forecast accurately. In many markets it is becoming impossible to remove or ignore sources of turbulence and volatility. Hence, managers of SCs face the situation where they have to accept uncertainty and cope with it. Therefore, proper strategies are needed for dealing with uncertainty in the SC context. An important question for SCM theory and practice is the influence of endogenous uncertainty on cooperation and integration with suppliers. Nowadays is often quoted as one of the most frequently used strategies in SCM**.** While Stonebraker and Liao [22] claimed that turbulence is positively related to SC integration, they offered no proof to support the claim. In line with the contingency theory, the correct answer may depend on the chosen strategy of the focal firm, the structure of its SC (customers, suppliers, and sources of uncertainties) and other factors. The claim has been substantiated for market turbulence and by for technology turbulence [22].

- *Market turbulence*

Market turbulence is likely to arise from the heterogeneity and rapid changes in the composition of customers in the market and their preferences [23]. It is characterized by continuous changes in customers' preferences/demands, in price/cost structures, and in the composition of competitors. In a turbulent market, the market shares of a SC (or its business units/divisions) and its competitors can change relatively quickly and it is difficult to forecast demand and customer tastes. Customers tend to look for new products constantly and new customers often have product-related needs that differ from existing customers. A firm in a more turbulent market has to modify its products and approaches to the market more frequently. Market turbulence can also be caused by mergers or acquisitions. If a supplier is acquired by another company or the divestiture of a certain division occurs, this can result in delivery or quality problems. There are different views on the impact of market turbulence on the relationship and behavior of firms in a SC. On one hand, a fast changing market might incline firms to co-ordinate their efforts to reduce uncertainty and respond to changes in demand. On the other hand, a firm operating on its own might be able to respond more quickly to the changes in customer preferences while the process of communication and joint-decision making between alliance partners might introduce delays and limit proactive measures. The answer might lie in the fact that (in line with the contingency theory) both views might be correct. A focal firm with a flawed strategy and structure of its SC can survive in a less-turbulent environment since most of the potential risks have a low likelihood. On the other hand, in a turbulent market a focal firm should have a very clear strategy for dealing with turbulence, although the chosen strategies for different suppliers and chains can be very different. This claim was substantiated by Koo [24] who found that market turbulence positively influences the level of adoption of different generic strategies (cost leadership, market differentiation, innovative differentiation, focus), while it does not have a direct impact on firm performance [24]. Obviously there are more or less successful chains in both more and less turbulent environments. In line with earlier authors, the following measures are proposed for market turbulence (a scale from 1 to 5, strongly disagree to strongly agree):

1. We cater too many of the same customers as in the past (reverse scoring).
2. In general, in this business unit (or division) the market share is stable among the same competitors (reverse scoring).
3. Demand and customer tastes are fairly easy to forecast (reverse scoring).
4. Our customers tend to look for new products all the time.
5. New customers tend to have product-related needs that differ from our existing customers.

- *Technological turbulence*

Technological turbulence refers to the degree to which technology changes over time in industry and the effects of those changes on the industry [25]. Technological turbulence arises from changes in the underlying technologies of products or services and their rates of obsolescence. Technical dynamics include how fast the related technology is changing, as well as breakthroughs in the manufacturing process, and mass production techniques. When technology is changing rapidly, the firm must be able to share information more quickly than when technology is more predictable. SCRM is therefore expected to play a more important role in such situations. Alliances may be more effective in highly technologically turbulent markets by making it possible to accelerate the time to market and gain access to complementary products or technologies without risks of internal development. Interestingly, a technology orientation enhances a firm's performance in highly turbulent markets while it is detrimental in less turbulent markets. However, the finding that greater technology turbulence does not make strengthen the relationship between SC relationship quality and SC performance seems not to support these claims. Similarly, Chatterjee claims that firms can take advantage of technological advances to significantly alter the components of an existing SC [25]. The answer to the question about whether to integrate with suppliers or to instead enable a more flexible change of a SC component might therefore be quite simple. A focal firm should integrate more with those suppliers that are able to cope with technological turbulence and provide critical components of products/services. It should not lock itself in with suppliers that are unable to do so and (if needed) change those suppliers in order to obtain the technological developments required to retain the chain's competitive advantage and reduce the risks. Once again, it should be emphasized that not only the different units of a focal firm but also different suppliers operate in markets with different technological turbulence and therefore different strategies should be employed. Based on these observations and the empirical findings of earlier authors, we propose the following measures for technological turbulence of the market of each individual supplier (a scale from 1 to 5, strongly disagree to strongly agree):

1. The technology in our industry is changing rapidly.

2. Technological changes provide big opportunities in our industry.

3. It is very difficult to forecast where the technology in our industry will be in the next 2–3 years.

4. A large number of new product ideas have been made possible by technological breakthroughs in our industry.

5. In our principal industry the modes of production and service often change. 6. The rate of product/service obsolescence in our industry is very high.

2.5.2 Exogenous uncertainty

In addition to changes in market and technology, a SC also have to deal with disruptions from its environment either in the form of natural disasters (e.g. hurricanes, floods, earthquakes) or human issues (e.g. a labor strike, fraud, a malfunction in production, delays in logistics, terrorist attacks). Possible disruptions can be classified as long-term uncertainties (e.g. raw material/ final product unit price fluctuations, seasonal demand variations) and short-term uncertainties (cancelled/ rushed orders, equipment failure, etc.) Generally, organizations plan to protect themselves against recurrent, low impact risks in their SCs but ignore high-impact, low-likelihood risks. Even though organizations are often unable to manage the source of the risk exposure, it is vital to identify the sources of potential problems and possible consequences. In this way a proper response that might range from avoidance, transfer, mitigation to monitoring or even acceptance of risk can be taken. Our proposed classification of exogenous uncertainty is novel by virtue of its distribution of risk on the probability distribution of its impact:

- *Continuous risk:* Events where the costs of potential changes are continuous in nature and relatively easy to predict (a typical example is changes in raw material prices).
- *Discrete events:* This category consists of low likelihood, high-impact events which can be classified as terrorism, the spread of diseases, natural disasters [27]**.** Political events such as those occurring in Venezuela or Myanmar can also pose a disruption risk. Transport disruptions between various links in the chain can also cause considerable delays or non-deliveries. These are often hard to predict and their consequences can be largely et hard to measure. Nevertheless, the likelihood of such events can often be estimated and therefore should be included in theirs crating. Therefore, the questionnaire for exogenous uncertainty includes the likelihood of such events which then add up to a higher score for the turbulence of the suppliers' environment. Such a division is important due to the different possible strategies for risk prevention and response. Continuous risk can be 'managed' in a way where by a focal company searches for an optimum between the probability of such events and the costs of their impact and prevention. It can be hard to predict exactly or estimate the impact of the occurrence of discrete events. Still it is possible to apply one of the strategies such as avoid, transfer, mitigate, minimize, respond, monitor or accept to manage those risks.

While endogenous uncertainty can be measured with precise (and previously validated) questionnaires, the exogenous uncertainty is harder to estimate. Therefore, a scale from 1 to 5, strongly disagree to strongly agree, is suggested.

Table 2.2 Risks in supply chain and implied techniques

Author/Date	SC risk factor	SC level	Technique
Sun et al., 2012	Delivery time, total coast increase, product quality loss	Demand forecast, production planning	P-chart solution model
Shaw et al., 2012	Information vagueness related to inputs, supply chain fragility	Input selection, supplier selection	Fuzzy-AHP, Fuzzy multi-objective linear programming
Wang et al., 2011	Product safety	Production planning	Fuzzy AHP
Olson &Wu, 2012	Production failure	Outsourcing analyze	Monte Carlo simulation
Tuzkaya et al., 2010	Production failure, coast increasing	Equipment selection	Fuzzy ANP, Fuzzy PROMETHEE
Liao & Kao, 2011	Supply chain fragility, production failure	Supplier selection	Fuzzy TOPSIS, Multi-choice goal programming (MCGP)
Amiria, et al., 2012	Choosing wrong locations of distribution centers	Supply chain design	DEMATEL
Chan & Zhang, 2011	Delivery time, supply chain efficiency	Supply chain design	Simulation model
Safaei et al., 2013	Production and distribution delay	Demand forecasting	Hybrid model, Simulation
Osvald & Stirn, 2006	Product quality loss	Transportation planning	Mathematical modeling
Kuo et el., 2010	Production failure	Supplier selection	Particle swarm optimization (PSO), Fuzzy neural network (FNN)
Moghadam et al., 2007	Failure inventory planning and controlling	Supplier selection	Fuzzy neural network (FNN), Genetic algorithm (GA)
Tratar, 2010	Inventory deficiency, delivery dilate	Demand forecasting	Holt–Winter's method
Ganga, 2011	Supply chain management failure	Supply chain management performance measurement	Supply Council Operations Reference model (SCOR) model
Lee et al., 2013	Wrong service quality criteria	Service quality control	Revised DEMATEL, ANP DEMATEL
Chang et al., 2011	Low supply chain performance, SC improvement's failure	Supplier selection	Fuzzy DEMATEL
Baykasoglu et al., 2013	Truck selecting, capacity increasing failure	Demand forecasting, equipment selection	Fuzzy TOPSIS, Fuzzy DEMATEL
Sumrit et al, 2013	Choosing wrong technology innovation capabilities (TICs) evaluation factors	Research and Development planning	DEMATEL
Moghadam et al., 2008	Uncertainties in parts demand from market, capacity of supplier, uncertainty in supplier lead time, quality uncertainty, and production failure	Supplier selection	Mixed-integer non-linear program (MINLP)
Valdés et al., 2010	The total cost, time needed for shipping the product	Supply chain design	L-shaped method
Saavedra et al., 2013	Low product quality	Production planning	Principal Component Analysis (PCA)

Liao& Kao, 2009	Low product quality, delivery time delay	Supplier selection	Taguchy loss function, analytical hierarchy process (AHP) and multi-choice goal programming (MCGP) model
Albadvi et al., 2006	Determine the ineffective criteria for industry company evaluation	Stock trading	PROMETHEE
Lam, et al., 2010	Wrong criteria selection	Material supplier selection	Fuzzy Principal Component Analysis (PCA)
Yilmaz & Dagdeviren, 2011	System inefficiency, the labor ineffectiveness and uncertain product quality	Equipment selection	The fuzzy PROMETHEE method, The zero–one goal programming method
Zavadskas et al., 2010	Uncertain service quality, fragile supply chain	Contractor selection	Saw-g, TOPSIS grey techniques
Andrejic et al., 2013	Selection of wrong indicators for measuring efficiency of decision criteria	Quality control system design	Data Envelopment Analysis Principal Component Analysis
Chang et al., 2011	Wrong supplier selection criteria	Supplier selection	Fuzzy DEMATEL

2.6 Risks in supply chain

In the Table 2.2 some of the risks that can be happen in supply chain are listed together with the techniques implied as a solution for decreasing, controlling or eliminate it.

After researching a number of various papers and studies related with supply chain risk management, my conclusion is that for risk controlling and/or eliminating, authors were concentrated mostly on malty-criteria decision analyses techniques such as AHP, ANP, TOPSIS, ELECTREE, PROMETHE etc. Very recently, in ranking the alternatives/criteria DEMATEL method started being in use. This method not only evaluates the importance of perspectives/criteria but also depicts the causal relations among those perspectives/criteria without requiring the assumption that the criteria are mutually independent. A case study applies DEMATEL method not only to evaluate the importance of perspectives/criteria but also to describe the contextual relationships among those perspectives/criteria

CHAPTER 3.

SCRM IN FOOD INDUSTRY

3.1 Food distribution services and risk in supply chain

The distribution of groceries and food is different from the distribution of other products. This products show continuous quality changes throughout the supply chain, all the way until final consumption. Hence, in food distribution, quality, health, and safety require central consideration. Food supply chains stretch from agricultural producers to consumers and usually involve a manufacturing stage, as well as foodservice or retail activities. Distribution management normally refers to the physical flows and storage of products from the final production point to the customer or end user.

