EVALUATION OF CUSTOMER SATISFACTION LEVEL WITH THE QUALITY OF LOGISTICS SERVICES USING FUZZY COGNITIVE MAP METHODOLOGY

(LOJİSTİK HİZMETLERİNDE MÜŞTERİ MEMNUNİYET SEVİYESİNİN BULANIK BİLİŞSEL HARİTALAMA YÖNTEMİ İLE DEĞERLENDİRİLMESİ)

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LIST OF SYMBOLS

MATLAB	:	Matrix Laboratory
CM	:	Cognitive Map
FCM	:	Fuzzy Cognitive Map
FMCG	:	Fast Moving Consumer Goods
COG	:	Center of Gravity
IT	:	Information Technology

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ABSTRACT

As the result of the globalization of economy, while competition is considerably increasing, it brings various business opportunities together for the companies in recent years. Customers can now easily reach a lot of choices and their behaviors are affected by this chance. In this world of lots of choices, quickness, price sensitivity and quality have become more and more important for customers. Adapting this changing dynamics and responding the customers' expectations and needs are now crucial for companies to gain competitive advantages and get sustainable growth. Therefore, companies need to ensure their customers' satisfaction for achieving goals and objectives.

Customer satisfaction can be defined as all the emotions customers get in a positive or negative way. And it can only be provided by bringing the customers' expectations and the values they received together. Evaluation of the product or service quality is involved in total customer satisfaction.

In order to achieve competitive advantage and increase their market share and of course profitability, companies are always searching for new ways of working and new approaches. Logistics service of a company aim to satisfy customers by overcoming the all challenges with considering customer expectations and needs.

In the fast-moving consumer goods industry, satisfying the customer expectations with the logistics services is particularly crucial. Today's fast changing business environment of all industries, especially fast-moving consumer goods companies', is increasing the importance of building strong relationship with customers. Due to customers' constantly and rapidly increasing strength, logistics service quality is a strong tool for suppliers to be one step ahead in the customers' mind.

This study is prepared to present a customer satisfaction evaluation model for logistics services and examines an international retailer's satisfaction criteria with the quality of logistics services provided by a supplier in fast-moving consumer goods industry by presenting a Fuzzy Cognitive Map approach. The term customer can be defined as the buyer of a product or service. Since this study examining the fast-moving consumer goods industry, a customer is considered as the retailer who buys manufacturers/suppliers' products and delivers them to consumers. Customer satisfaction criteria are determined with the help of a large literature survey and with the guidance of logistics experts who work at the mentioned fast-moving consumer goods company. Based on the presence of positive and negative relations among criteria, Fuzzy Cognitive Map methodology is chosen to be used. Relationships between concepts and relate linguistic variables are identified by decision makers who work in fast-moving goods company and retailer. Moreover, fuzzy number is determined for each linguistic variable. Aggregation and defuzzification steps are completed respectively by using "MATLAB (Matrix Laboratory) Fuzzy Toolbox". Thereafter, by using iterative formulation, each concept value is calculated and the results are evaluated. In addition, scenario analyses are provided in order to find out the importance of each concept.

With the help of literature review, it is observed that the customer satisfaction evaluation with the logistics services has been studied for many researchers, but this studies focus on statistical methods. Since, the positive and negative relationships exist between customer satisfaction criteria in logistics services, Fuzzy Cognitive Map methodology is proposed to use. This study combines the evaluation of customer satisfaction evaluation in logistics services with Fuzzy Cognitive Map methodology. Hence, this will be a novelty to the literature. This study will also be a guideline for companies operates in Fast Moving Consumer Goods industry to assess their own performance and for retailers to evaluate the service they get. Therefore, this thesis presents a mutual benefit.

ÖZET

Günümüzde ekonominin küreselleşmesinin bir sonucu olarak, rekabet önemli ölçüde artarken, şirketler için çeşitli iş fırsatları da ortaya çıkıyor. Müşteriler, artık birçok seçeneğe kolayca ulaşabilir hale geliyor ve bu durum davranışlarını da etkiliyor. Hız, fiyat ve kalite müşteriler için giderek daha da önemli hale geliyor. Bu değişen dinamiklere uyum sağlamak ve müşterilerin ihtiyaçlarını karşılayabilmek, şirketlerin rekabet avantajı sağlaması ve sürdürülebilir bir büyüme elde edebilmesi için çok önemlidir. Bu nedenle, şirketlerin hedeflerine ulaşmak için müşterilerinin memnuniyetini sağlamaları gerekir.