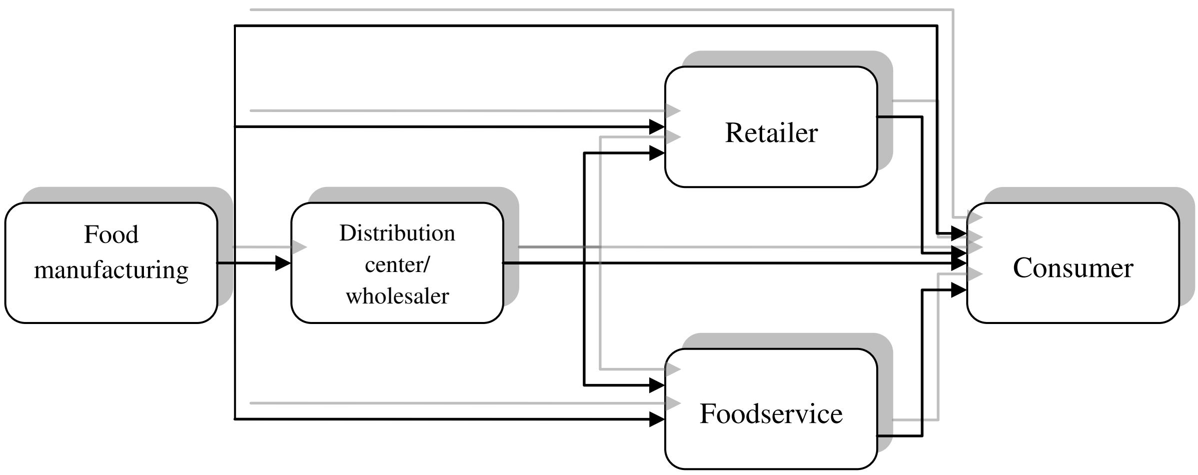

Figure 3.1 General structure of the food distribution in supply chain

Even in the companies that have been maximizes the quality of logistic system and minimized the risk of damaging the goods in transportation, we still cannot say that all products can and will be delivered by agreed time and to right costumers. Considering that the markets and costumers' needs are very changeable, competition every day stronger, all companies should be aware of the risks that distributor's job brings.

This chapter provides a summary of Hedef Gida, the organizations studied. It begins with a summary of the structure, Hedef Gida's supply chain and some recent changes which have affected the supply chain. Although Hedef Gida company has facilities in five different region in Turkey, in this research will be considered only the facilities placed in Istanbul.

3.2 HedefGida company

Hedef Gida is part of Hedef Group, established about 45 years ago in Erzurum as a company for food sale and distribution. Nowadays it is one of the biggest Turkish distribution companies with its base in Istanbul (European and Asian side) and facilities in five region more (Ankara, Antalya, Adana, Ezurum, Trakya).

Mission of Hedef Gida is;

"Contributing to Turkey's economy in a growing trend with satisfying all of our customers with qualified service."

Company's vision is;

- *To be an example and leader for the sectors we serve.*
- *To have sustainability about our quality conscious.*
- *Increasing the customer satisfactory*
- *Increasing the efficiency in our business progresses by following technology closely*
- *Contributing our social values.*

Hedef Gida company currently dessposses147 vehicles, 19 600 m^2 closed area warehouses, employs 276 people and 18 suppliers (what is attached in Apendix1). Since the year of 1994 number of customers is constantly increasing and current number is 3500 so logistic is the critical area within Hedef Gida company that has ability to destroy the business if done badly, or can significantly aid in the achievement of a mission if done well. Logistics plays a significant role in any distribution firm whether it is small, middle-size or big.

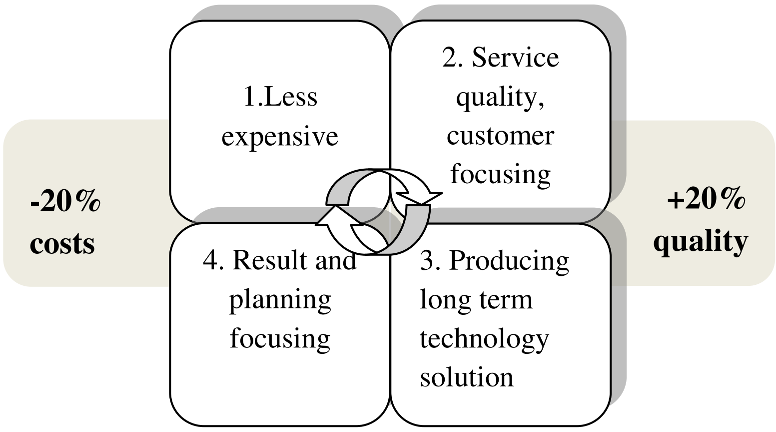

Figure 3.2 Goals of the 2013 year

3.3 Supply chain of Hedef Gida

Hedef Gida has gone through a number of big changes in their supply chain over the last 18 years. These changes include restructuring of human resource management, upgrading of informational management systems and commercializing.

3.3.1 The supply chain structure

Between years of 1995 and 2009 Hedef Gida company has spread its facilities to six different regions so they can be closer to the producers as well as the costumers. New working regions were established in Istanbul East (1995), Erzurum (1998), Adana (2000), Ankara (2001), Antalya (2003) and Trakya (2009). In this way the reliability of their services was much more increased cause decisions regarding opening new warehouses and sales facilities were based on number of costumers that was increasing approximately 6-9% annually followed by constantly increase of annual turnover which is showed in tables 3.1 and 3.2.

In the year of 2011 in East and West Istanbul “Root optimization” project was implement and GPRS system has been established. Before this project in research and development department has been noticed that number of vehicle in use can be reduced thus the number of workers and transportation costs. Also the GPRS provided a base for higher flexibility and efficiency in work. In previous system there was no curtain days or hours for ordering the goods. So the delivery had been doing 3-4 times in a week and often two or even more vehicles were going to similar direction but in different days. Old working system provided very high level of costumer’s trust and loyalty but also huge transportation costs.

Table 3.1 Regions of Hedef Gida's facilities

Region	Num. of Employees	Warehouse (Closed Area)	Vehicle Fleet	Num. of costumer
Istanbul West	153	6,500 m2	86	2,500
Istanbul East	123	13,100 m2	61	1,000
Adana	73	3,700 m2	45	5,600
Ankara	143	7,000 m2	95	8,000
Antalya	44	4,000 m2	27	1,200
Trakya	35	3,500 m2	16	600
TOTAL	571	34,200m2	330	18,900

Table 3.2 Hedef Gida's annual turnover

Year	Facility location	Turnover (mm$)
1995	Istanbul East	16
1998	Erzurum	32
2000	Adana	45
2001	Ankara	47,5
2003	Antalya	115
2009	Trakya	350,5

In the year of 2011 in East and West Istanbul "Root optimization" project was implement and GPRS system has been established. Before this project in research and development department has been noticed that number of vehicle in use can be reduced thus the number of workers and transportation costs. Also the GPRS provided a base for higher flexibility and efficiency in work. In previous system there was no curtain days or hours for ordering the goods. So the delivery had been doing 3-4times in a week and often two or even more vehicles were going to similar direction but in different days. Old working system provided very high level of costumer's trust and loyalty but also huge transportation costs.

After "Root optimization" project all costumers had been divided to certain regions and for each region there are two days in a week for making the orders and product delivering. The example of this project is shown on the picture A and the whole plan of order-deliver system is shown in Apendix A.

In the year of 2012 was realized "East to West transfer" project. This change in logistic system was initiated because of increased demand sent to West European warehouse from costumers located in East Istanbul. Since the ordering system for West and East Istanbul were separated all orders were being sent either to West or East Istanbul warehouse. In those conditions vehicles from European side were passing to Asian side on average 25 times per month and the number of customers located in Asian side was 51 out of 865. The redundant expenses were about 4500 TL. After realizing the “West to East transfer” project delivering system and the annual saving look like follows.

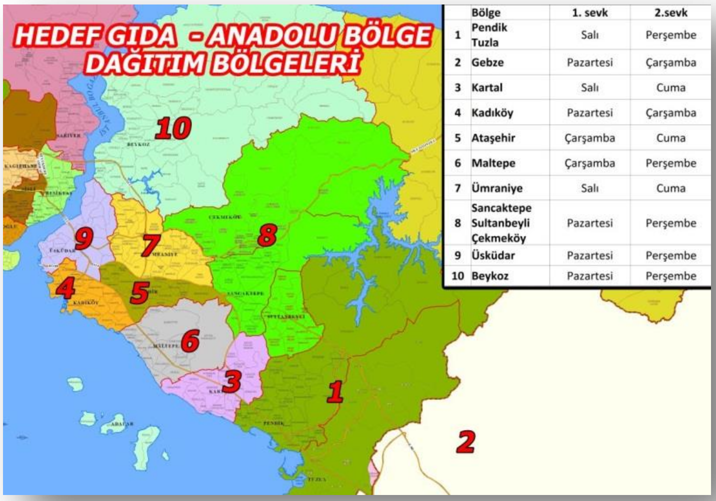

Figure 3.3 Distribution areas of Hedef Gida in Asian side

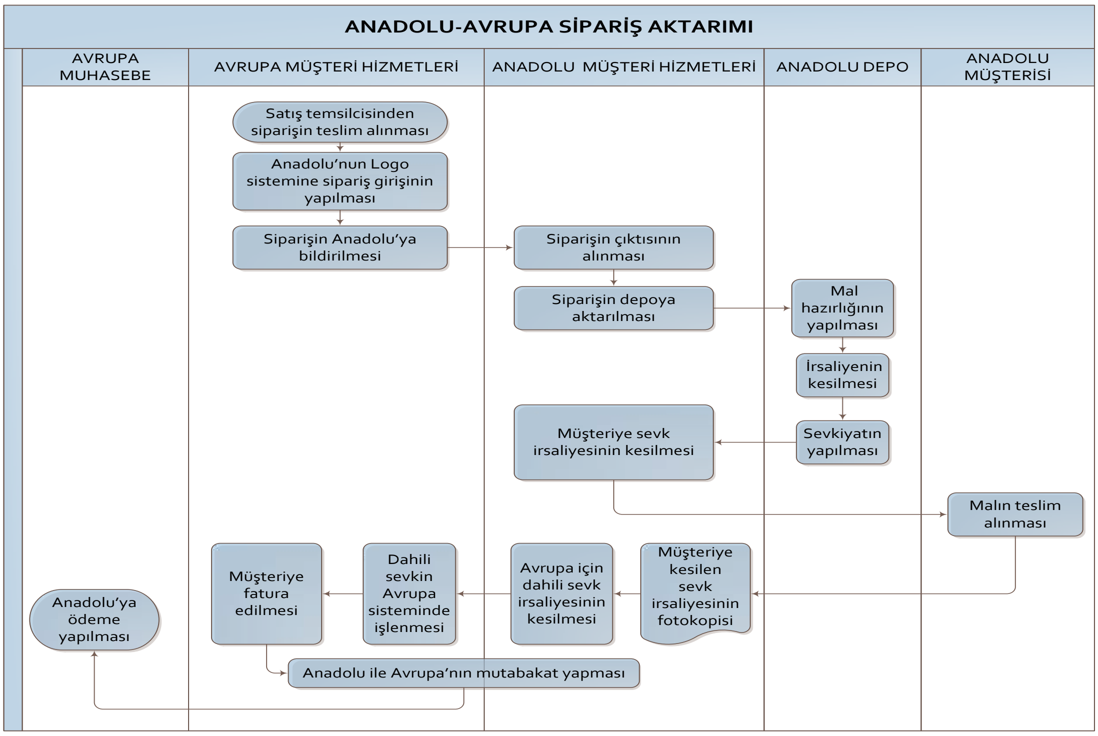

Figure 3.4 Ordering process before project "West to East transfer"

Table 3.3 Annual saving in Hedef Gida

Annual saving	About 1.5 mm TL
Routing/Truck utilization	300
Information research analyze	60
Human resource	500
Trucking elimination	90
Fix route/load combination	400

Table 3.4 Annual saving after project "West To East Transfer”

	Number of transactions	Km	OGS	TL/km	Month expenses	Annual expenses
Europe	25	250	4TL	0,8	5.100	61.200
Asia	15	50	0	0,8	600	7.200
Save					4.500	54.000
1 driver, 1 assistant, 1 warehouse employee						66.000TL
1 vehicle (about 20.000TL)						
Total safe					4.500TL	120.000TL

At the moment Hedef gida company is doing distribution services for more than 30 domestic and foreign companies (such as Danone, Tukas, Filiz, Etti, Read Bull, Kraft….) and more than 3500 direct customers in Istanbul. Total number of suppliers is 20 and the details about facility organization are presented in the Table 3.5.

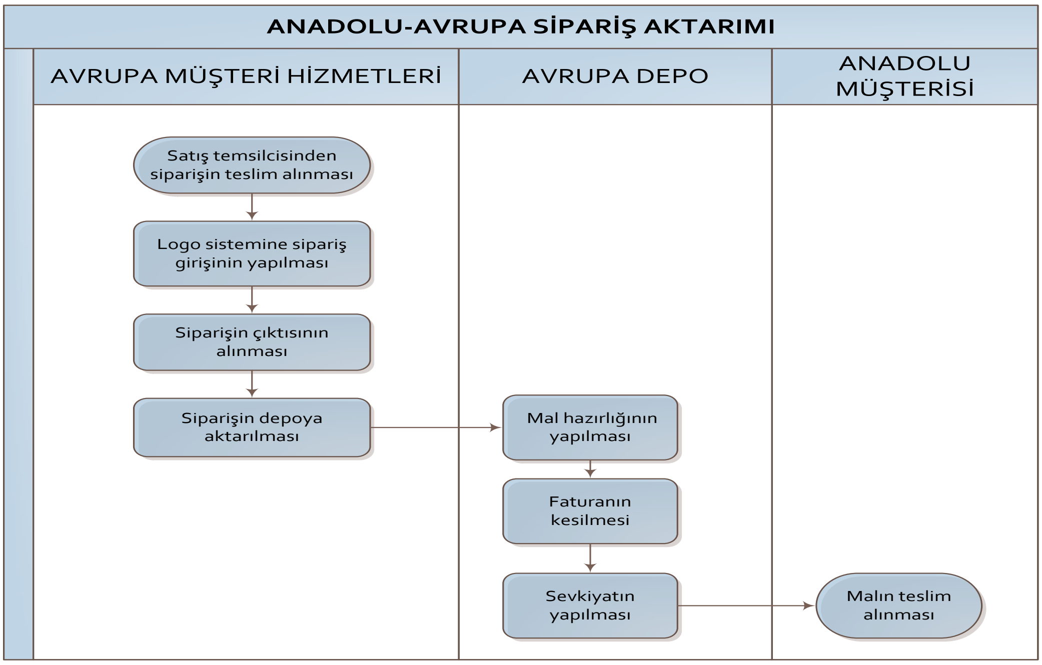

Figure 3.5 Ordering process after project "West to East transfer"

3.3.2 Current problem in SCM of Hedef Gida

Although Hedef Gida company has implemented four projects for controlling the stock and orders of costumers, in some certain weeks logistic department is still facing a problems with delivering the products to the costumers. After the project "West to East transfer" regarding reorganizing ordering system of the company the costumer's orders has been followed for 6 month. After 6 month of following the orders (from November 2012 till April 2013), statistics showed the following results;

- Inventory reduction (as it is shown on the picture below) and net sawing of 335 million $.
- Reclamation cause of wrongly delivered weight or\ and products (from 3% decreased to 1.79%).
- There were no complains about the ordering process.

Delivers from European warehouse to costumers located in Asian side was decreased from 25 to 15, what brings the save of 54000TL per year.

Table 3.5 Facility organization for the year 2013

Organization	
Total num. of warehouse employees	192-200
Facility	
Number of suppliers	20
Number of monthly inputted products (packets)	1.000.000
Number of monthly outputted products (packets)	1.000.000
Number of stock keeping unit (SKU)	2.000
Number of delivery points	100.000
Number of invoices (monthly)	50.000
Team	
Warehouses area (m²)	30.000
Number of vehicles	80
Number of vehicles with air-conditions for hot weather	64
Gates number	23
Forklift number	11
Tran pallet number	70
Reach truck	1
Capacity	
Max. downloading capacity per day	68
Max. uploading capacity per day	107
Workers/day/packets	10.400
Expenses per year (TL)	8MM

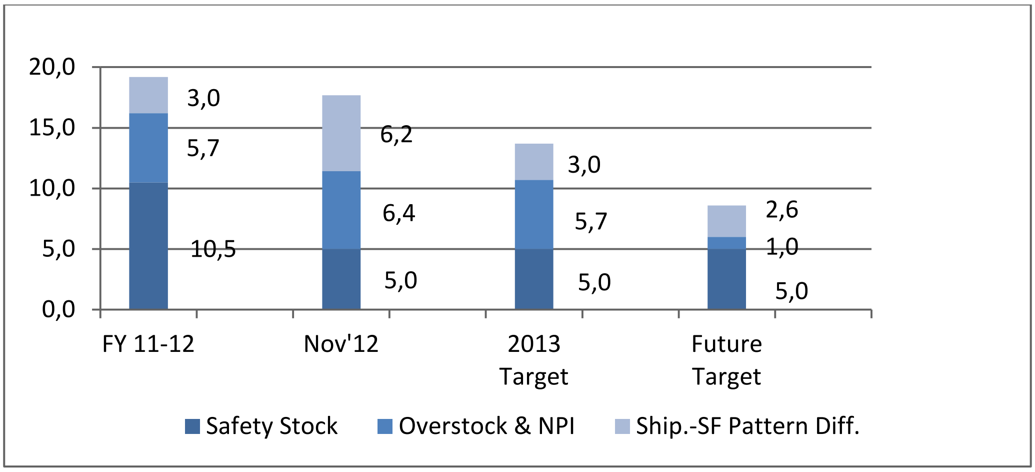

Figure 3.6 Stock changes after project “West to East transfer”

The changes that didn’t happen the way management expected were:

- Coasts of the perishable goods; getting out of use and/or damaged cause of delay in warehouse
- Canceled delivers because of the transportation capacity (that was not large enough to cover all orders at the moment)
- Late delivers
- Damages in transportation
- The budget was still unclear till the last days of the month.

Table 3.6 Weekly shipment and stock flow pattern for six month

	W1	**W2**	**W3**	**W4**
SFP	4	19	18	59
SHIPMENT	16	18	28	38

Table 3.7 Weekly stock flow pattern for six month

SFP	**W1**	**W2**	**W3**	**W4**
Europe	9	24	25	42
Asia	2	16	25	57

Table 3.8 Weekly shipment pattern regionally for six month

SHIPMENT	**W1**	**W2**	**W3**	**W4**
Europe	21	18	32	28
Asia	13	16	32	39

Thus the company didn’t reach the goals regarding service quality the general manager for logistic, manager of the financial department and sales manager realized that the solution could be in choosing small or middle sized company which will be their contractor. In this way when Hedef Gida is not able to respond to all costumers’ requests or demand changes contractor will be.

Cause the quality level of any service can be estimated in many different ways, first and the most important step of choosing the contractor is defining the main criteria and third ranking. After finding the main selection criteria, the number of suitable candidates is getting decreased and ranking the criteria makes estimation of the total quality service more precise. After completing the whole project, instead of canceling the orders and losing the profit in the busiest days of the month, Hedef Gida company will share the errand and profit with one contractor.

Before finding and ranking the most important criteria in choosing the contractor, managers of the company had to collect some of the previously made reports, analyze the ordering trends, and collect employees’ opinion regarding selection criteria and the way they are influencing each other and the mine criteria. The project was occurring in following steeps;

- Choosing the team that will be responsible for project implementation by general manager of Hedef Gida company and human resource manager,
- Confer the responsibility and duties to team members,
- Analyzing the ordering trend and identifying the busiest days/weeks,
- Choosing the methods and techniques that will be used in defining and ranking the most important criteria,
- Collecting the criteria from questionnaire,
- Ranking the criteria and estimating their influence to each other and main criteria.

All dates have been collected between August 2012 and September 2013 and the project will be implemented at latest till September 2014 in Istanbul.

Considering that the crucial criteria for choosing the right contractor were numerous and not certain, for choosing and ranking the most important ones we decided to use one of the newest multi criteria decision making (MCDM) method, Decision-Making Trial and Evaluation Laboratory (DEMATEL) method .

Over the years, a number of techniques have been proposed to solve the selection problem. The long list of approaches includes linear programming (LP), mathematical programming models, multiple-objective programming, statistical and probabilistic methods, data envelopment analysis (DEA), cost-based methods (CBM), case-based reasoning (CBR), neural networks (NN), AHP, analytic network process (ANP), fuzzy set theory, and techniques for order preference by similarity to ideal solution (TOPSIS). The reason we choose DEMATEL method is visual presentation of the results and connection between the subsystem's elements. So this method is providing, not only the importance of criteria but also the influence between them.

DEMATEL method's steps and details about how the project has been done are showed in Chapter 4.

CHAPTER 4

APPLYING DEMATEL

In this chapter, literature review and implementation process of DEMATEL method is presented with the aim to identify the most important criteria for contractor assessment in Hedef Gida company, according to the influence on each other. Since in literature review DEMATEL method has been implemented in two different ways, with and without perspectives, we decided to implement it in both ways and to compare the results. For method implementation, all necessary data were collected from management and employees of Hedef Gida company.

4.1 Selecting and ranking main criteria

In many industrial engineering applications the final decision is based on the evaluation of a number of alternatives in terms of a number of criteria. Contractor selection is an important issue in logistics. In recent years, determining the best contractor or/and suppler in the supply chain has become very important strategic consideration. These decisions usually involve several objectives or criteria, and it is often necessary to compromise among possibly conflicting factors. This problem may become a very difficult one when the criteria are influencing the main goal and other criteria in the same time with various effecting levels.

The DEMATEL method has become our final choose, because of its ability to pragmatically visualize complicated causal relationships. Specifically, the DEMATEL method is based on diagraphs, which separate involved factors into cause group and effect group. Diagraphs are quite useful elements because of ability to demonstrate the directed relationships of sub-systems. The diagraph may portray a basic concept of contextual relation among elements of a system, in which the values represent the strength of influence. Hence, the DEMATEL can convert the relationship between cause and effect factors into an intelligible structural model of the system. The DEMATEL can propose the most important criteria which affects other criteria.

4.2 Literature review and the method

DEMATEL is a sophisticated method for establishing a structural model involving causal relationships among complex factors [28]. It was developed by the science and human affairs program of the Battelle Memorial Institute of Geneva between 1972 and 1976 and it was used to solve the complicated and intertwined problem group. The methodology, according to the properties of objective affairs, can confirm the interdependence among the variables/attributes and restrict the relation that reflects the properties with an essential system and development trend. The end product of the DEMATEL process is a visual representation by which the respondent organizes his or her own action. The procedures of the DEMATEL method [28] are discussed below.

In DEMATEL structure, each factors or parts may exert on and obtain from other higher or lower level factors. One of excellence of this technique rather than others decision making method in applying feedback application. The entire factors establish worth and importance of factors instead of considering only specific factors [28] .

For applying DEMATEL, there are following main step;

- making the direct-influenced matrix
- calculating the direct-influenced matrix normalization
- achieving the total-relation matrix
- producing a causal diagram
- obtaining the inner dependence matrix and impact relationship map.