Müşteri memnuniyeti, ürün ya da hizmetlerin müşterilere sunduğu olumlu ya da olumsuz duygular olarak tanımlanabilir. Müşteri memnuniyetinin sağlanması, müşteri beklentilerinin ve sağlanan değerlerin aynı noktada buluşması ile sağlanabilir. Rekabette avantaj elde etmek ve bulundukları kategorilerde pazar paylarını artırmak için şirketler her zaman yeni çalışma yöntemleri ve yeni yaklaşımlar ararlar. Bir şirketin lojistik hizmetleri süreçleri, müşteri beklenti ve ihtiyaçlarını göz önünde bulundurarak onları memnun etmeyi amaçlar.

Hızlı Tüketim Ürünleri sektöründe, sunulan lojistik hizmetleri ile müşteri beklentilerininin karşılanması oldukça önemlidir. Günümüzde tüm sektörler için hızla değişen dinamikler, ki bu Hızlı Tüketim Ürünleri sektöründe en yüksek seviyededir, müşterilerle güçlü ilişkiler kurmanın önemini artırır. Müşterilerin sürekli ve hızla artan gücü nedeniyle, lojistik hizmet kalitesi, tedarikçilerin müşterilerin gözünde bir adım önde olması için güçlü bir araçtır.

Bu çalışma, Türkiye’de de operasyonunu sürdüren uluslararası bir Perakende Zincirinin, uluslararası bir Hızlı Tüketim Ürünleri şirketinin sunduğu lojistik hizmetlerinden memnuniyetini değerlendiren bir model nık Bilişsel Haritalama yöntemi ile ele almaktadır.

Müşteri terimi, bir ürün veya hizmetin alıcısı olarak tanımlanabilir. Bu çalışmanın yapıldığı Hızlı Tüketim Ürünleri sektöründe, üreticinin ürünlerini alarak, bu ürünleri mağazalar üzerinden alışverişçiler ile buluşturan Perakende Zinciri müşteri olarak tanımlanmaktadır. Bu çalışma için müşteri memnuniyeti kriterleri, kapsamlı bir yazın taraması ve söz konusu hızlı tüketim ürünleri firmasında çalışan lojistik uzmanlarının rehberliğinde belirlenmiştir. Ölçütler arasında pozitif ve negatif nedensellik ilişkileri olması nedeniyle Bulanık Bilişsel Haritalama yönteminin kullanılmasına karar verilmiştir. Çalıştığı şirkette lojistik süreçlerinde görev alan üç ayrı karar vericiyle görüşülüp her ölçüt çifti için nedensellik ilişkisinin varlığı, eğer varsa ilişkinin gücünün sözel değişkenler kullanılarak belirlenmesi sağlanmıştır. Ardından her bir sözel değişken, kullanılan üyelik fonksiyonunda kendisine karşılık gelen bulanık sayıyla ifade edilmiştir. Her bir karar vericinin görüşü sonucu elde edilen bulanık sayılar "MATLAB Fuzzy Toolbox" kullanılarak birleştirilmiş ve ağırlık merkezi yöntemi yardımıyla kesin sayılara dönüştürülmüştür. Bu işlemlerin sonucunda elde edilen ağırlık matrisi, bulanık bilişsel haritanın oluşturulmasını sağlamış olup, müşteri memnuniyeti ölçütleri arasındaki sebep-sonuç ilişkileri kesin sayılarla ifade edilmiştir. Her bir ölçütün değerini bulmak için Bulanık Bilişsel Haritalama yönteminin yinelemeli formülü "FCMapper" adı verilen yazılım ile çalıştırılmış, sonuçlar incelenmiş ve yorumlanmıştır. Bazı ölçütlerin öneminin değişik etmenler sebebiyle azalması veya artması durumunun diğer ölçütler üzerinde yaratacağı değişimi, nedensellikleri göz önünde bulundurarak gözlemlemek amacıyla senaryo analizleri yapılmıştır.