In this step, the sum of each column in total-relation n×n matrix is equal to 1 by the normalization method and then the inner dependence matrix can be acquired. The procedure of DEMATEL method is presented below:

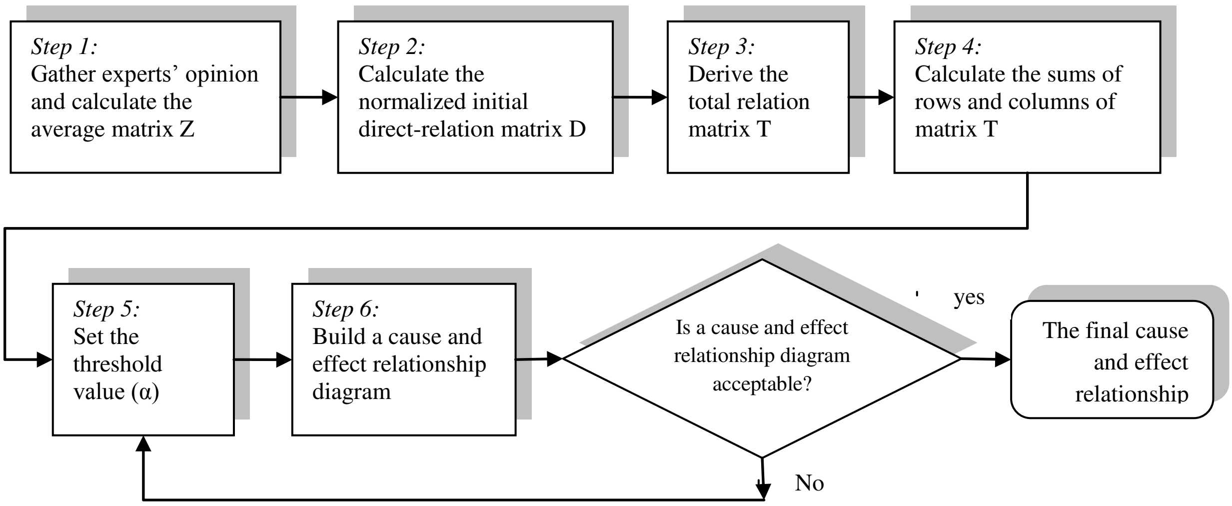

Figure 4.1 Process of the DEMATEL method

Step 1: *Gather experts' opinion and calculate the average matrix Z.*

A group of *m* experts and *n* factors are used in this step. Each expert is asked to view the degree of direct influence between two factors based on pair-wise comparison. The degree to which the expert perceived factor *i* affects on factor *j* is denoted as x_{ij}. The integer score is ranged from 0 (no influence), 1 (low influence), 2 (medium influence), 3 (high influence), and 4 (very high influence), respectively. For each expert, an *n x n* non-negative matrix is constructed as $X^k = [x_{ij}^k]$, where *k* is the expert number of participating in evaluation process with $1 \leq k \leq m$.

Thus, *X1, X2, X3,.., Xm* are the matrices from *m* experts.

To aggregate all judgments from *m* experts, the average matrix $Z = [z_{ij}]$ is shown below.

$$z_{ij} = \frac{1}{m} \sum_{i=1}^{m} x_{ij}^k \quad (1)$$

In some papers average matrix is marked with *A*.

Step 2: *Calculate the normalized initial direct- relation matrix D*

The normalized initial direct-relation matrix $D = [d_{ij}]$, where value of each element in matrix *D* is ranged between [0, 1]. The calculation is shown below.

$$D = \lambda * Z \quad (2)$$

or

$$[d_{ij}]_{nxn} = \lambda [z_{ij}]_{nxn} \quad (3)$$

Where

$$\lambda = Min\left[\frac{1}{max\ 1 \le i \le n \sum_{i=1}^{n} |z_{ij}|}, \frac{1}{max\ 1 \le i \le n \sum_{i=1}^{n} |z_{ij}|}\right] \tag{4}$$

Based on Markov chain theory, D^m is the powers of matrix D, e.g. $D2, D3, ..., D^{\infty}$ guarantees the convergent solutions to the matrix inversion as shown below.

$$log_{m \to \infty} D^m = [0]_{nxn} \tag{5}$$

Step 3: *Derive the total relation matrix T*

The total-influence matrix T is obtained by utilizing Eq. (7), in which, I is an $n\ x\ n$ identity matrix. The element of t_{ij} represents the indirect effects that factor i had on factor j, then the matrix T reflects the total relationship between each pair of system factors.

$$T = lim_{m \to \infty}(D + D^2 + D^3 + \cdots + D^m) \tag{6}$$

$$= \sum_{m=1}^{\infty} D^i$$

Where

$$\begin{aligned} \sum_{m=1}^{\infty} D^i &= D^1 + D^2 + D^3 + \cdots + D^m \\ &= D\,(I + D^1 + D^2 + D^3 + \cdots + D^{m-1}) \\ &= D\,(I - D)^{-1}(I - D)(I + D^1 + D^2 + \ldots + D^{m-1}) \\ &= D\,(I - D)^{-1}(I - D^m) \end{aligned}$$

$$T = D\,(I\text{-}D)^{-1} \tag{7}$$

Step 4: *Calculate the sums of rows and columns of matrix T*

In the total-influence matrix T, the sum of rows and the sum of columns are represented by vectors r and c, respectively or d and r respectively.

$$r = [r_i]_{nx1} = \left(\sum_{j=1}^{n} t_{ij}\right)nx1 \tag{8}$$

$$c = \left[c_j\right]'_{nx1} = \left[\sum_{j=1}^{n} t_{ij}\right] \tag{9}$$

where $\left[c_j\right]'$ is denoted as transposition matrix.

Let r_i be the sum of i^{th} row in matrix T. The value of r_i indicates the total given both directly and indirectly effects, that factor i has on the other factors.

Let r_j be the sum of the j^{th} column in matrix T. The value of c_j shows the total received both directly and indirectly effects, that all other factors have on factor j. If $j = i$, the value of $(r_i + c_i)$ represents the total effects both given and received by factor i. In contrast, the value of (r_i-c_i) shows the net contribution by factor i on the system. Moreover, when (r_i –c_i) was positive, factor i was a net cause. When (r_i –c_i) was negative, factor i was a net receiver [28]. The values r_i and c_i are in some papers presentet as d_i and r_i. Both marking systems are correct.

Step 5: *Set a threshold value (α)*

The threshold value *(α),* was computed by the average of the elements in matrix *T*, as computed by Eq. (10). This calculation aimed to eliminate some minor effects elements in matrix *T*.

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} t_{ij}}{N} \tag{10}$$

where N is the total number of elements in the matrix *T*.

Step 6: *Build a cause and effect relationship diagram*

The cause and effect diagram is constructed by mapping all coordinate sets of (r_i +c_i, r_i –c_i) to visualize the complex interrelationship and provide information to judge which are the most important factors and how influence affected factors.

4.3 Research methodology

This section builds a structure for determining priorities of contractor's service quality from strategic point of view based on various influential factors mentioned previously. The procedure of the proposed method is explained as it is showed on the Figure 4.2.

Stage1: Define the problem

At the beginning we identify the people who have the knowledge about organizational processes so that we can properly plan the project and avoid wasting effort in gathering the required knowledge. For each particular topic, it was very useful to understand which expert can determine the relations among the influential factors of contractor's service quality. Also, it was necessary to form a committee comprising of selected experts from all departments, for determining the relations among balanced scorecard from strategic supply chain dimension. The members of committee, their professional profile and responsibilities during the project are presented in figure 4.3.

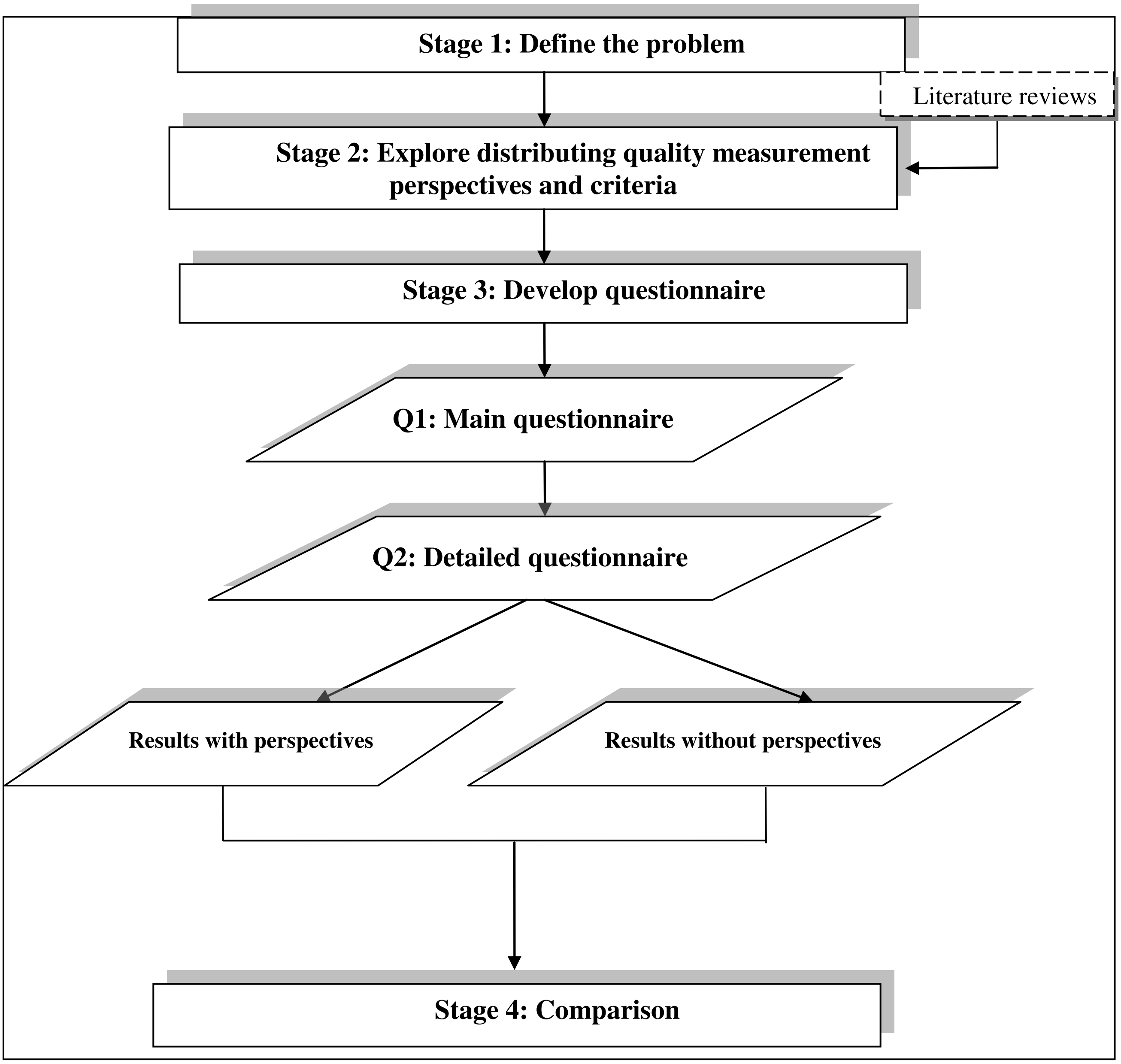

Figure 4.2 Procedure of DEMATEL implying for criteria assessment

Stage 2: Explore distributing quality measurement perspectives and criteria

In stage 2 we defined the quality features of distribution service, based on literature review and experience of Hedef Gida's management. This stage helped us in making our new questionnaires for researching the criteria's influence and importance.

Stage 3: Develop questionnaire

Exploring the quality measurement perspectives and criteria was a long process that required many documents and reports of Hedef Gida combined with the literature review results. To identify all possible multi-attributions and multi-dimensionalities of contractor quality we made the questionnaire 1. Based on the reviews and questionnaire 1, as shown on Table 4.1, four perspectives and ten evaluation criteria were derived. In defining the perspectives and criteria were used examples from the literature review as well as members of the committee and 32 employees more. Totally, 37 employees have been requested from what answers of two people were eliminated cause of invalidity.

Questionnaire 1

The Questionnaire 1. has been completed as first step of stage 3. Including all available employees we provided a list of all important factors that should be considered in choosing the contractor. Questionnaire contents the questions regarding employees' working experience, position in the company, employment status and service quality criteria. In first part of Questionnaire 1, respondents were offered to give their opinion about importance and influence of criteria we collected from literature review. In second part of questionnaire they were asked to suggest their own factors that should be considered in choosing the contractor.

After collecting the answers we created the final list of 4 perspectives and 10 criteria which should be included in next stages of research. The example of Questionnaire 1 is showed in Appendix B.

Questionnaire 2

After obtaining the list of criteria and perspectives for contractor selection evaluation, Questionnaire 2 was designed. A group of qualified experts reviewed and tested the designed questionnaire to assure the content validity of questionnaire. The group of qualified experts was consisted of one customer service manager, general manager of logistic and his assistant, one financial and sales manager and director of warehouse in Istanbul (European side). They had between 1 and 17 years working experiences in management positions in Hedef Gida company as well as in other firms. Experts were asked to give their opinion which perspective and criteria are influencing other ones and what is the level of each influence. After fulfilling the questionnaire, we were able to imply DEMATEL. The example of questionnaire 2 is presented in Appendix C.

Table 4.1 Perspectives and criteria for choosing the contractor

Perspectives		**Criteria**
1.	Financial criteria (P1)	*Service price (C1)*
2.	Technical capability (P2)	*Number of vehicle (C2)*
		Type of vehicle (C3)
		Human resource capability (C4)
3.	Service time (P3)	*Ordering time (C5)*
		Delivering time (C6)
		Unloading time (C7)
4.	Reliability (P4)	*Product's safety (C8)*
		Delivery on time (C9)
		Availability (C10)

Stage 4: Analyzing

Based on the four perspectives and ten criteria of contractor selection's evaluation as described above, this study implied the DEMATEL method to indicate the relationship between the factors and identify the significant contractor selection's evaluation perspectives and criteria. In this stage, the computation was divided in two parts where first one provided the influence of criteria with the perspectives and criteria without perspectives.

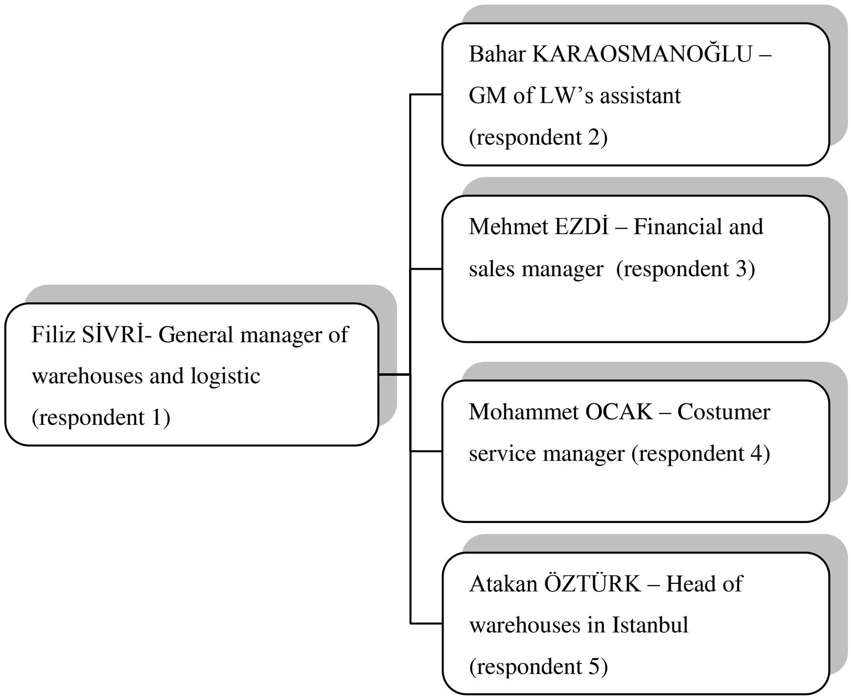

Figure 4.3 Members of the committee

4.4 The application of DEMATEL

In next part we will be able to see the results of DEMATEL method where criteria are sorted under the perspectives and without perspectives.

4.4.1 DEMATEL method with perspectives

On perspectives

X^k showed the data gathered in terms of the four perspectives of expert *k,* where X^k = $[x_{ij}^k]$. Steps of the procedures of applying DEMATEL method are shown below.

$$X^1 = \begin{bmatrix} 0 & 3 & 2 & 3 \\ 4 & 0 & 4 & 4 \\ 2 & 0 & 0 & 3 \\ 3 & 0 & 1 & 0 \end{bmatrix} \qquad X^2 = \begin{bmatrix} 0 & 4 & 1 & 2 \\ 3 & 0 & 4 & 4 \\ 3 & 0 & 0 & 1 \\ 3 & 1 & 3 & 0 \end{bmatrix} \qquad X^5 = \begin{bmatrix} 0 & 2 & 1 & 2 \\ 4 & 0 & 3 & 3 \\ 4 & 0 & 0 & 3 \\ 4 & 0 & 3 & 0 \end{bmatrix}$$

$$X^3 = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 4 & 0 & 3 & 3 \\ 1 & 0 & 0 & 4 \\ 4 & 0 & 4 & 0 \end{bmatrix} \qquad X^4 = \begin{bmatrix} 0 & 3 & 1 & 3 \\ 4 & 0 & 3 & 4 \\ 3 & 0 & 0 & 3 \\ 4 & 0 & 2 & 0 \end{bmatrix}$$

(1) The computation of the average matrix *Z* was constructed by using Eq. (1).

$$Z = \begin{bmatrix} 0 & 0.2 & 2.6 & 2.2 \\ 3.8 & 0 & 3.4 & 3.6 \\ 2.6 & 0 & 0 & 2.8 \\ 3.6 & 0.2 & 2.6 & 0 \end{bmatrix}$$

(2) The normalized initial direct-relation matrix *D* was calculated by using Eq. (2) to Eq.(5).

$$D = \begin{bmatrix} 0 & 0.0185 & 0.2405 & 0.2035 \\ 0.3515 & 0 & 0.3145 & 0.333 \\ 0.2405 & 0 & 0 & 0.259 \\ 0.333 & 0.0185 & 0.2405 & 0 \end{bmatrix}$$

(3) The total relation matrix *T* was calculated by using Eq. (6) to Eq. (7) as shown below.

$$T=\begin{bmatrix} 0,22396463 & 0.02930108 & 0.39012923 & 0.35987753 \\ 0.74028924 & 0.0259663 & 0.66022836 & 0.66329479 \\ 0.43027551 & 0.01545249 & 0.20574211 & 0.40499395 \\ 0.52475683 & 0.03245396 & 0.43210824 & 0.22951122 \end{bmatrix}$$

Table 4.2 The sum of given and received influence among perspectives

T	P1	P2	P3	P4	D	D+R	D-R
P1	0.22396463	0.02930108	0.39012923	*0.35987753	1.00327247	2.92257247	-0.9160275
P2	*0.74028924	0.0259663	*0.66022836	*0.66329479	2.08977869	2.19297869	1.98657869
P3	0.43027551	0.01545249	0.20574211	0.40499395	1.05646406	2.74466406	-0.6317359
P4	0.52475683	0.03245396	0.43210824	0.22951122	1.21883024	2.87653024	-0.4388698
R	1.91928621	0.10317383	1.68820794	1.65767749			

Under each perspective, the significant criteria were determined by using the same procedures as described in steeps (1) to (6) above. The results and visualization of it is presented in following paragraph.

On criteria

The sum of given and received influence is determinate for each criterion under the perspectives P2, P3 and P4. Since perspective P1 contains only one criterion we couldn't imply DEMATEL. The results are presented in tables 4.3 to 4.5.

Table 4.3 The sum of given and received influence under P2

P2	C2	C3	C4	D	D+R	D-R
C2	0.49977728	1.49947114	1.49948445	3.49873288	4.98337526	2.0140905
C3	0.38151185	0.7127067	1.00263584	2.09685439	5.62220344	-1.4284947
C4	0.60335325	1.31317121	0.93450817	2.85103264	6.28766111	2.85103264
R	1.48464238	3.52534906	3.43662847			

Table 4.4 The sum of given and received influence under P3

P3	C5	C6	C7	D	D+R	D-R
C5	0.07766791	0.50860528	0.7691621	1.3554353	1.59985915	1.11101145
C6	0.10213806	0.0714146	0.20636027	0.37991292	1.1683778	-0.4085519
C7	0.06461788	0.208445	0.06933016	0.34239303	1.38724556	-0.7024595
R	0.24442385	0.78846487	1.04485253			

Table 4.5 The sum of given and received influence under P4

P4	C8	C9	C10	D	D+R	D-R
C8	0.30343167	0.86995786	0.62612884	1.79951836	3.20168573	0.39735099
C9	0.63816978	0.86935581	0.99939795	2.50692354	5.47742324	-0.4635762
C10	0.46056592	1.23118603	0.66465984	2.3564118	4.64659843	0.06622517
R	1.40216737	2.9704997	2.29018663			

4.4.2 DEMATEL method without perspectives

The results of implied method on criteria without perspectives could be significantly different from the results where DEMATEL is implied on criteria together with the perspectives. For this reason we decided to do implementation also on criteria without perspectives and compare the results.

Committee members estimated the importance and the influence of criteria and fulfill the questionnaire 2. The results are presented in matrix X^1 to X^5.

$$X^1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 2 & 0 & 0 & 1 & 2 \\ 3 & 0 & 0 & 0 & 2 & 3 & 0 & 2 & 4 & 4 \\ 4 & 0 & 0 & 0 & 2 & 3 & 1 & 4 & 3 & 4 \\ 2 & 0 & 0 & 0 & 0 & 3 & 3 & 0 & 3 & 3 \\ 3 & 0 & 0 & 0 & 0 & 3 & 0 & 0 & 1 & 1 \\ 3 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 3 & 2 \\ 0 & 0 & 0 & 0 & 0 & 4 & 0 & 0 & 4 & 1 \\ 2 & 0 & 3 & 0 & 0 & 2 & 1 & 0 & 0 & 0 \\ 3 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 3 \\ 3 & 0 & 0 & 0 & 2 & 3 & 0 & 0 & 3 & 0 \end{bmatrix} \quad X^2 = \begin{bmatrix} 0 & 2 & 2 & 1 & 1 & 0 & 0 & 2 & 0 & 3 \\ 0 & 0 & 2 & 1 & 1 & 0 & 0 & 2 & 0 & 3 \\ 4 & 0 & 0 & 0 & 2 & 3 & 0 & 0 & 4 & 4 \\ 2 & 1 & 1 & 0 & 0 & 3 & 3 & 3 & 4 & 4 \\ 3 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 3 \\ 3 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 4 & 4 \\ 0 & 0 & 0 & 0 & 0 & 3 & 0 & 3 & 4 & 3 \\ 2 & 1 & 1 & 0 & 1 & 2 & 2 & 0 & 1 & 0 \\ 3 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 3 \\ 3 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 3 & 0 \end{bmatrix}$$

$$X^3 = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 3 \\ 4 & 0 & 3 & 3 & 3 & 1 & 0 & 0 & 4 & 4 \\ 4 & 0 & 0 & 0 & 3 & 1 & 1 & 4 & 4 & 4 \\ 3 & 1 & 2 & 0 & 3 & 3 & 3 & 3 & 4 & 4 \\ 2 & 2 & 2 & 0 & 0 & 0 & 0 & 0 & 2 & 0 \\ 4 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 4 & 4 \\ 1 & 0 & 0 & 0 & 0 & 3 & 0 & 4 & 3 & 3 \\ 3 & 0 & 0 & 0 & 2 & 3 & 3 & 0 & 3 & 1 \\ 4 & 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 2 \\ 3 & 0 & 0 & 0 & 3 & 3 & 0 & 0 & 4 & 0 \end{bmatrix} \quad X^4 = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 1 & 0 & 3 & 2 & 3 \\ 4 & 0 & 1 & 3 & 2 & 2 & 0 & 2 & 4 & 4 \\ 4 & 1 & 0 & 3 & 3 & 3 & 2 & 4 & 4 & 3 \\ 2 & 1 & 3 & 0 & 2 & 2 & 4 & 3 & 4 & 3 \\ 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 3 \\ 3 & 0 & 0 & 0 & 2 & 0 & 0 & 2 & 3 & 3 \\ 1 & 0 & 0 & 1 & 1 & 3 & 0 & 3 & 3 & 2 \\ 4 & 2 & 4 & 4 & 1 & 2 & 2 & 0 & 3 & 1 \\ 4 & 2 & 2 & 1 & 0 & 0 & 0 & 2 & 0 & 2 \\ 3 & 3 & 2 & 2 & 2 & 0 & 0 & 1 & 3 & 0 \end{bmatrix}$$

$$
X^5 = \begin{bmatrix}
0 & 1 & 1 & 2 & 0 & 1 & 1 & 0 & 0 & 3 \\
4 & 0 & 1 & 1 & 2 & 3 & 0 & 0 & 2 & 4 \\
4 & 0 & 0 & 2 & 3 & 4 & 2 & 3 & 4 & 4 \\
3 & 1 & 2 & 0 & 2 & 4 & 4 & 3 & 4 & 4 \\
2 & 0 & 0 & 1 & 0 & 0 & 0 & 2 & 4 & 4 \\
4 & 2 & 2 & 1 & 2 & 0 & 0 & 2 & 3 & 2 \\
1 & 0 & 0 & 0 & 0 & 2 & 0 & 2 & 2 & 1 \\
4 & 0 & 3 & 3 & 0 & 2 & 2 & 0 & 3 & 1 \\
4 & 2 & 2 & 1 & 0 & 0 & 0 & 2 & 0 & 2 \\
3 & 3 & 2 & 2 & 2 & 0 & 0 & 1 & 3 & 0
\end{bmatrix}
$$

In following work, computation of the average matrix *Z* and normalized matrix *D* is showed, constructed by using Eq. (1) and Eq. (2).

$$
Z = \begin{bmatrix}
0 & 0.6 & 0.6 & 1 & 0 & 0.8 & 0.2 & 1.2 & 0.6 & 2.8 \\
3 & 0 & 1.4 & 1.6 & 1.8 & 1.8 & 0 & 1.2 & 2.8 & 3.8 \\
4 & 0.2 & 0 & 1.4 & 2.8 & 2.8 & 1.2 & 3 & 3.4 & 3.6 \\
2.4 & 0.8 & 1.6 & 0 & 1.6 & 3 & 3.4 & 2.4 & 3.6 & 3.6 \\
2.4 & 0.4 & 0.4 & 0.4 & 0 & 0.6 & 0 & 0.4 & 1.8 & 2.2 \\
3.4 & 0.4 & 0.4 & 0.2 & 0.8 & 0 & 0 & 2 & 3.4 & 3 \\
0.8 & 0 & 0 & 0.2 & 0.2 & 3 & 0 & 2.4 & 3.2 & 2 \\
3.2 & 0.6 & 2.2 & 1.6 & 0.6 & 2.4 & 1.8 & 0 & 1.8 & 0.8 \\
3.8 & 1 & 1 & 0.8 & 0.2 & 0 & 0.2 & 1.6 & 0 & 2.4 \\
3 & 1.2 & 0.6 & 0.8 & 2.6 & 2 & 0.4 & 0.2 & 3.2 & 0
\end{bmatrix}
$$

$$
D = \begin{bmatrix}
0 & 0.023077 & 0.023077 & 0.038462 & 0 & 0.03077 & 0.007692 & 0.046154 & 0.023077 & 0.107694 \\
0.115386 & 0 & 0.053847 & 0.061539 & 0.069232 & 0.069232 & 0 & 0.046154 & 0.107694 & 0.146156 \\
0.153848 & 0.0076924 & 0 & 0.053847 & 0.107694 & 0.107694 & 0.046154 & 0.115386 & 0.130771 & 0.138463 \\
0.0923088 & 0.038462 & 0.061539 & 0 & 0.061539 & 0.115386 & 0.130771 & 0.092309 & 0.138463 & 0.138463 \\
0.0923088 & 0.0153848 & 0.0153848 & 0.0153848 & 0 & 0.023077 & 0.130771 & 0.0153848 & 0.069232 & 0.084616 \\
0.1307708 & 0.0153848 & 0.0153848 & 0.007692 & 0.03077 & 0 & 0 & 0.0076924 & 0.130771 & 0.115386 \\
0.03077 & 0 & 0 & 0.007692 & 0.007692 & 0.115386 & 0 & 0.092309 & 0.123078 & 0.076924 \\
0.1230784 & 0.0230772 & 0.084616 & 0.061539 & 0.023077 & 0.092309 & 0.069232 & 0 & 0.069232 & 0.03077 \\
0.1461556 & 0.038462 & 0.038462 & 0.03077 & 0.007692 & 0 & 0.007692 & 0.061539 & 0 & 0.092309 \\
0.115386 & 0.0461544 & 0.023077 & 0.03077 & 0.100001 & 0.076924 & 0.015385 & 0.007692 & 0.123078 & 0
\end{bmatrix}
$$

By using Eq. (6) to Eq. (7) as shown below, the total relation matrix *T* was calculated.

$$
T = \begin{bmatrix}
0.0690011 & 0.0410133 & 0.041665 & 0.041665 & 0.031480 & 0.069949 & 0.026205 & 0.076042 & 0.081957 & 0.157735 \\
0.2470898 & 0.0368470 & 0.088876 & 0.102443 & 0.121921 & 0.137167 & 0.032557 & 0.109463 & 0.212678 & 0.256290 \\
0.3115905 & 0.0515308 & 0.047650 & 0.104167 & 0.162884 & 0.189903 & 0.083696 & 0.190025 & 0.257247 & 0.272298 \\
0.2421230 & 0.0769325 & 0.044622 & 0.047236 & 0.113834 & 0.194802 & 0.158403 & 0.165998 & 0.261305 & 0.262024 \\
0.1531823 & 0.0337022 & 0.033468 & 0.036683 & 0.025679 & 0.054893 & 0.013672 & 0.045368 & 0.116551 & 0.137465 \\
0.2264851 & 0.0437540 & 0.046986 & 0.042637 & 0.066852 & 0.050015 & 0.022263 & 0.119408 & 0.198779 & 0.193745 \\
0.1272811 & 0.0247647 & 0.029272 & 0.036245 & 0.039037 & 0.155235 & 0.020036 & 0.133295 & 0.190412 & 0.147757 \\
0.2336777 & 0.0509680 & 0.111638 & 0.096328 & 0.067048 & 0.156035 & 0.096957 & 0.068261 & 0.167090 & 0.140840 \\
0.2213907 & 0.0603706 & 0.063191 & 0.061023 & 0.043438 & 0.051178 & 0.030285 & 0.100362 & 0.068826 & 0.163526 \\
0.2131374 & 0.0710831 & 0.050507 & 0.061939 & 0.130695 & 0.120927 & 0.034578 & 0.059662 & 0.19596 & 0.096509
\end{bmatrix}
$$

The sums of rows and columns of Matrix *T* were calculated by using Eq. (8) to Eq. (9) and the result is presented in Table 4.6.

As it is mentioned in Eq. (10), threshold value *(α)* can be applied on perspectives and criteria by using T matrix. In further work we used average values of elements in matrixes *T* and we got the values showed on pictures below.

Table 4. 6 The sum of given and received influence among criteri

Matrix T	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10
c1	0.0690011	0.0410133	0.041665	0.059162	0.03148	0.069949	0.026205	0.076042	0.081957	*0.157735
c2	*0.2470898	0.036847	0.088876	0.102443	*0.121921	*0.137167	0.032557	*0.109463	*0.212678	*0.25629
c3	*0.3115905	0.0515308	0.04765	0.104167	*0.162884	*0.189903	0.083696	*0.190025	*0.257247	*0.272298
c4	*0.242123	0.0769325	0.044622	0.047236	*0.113834	*0.194802	*0.158403	*0.165998	*0.261305	*0.262024
c5	*0.1531823	0.0337022	0.033468	0.036683	0.025679	0.054893	0.013672	0.045368	*0.116551	*0.137465
c6	*0.2264851	0.043754	0.046986	0.042637	0.066852	0.050015	0.022263	*0.119408	*0.198779	*0.193745
c7	*0.1272811	0.0247647	0.029272	0.036245	0.039037	*0.155235	0.020036	*0.133295	*0.190412	*0.147757
c8	*0.2336777	0.050968	*0.111638	0.096328	0.067048	*0.156035	0.096957	0.068261	*0.16709	*0.14084
c9	*0.2213907	0.0603706	0.063191	0.061023	0.043438	0.051178	0.030285	0.100362	0.068826	*0.163526
c10	*0.2131374	0.0710831	0.050507	0.061939	*0.130695	*0.120927	0.034578	0.059662	*0.19596	0.096509
D	2.044959	0.490966	0.55788	0.64786	0.80287	1.1801	0.51865	1.06788	1.7508	1.82819

CHAPTER 5

RESULTS AND DISCUSSION

This study integrates 35 questionnaires from employees to collect the crucial criteria for contractor selection and 5 questionnaires of company's management, with the aim to evaluation the significances of perspectives and criteria. The purpose of this study is funding the crucial criteria that will be used in process of selecting the contractor of food distribution company. Major risks that we avoided by using DEMATEL method are:

1. Using wrong criteria in alternative evaluation
2. Putting the criteria wrong importance according to main goal.

After implementing DEMATEL method and selecting the contractor, the fragility of supply chain and delay in delivery will be decreased and/or eliminated. The important of evaluation perspectives was determined by (*D*+*R*) values while (*D*-*R*) values are dividing criteria into

(i) cause group and

(ii) (ii) effect group.

5.1 Results

Based on Table 4.2, *Financial Criteria (P1)* and *Reliability (P4)* were the most important perspectives with the largest (*D*+*R*) value 2.922572 and 2.8765304 respectively. *Technical Capability* (*P2*) was the least important perspective with the smallest (*D*+*R*) value 2.192979. Regarding to (*D*+*R*) values, the prioritization of the importance of four evaluation perspective is *P1>P4>P3>P2*.

Based on (*D*-*R*) values, the four perspectives were divided into cause group and effect group. If the value of (*D*-*R*) was positive or net cause, such perspective was classified in the cause group, and directly affected the others. In this study, only *Technical Capability (P2),* was classified in the cause group, having the *(D-R)* values of 1.986579. It indicates that *P2* is the only perspective in cause group. *Financial Criteria (P1), Service Time (P3)* and *Reliability (P4)* have negative values of (*D-R*), -0.916027, -0.631736, -0.438870 respectively, what means that they receive the influence more than dispatch. Visual presentation of influence among perspectives is shown on picture 5.1.

Similarly to the perspectives, we are able to present and analyze the result of criteria under each one of the perspectives. Figure 5.2. to 5.4. are indicating the visual influence of criteria under three perspectives, P2, P3, P4.

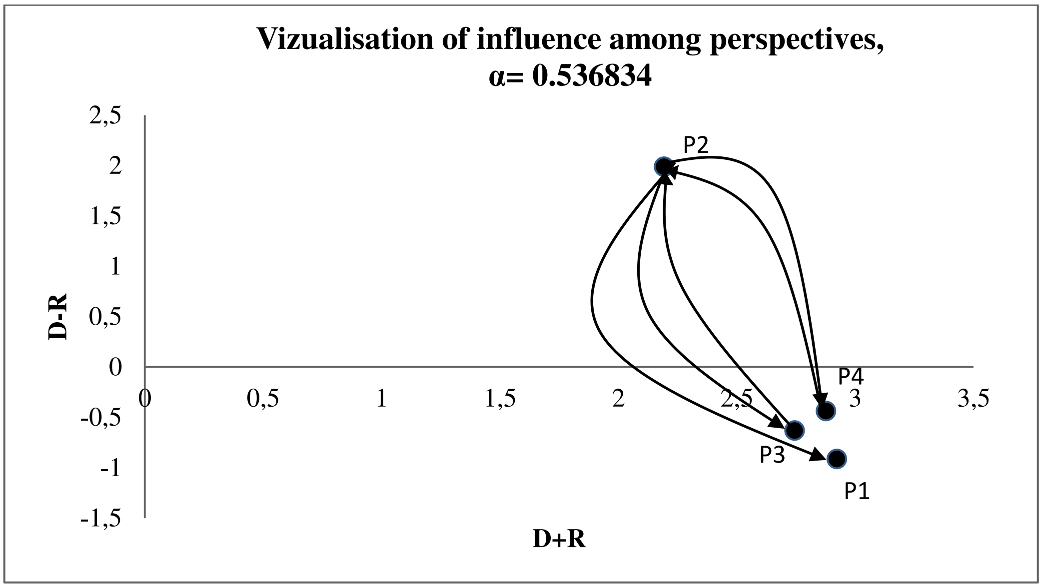

Figure 5.1 Causal relations among perspectives

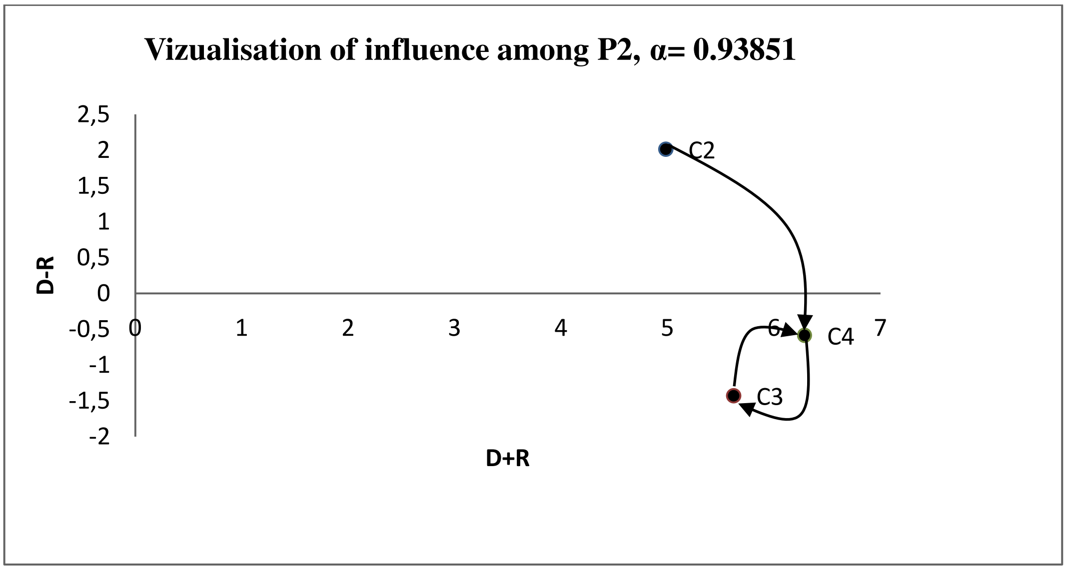

Figure 5.2 Causal relation among criteria of perspective 2

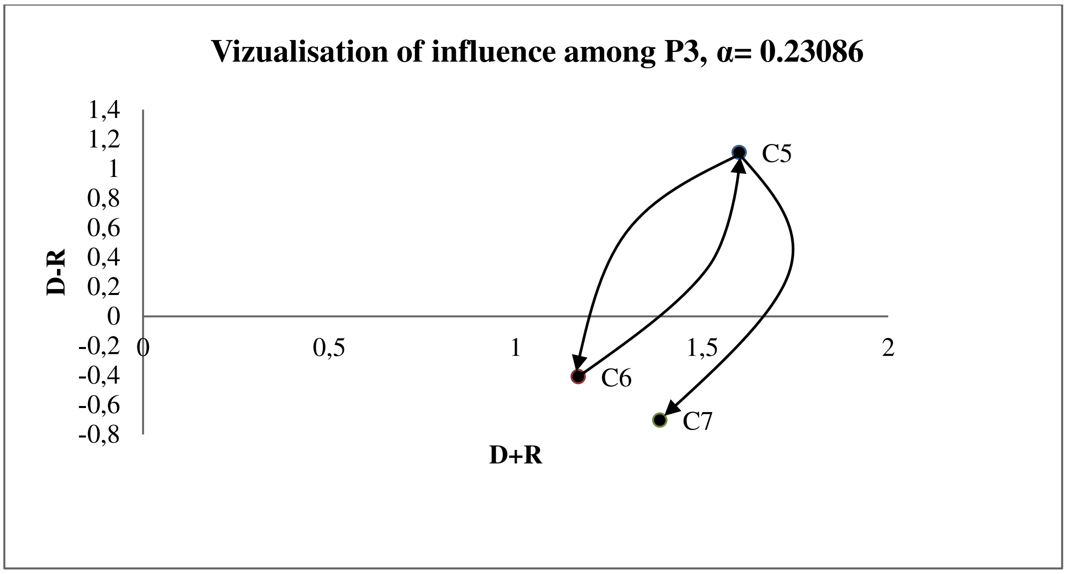

Figure 5.3 Causal Relation among criteria of perspective 3

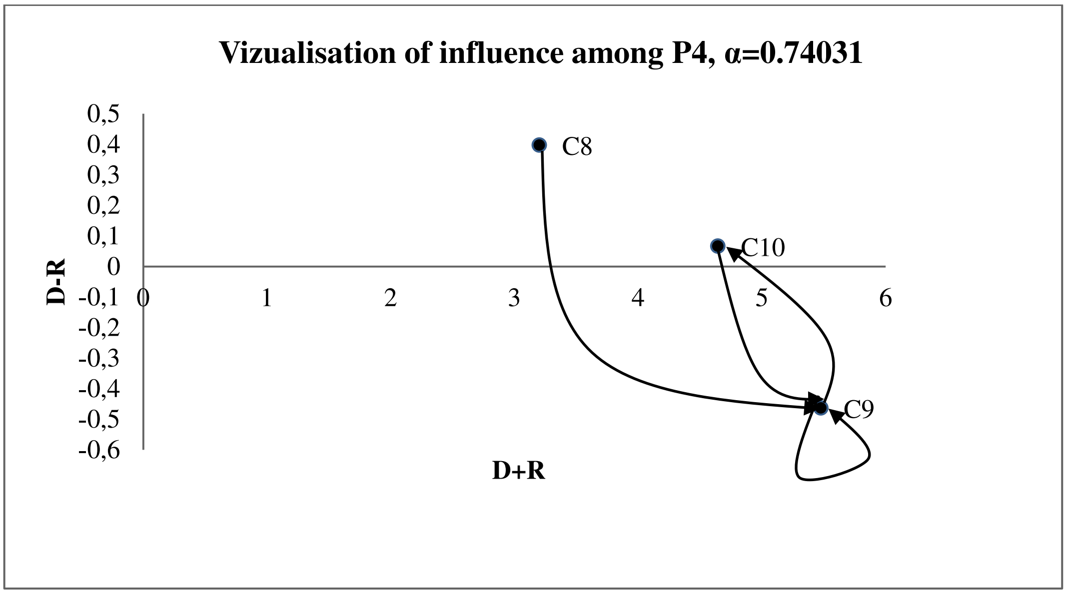

Figure 5.4 Causal relation among criteria of perspective 4

Under perspective Technical Criteria *(P2),* that has the strongest influence to the other perspectives, criteria are affecting each other in following way. Number of Vehicle *(C2)* is affecting Type of vehicle *(C3)* and Human resource capability *(C4).* The value of (D-R) is positive 2.0140905, what means that this criterion dispatches influence more then it accepts. Criteria Type of Vehicle (*C3)* and Human resource capability *(C4)* are affecting each other. Under this perspective according to (D+R) value, the strength of (received) influence is for *C4* and *C3,* 6.287661, 5.622203 respectively while for *C2* strength of (dispatched) influence is 4.983375.

Under perspective *P3*, Ordering Time *(C5)* is directly affecting criterion Delivering time *(C6)* and Uploading time *(C7),* while *C6 and C7* are not affecting any of other criteria. Criterion *C5* also have the greatest (D+R) value 1.5998591 what makes it the most important factor in perspective *P3.* The biggest strength of (received) influence is on *C7*, according to the value of (D+R) that is 1.38724556 and (D-R) value -0.7024595.

For the perspective of Reliability *(P4),* criteria Product Safety *(C8)* and Availability *(C10)* has positive value (D-R), 0.39735099, 0.06622517 respectively. They are influencing criteria *C9,* Delivery on time, while C9 is influencing C10. Under this perspective Delivery on time *(C9)* is the most important criteria according to the value of (D+R) that is 5.47742324.

Figure 5.5 is showing the influence of criteria that are not sorted under the perspectives. We implied DEMATEL in this way to see if there is any difference in relation between criteria and if there is how it affects the main goal.

The same method implied on criteria without perspectives, brings us the following results.

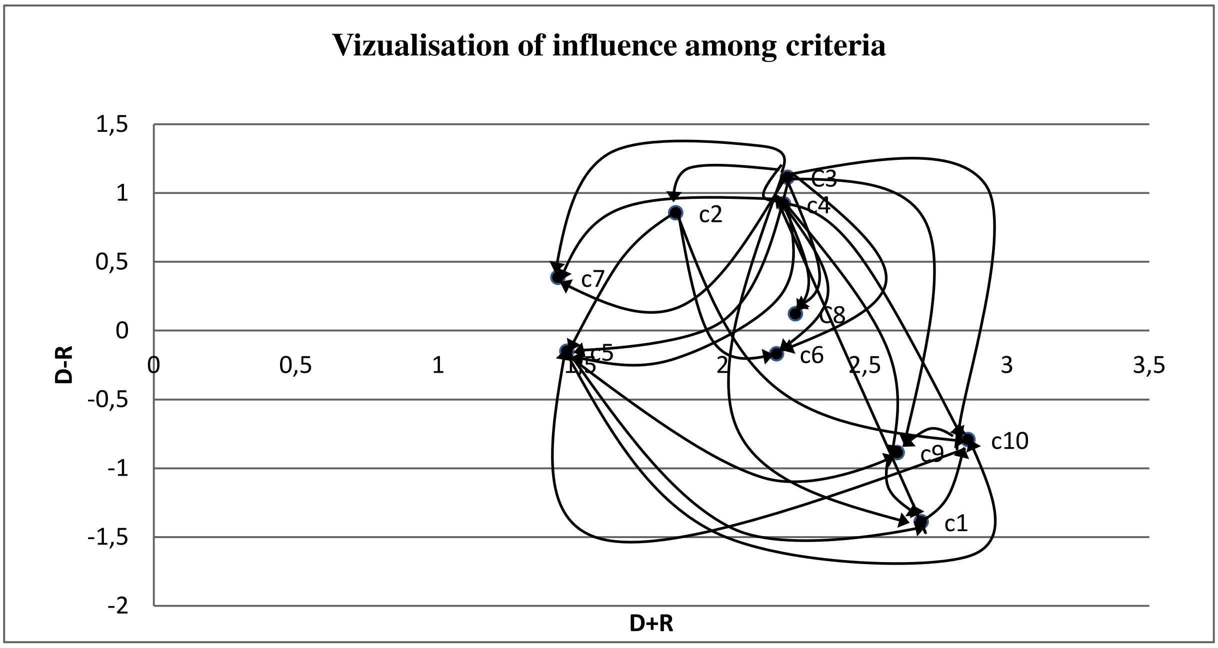

Figure 5.5 The visualization of the causal relation among criteria

According to the result of study we found that Type of vehicle *(C3)* Human resource capability *(C_4),* Number of vehicle *(C_2),* Unloading time *(C_7)* and Product's safety *(C_8)* were in the cause group based on their positive (D-R) values, 1.113112, 0.919419, 0.854365, 0.384685, 0.120964 respectively. It is the group from which the influence is dispatched to other 5 criteria. For ranking the criteria, with the biggest strength of influence, we need to consider the values of (D+R), which are shoving the following order; *C10>C1>C9>C8>C3>C4>C6>C2>C5.* For Service price *(C1),* Ordering time *(C5),* Delivering time *(C6),* Delivery on time *(C9),* Availability *(C10),* that are in the effect group, we found negative (*D-R*) values of -1.39075, -0.1522, -0.16918, -0.88721, -0.79319 respectively what means they are influenced by criteria from cause group. We can see that criteria *C10* and *C1* are the most important criteria even they are from group of effected criteria. Availability and Price, with (D+R) value 2.863188 and 2.699168 respectively have the greatest strength of (received) influence.

5.2 Conclusion

This study uses the DEMATEL method to analyze and forecast food distribution contractors. The DEMATEL method was implied in two ways, what resulted two different solution. With this results management of Hedef Gida company will be able to choose the crucial factors and forecast the most suitable contractors.

Since supply chain fragility and delivery delay are identified as biggest risks in Hedef Gida company, finding a contractor for distribution service was the most suitable solution. In Chapter 3 the risk was identify and analyzed, while in Chapter 4 we applied DEMATEL on criteria with and without perspectives. In Chapter 5 we made a comparison of the results what brought us to the followed conclusion.

Implying the method on criteria and perspectives is offering the clear result of how perspectives are affecting each others, and criteria under each perspective, but without possibilities to compare the influence of criteria from different perspectives. After analyzing the perspectives, criteria under the perspective with the greatest value of (D+R) and (D-R) are the most important criteria.

Implying DEMATEL directly to criteria is bringing very different result, where all criteria are analyzed comparing with an others. This result implies not only the importance of criteria but also cause and affect relation between all of them.

After the study, and analyzing results in both ways with and without perspectives, we can conclude that for choosing the right criteria, for any selection process, perspectives are not recommended. Analyzing the criteria together with perspectives is bringing the risk of missing the important criteria for ranking the alternatives. In selecting the group of right criteria DEMATEL should be implied directly to the criteria. The cases where criteria are recommended to be in use together with the perspectives, are the ones where DM should decide how to rank and weigh the criteria that are already chosen.

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APPENDIX - A

ORDER-DELIVER ANALYZE

Toplu Yükleme Emri	
Sevk No.	748
Sipariş Sayısı	9
Satır Sayısı	70
SKU Sayısı	42
Sevk Nokta sayısı	8
Otomatik Hesaplamaya Göre Palet Sayısı	2.18
Oluşturulan Palet Sayısı	4
Araç Sayısı (Minibüs)	1

	Yol (m)	Süre (dk)
1.paletin alınması	0.00	13:10
1.paletin oluşturulması	17.10	0:16
1.paletin yüklemeye bırakılması	5.50	13:26
2.paletin alınması ve devam	20.50	13:28
2.paletin oluşturulması	15.00	0:15
2.paletin yüklemeye bırakılması	15.50	13:43
3.paletin alınması ve devam	33.00	13:45
3.paletin oluşturulması	20.50	0:11
3.paletin yüklemeye bırakılması	23.00	13:56
4.paletin alınması ve devam	40.50	13:59
4.paletin oluşturulması	17.50	0:12
4.paletin yüklemeye bırakılması	6.00	14:11
4 paletin hazırlanması-toplam	214.10	##########

Sipariş Bazlı Toplama	
Sevk No.	728,729, … ,743,744
Sipariş Sayısı	19
Satır Sayısı	206
SKU Sayısı	62
Sevk Nokta sayısı	14
Otomatik Hesaplamaya Göre Palet Sayısı	2.47
Oluşturulan Palet Sayısı	4
Araç Sayısı (Minibüs)	1

	Yol (m)	Süre (dk)
1.paletin alınması	0.00	9:07:50
1.paletin oluşturulması	342.50	0:26:12
1.paletin yüklemeye bırakılması	0.00	9:34:02
2.paletin alınması ve devam	20.00	9:36:38
2.paletin oluşturulması	248.00	0:21:25
2.paletin yüklemeye bırakılması	0.00	9:58:03
3.paletin alınması ve devam	20.00	10:32:01
3.paletin oluşturulması	201.00	0:56:24
3.paletin yüklemeye bırakılması	0.00	11:28:25
4.paletin alınması ve devam	20.00	11:29:35
4.paletin oluşturulması	292.50	0:29:11
4.paletin yüklemeye bırakılması	0.00	11:58:46
4 paletin hazırlanması-toplam	1144.00	2:13:12 AM

Sipariş Detayı	748 Nolu Sevkiyat.xls	**Sipariş Detayı**	pariş Bazlı lama.xlsx

Toplu Yükleme Emri	Sipariş Bazlı Toplama
1. Ürün bazlı toplama yapılmaktadır. Ağırlık,ürüne hasar vermeme durumuna göre yerleşim düzeni imkanı sağlamaktadır.	**1.** Depo elemanı siparişin içeriğini göremediği için palet yerleşimini ön görememektedir.Toplama sonrasında düzenlemeye ihtiyaç duymakta ve zaman kaybetmektedir.
2. Sevkiyatta dağıtım sırasında zorluk yaratmaktadır.	**2.** Sevkiyatta dağıtım sırasında avantaj sağlamaktadır.
3. Ürün dizilimine göre lokasyonlar sıralanmakta ve terminalde toplama sırası oluşmaktadır. Kat edilen yol ve süreye yansımaktadır.	**3.** Bir lokasyona farklı siparişler için farklı zamanlarda birden fazla uğramak durumunda olduğu için depo içinde kat edilen yol ve süreye yansımaktadır.
4. Mevcut eleman ve çalışma etkinliği ile operasyon sürdürülebilmektedir.	**4.** Depo operasyonunun aksama riski söz konusudur.
5. Araç doluluğunu maksimize etmek için sipariş yoğunluğuna göre dökme ürün yerleşimi yapılabilir.	**5.** Siparişlerin karışmaması/kolay bulunabilmesi için ayrı konumlandırılmak durumundadır. Toplama sırasında yapılabilecek extra düzenleme ile araç doluluğu maksimize edilebilir.
	6. Ay ortası/sonu siparişlerde palet sayısının artması söz konusudur. Palet sayısının artması minibüs ihtiyacını doğurmaktadır. (1 minibüs 4 palet kapasitelidir.)

APPENDIX - B

QUESTIONNAIRE 1

Questionnaire 1

This questioner with the purpose of identifying the most important criteria before choosing the best contractor (for transportation service).

1. Are you officially employed in Hedef gida company? If yes, for how long you have been working?
   - No
   - Yes
     - Less than 1 year
     - 1-3 years
     - 3-5 years
     - 5-7 years
     - More than 7 years
2. What is the position/department you are working in?
   - Logistics, warehouse manager, stock planning
   - Accounting, finances
   - Business administration
   - Trading, marketing
   - Other (security, hygienist, programming…)
3. Have you ever used the service of any transportation company?
   - Yes
   - No

4. Have you ever worked in transportation company before?
    - Yes
    - No
5. For choosing the contractor of transportation service, in your opinion which one of the followed factor is the most important?
    - Service quality
    - Finances
    - Reputation and experience
    - Strong relations and trust
6. In your opinion what should be the most important criterion in choosing the contractor by Hedef gida company? Please give us a short explanation of specified criteria.
    ………………………………………………………………………………………
7. Why your suggested answer should be considered as the most important one?
    ………………………………………………………………………………………
8. Do you think some of following criteria should be also considered in choosing the contractor?
    - Flexibility
    - Reliability
    - Availability
    - Non of listed criteria
9. Do you think some of following criteria should be also considered in choosing the contractor?
    - Location of potential contractor
    - Organizational profile
    - Administrative barriers
    - Working experience and costumers
    - Non of listed criteria is important
10. Do you think some of following criteria should be also considered in choosing the contractor?
    - Technical capability
    - Delivery time
    - Delivering the product without any damages

- Non of offered criteria is important

11. Specify the criterion which in your opinion has very high influence to total service quality.
    - ……………………………….
12. Specify the criterion which in your opinion has very high influence to service price.
    - ………………………………..
13. Specify the criterion which in your opinion has very high influence to service' time.
    - ………………………………….
14. Do you think that total service quality is influenced by:
    - Price
        - No
        - Yes
    - Time
        - No
        - Yes
    - Technical capability
        - No
        - Yes
15. Do you think that service price is influenced by:
    - Total service quality
        - No
        - Yes
    - Service time
        - No
        - Yes
    - Technical capability
        - No
        - Yes
16. Do you think that service time is influenced by:
    - Total quality service
        - No
        - Yes
    - Price

- No
- Yes

- Technical capability
    - No
    - Yes

17. Do you think that technical capability is influenced by:

- Total service quality
    - No
    - Yes
- Prices
    - No
    - Yes
- Service time
    - No
    - Yes

18. Do you think that total service quality influencing:

- Service price
    - No
    - Yes
- Service time
    - No
    - Yes
- Technical capability
    - No
    - Yes

19. Do you think service price is influencing:

- Total service quality
    - No
    - Yes
- Service time
    - No
    - Yes
- Technical capability

- No
- Yes

20. Do you think service time is influencing:

- Total service quality
  - No
  - Yes
- Service price
  - No
  - Yes
- Technical capability
  - No
  - Yes

21. Do you think technical capability is influencing:

- Total service quality
  - No
  - Yes
- Service price
  - No
  - Yes
- Service time
  - No
  - Yes

APPENDIX - C

QUESTIONNAIRE 2

Questionnaire 2

Purpose of the Questioner 2 is estimating the level of influence of the criteria for choosing the contractor. The result was implied in DEMATEL method and the respondents are listed below;

- R1- general manager of logistic
- R2- general manager of logistics assistant
- R3- manager of warehouse in Istanbul
- R4 – costumer service manager
- R5 – sales manager

1. In your opinion do any of the following factors influence the **financial criteria**, if yes how strong the influence is;
    - Technical capability (low influence, medium influence, strong influence, very strong influence)
    - Service time (low influence, medium influence, strong influence, very strong influence)
    - Reliability (low influence, medium influence, strong influence, very strong influence)
    - None of the listed factors is influencing financial criteria
2. In your opinion do any of the following factors influence the **technical capability**, if yes how strong the influence is;
    - Financial criteria (low influence, medium influence, strong influence, very strong influence)

- Service time (low influence, medium influence, strong influence, very strong influence)
- Reliability (low influence, medium influence, strong influence, very strong influence)
- None of the listed factors is influencing financial criteria

3. In your opinion do any of the following factors influence **service time**, if yes how strong the influence is;
    - Financial criteria (low influence, medium influence, strong influence, very strong influence)
    - Technical capability (low influence, medium influence, strong influence, very strong influence)
    - Reliability (low influence, medium influence, strong influence, very strong influence)
    - None of the listed factors is influencing financial criteria

4. In your opinion do any of the following factors influence **reliability**, if yes how strong the influence is;
    - Financial criteria (low influence, medium influence, strong influence, very strong influence)
    - Service time (low influence, medium influence, strong influence, very strong influence)
    - Technical capability (low influence, medium influence, strong influence, very strong influence)
    - None of the listed factors is influencing financial criteria

5. Fulfill the following diagram about the criteria influenced by other factors;

Number of vehicles (C1)

Type of vehicles (C2)

Human resource capability (C3)

Influenced criteria	Influence level		
	C1	C2	C3
Service price			
Number of vehicles			
Type of vehicles			
Human resource capability			
Ordering time			
Delivering time			
Uploading time			
Product safety			
Delivery on time			
Availability			

6. Fulfill the following diagram about the criteria influenced by other factors;

Influencing criteria

Ordering time (C4)

Delivering time (C5)

Uploading time (C6)

Influenced criteria	Level of influence		
	C4	C5	C6
Service price			
Number of vehicles			
Type of vehicles			
Human resource capability			
Ordering time			
Delivering time			
Uploading time			
Product safety			
Delivery on time			
Availability			

7. Fulfill the following diagram about the criteria influenced by other factors;

Influencing criteria

- Product safety
- Delivering on time
- Availability

Influenced criteria	**Level of influence**		
	C7	**C8**	**C9**
Service price			
Number of vehicles			
Type of vehicles			
Human resource capability			
Ordering time			
Delivering time			
Uploading time			
Product safety			
Delivering on time			
Availability			

8. Fulfill the following diagram about the criteria influenced by other factors

Influencing criteria

- Service price

Influenced criteria	**Level of influence**		
	C10		
Service price			
Number of vehicles			
Type of vehicles			
Human resource capability			
Ordering time			
Delivering time			
Uploading time			
Product safety			
Delivery on time			
Availability			

CURRICULUM VITAE

PERSONAL INFORMATION

Name Surname : Snezana JOVIC

Date of birth and place : 04.03.1984

Foreign Languages : English, Turkish, German

E-mail : snekica_j@yahoo.com

EDUCATION

Degree	**Department**	**University**	**Date of Graduation**
Master	Industrial engineering	Yildiz Technical University	July, 2014
Undergraduate	Quality engineering,	Belgrade University	March, 2009
High School	Social Sciences and Foreign languages		Jun, 2003

PUBLISHMENTS

Papers

1. "Inter-laboratory comparisons as a way of increasing laboratory competence", SymOrg 2008, Belgrade

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