Lojistik hizmetlerinde müşteri memnuniyetinin değerlendirmesi konusu literatürde daha once de yer bulmuştur, ancak bu çalışmalada araştırmacıların çoğunlukla istatistiksel yöntemlere odaklandığı görülmektedir. Hâlbuki ölçütler arasında hem negatif hem de pozitif ilişkiler bulunması çift yönlü etkileşimleri hesaba katan bir yöntemin kullanılmasının daha uygun olduğunu gözler önüne sermektedir. Bu çalışma, lojistik hizmetlerinde müşteri memnuniyetinin değerlendirilmesinde daha once Bulanık Bilişsel Haritalama yöntemi kullanılmamış olması nedeniyle literature yeni bir yaklaşım önermektedir. Bu çalışma aynı zamanda, Hızlı Tüketim Ürünleri sektöründe faaliyet gösteren şirketler için kendi performanslarını değerlendirmek ve Perakendeciler için ise aldıkları hizmeti değerlendirmek için bir rehber olacaktır. Değerlendirme ve özdeğerlendirme sağlayan bu çalışa iki yönlü bir bakış açısı sunmaktadır.

1. INTRODUCTION

Globalization of the world economy causes increased competition for companies. Customers now have a huge number of choices and this influences their behaviors. Obtaining goods and services more quickly and efficiently with lower prices and higher quality have become crucial for the customers. Companies need to respond customers' expectation to ensure their long term success and competitiveness. Since the customers always can choose alternatives in a competitive market, companies have to provide high level of customer satisfaction to be successful. Repeat purchase, lower price elasticity, more chance of cross selling and strong marketing efficiency, which lead to profit growth for a company, can only be provided by customer satisfaction (Fornell et al. 1996).

Customer satisfaction is characterized from numerous points of view by researchers in the literature. Kotler & Armstrong (2000) describe customer satisfaction as the feeling experienced by customers, after the service is used which meets their expectations. Barnes et al. (2004) indicate that customer satisfaction can be explained by the all positive and negative emotions which customers receive from the services or products provided. Total customer satisfaction includes the customers' overall evaluation of the perceived service or product quality (Giese & Cote, 2002).

Companies are always looking for new approaches to achieve competitive advantage and increase their share of market. Providing logistics service that satisfies customers and helps them to reach their objectives is one of the most vital initiatives in recent years. Strategic importance of logistics has significantly increased for companies. Researchers have drawn attention to the strategic role of logistics services to increase customer satisfaction and to gain and sustain competitive advantage (Mentzer, 2001; Stank et al., 2001b).

Filho & Souki (2007) indicates that logistics is a crucial tool for any organization to compete in the market, since it improves flexibility and reduces cost. According to Fawcett (1996), customer satisfaction can be increased through the improvement of services with the logistics processes management. Customer satisfaction is a standout amongst the most important measurements for evaluating the logistics services provided by a company. In addition, Christopher (1998) states that logistics is a fundamental business process which improves customer satisfaction and decreases operational costs. Raising the quality of logistics services increases customer satisfaction, therefore strategic partnership is strengthened and profitability is increased (Sharma et al., 1995).

Fulfillment of the customers' expectation with the logistics services is especially crucial in the fast-moving consumer goods (FMCG) industry, that can be identified by strong pressure for stock management, continuous research and development, extensive supply chain and huge spending for all marketing tools (Diehl & Spinler, 2013). In today's world with the increasing competition and quickly changing business climate, establishing long-term relationships is fundamental for suppliers' success, hence the retailers/customers' is continuously gaining strength. Quality of services provides competitive advantage to suppliers, since it differentiates them in the retailers' eye (Giovanis et al., 2013).

Buyer of a product or service is defined as a customer, whereas a consumer is a user of this product or service (Applebaum, 1951). Since the customer and the consumer terms don't have the same meaning, in fast moving consumer goods industry a customer is considered as the retailer who buys manufacturers/suppliers' products and delivers them to consumers.

This study presents a customer satisfaction evaluation model by using fuzzy cognitive map (FCM) approach for logistics services and aims to examine an international retailer's satisfaction criteria with the quality of logistics services provided by a supplier in fast moving consumer goods industry by presenting a fuzzy cognitive map approach.

For this aim, a large literature survey has been conducted and experts' decisions were analyzed in order to determine factors affecting the customer satisfaction with the quality of logistics services and the causal relationships between them. Afterwards, these factors will be evaluated with an FCM approach by taking into consideration their effect on customer satisfaction, and causal links among each pair of these criteria.

This approach fundamentally assumes that people has internal cognitive models in regard to their observation of the world (Bauer, 1975) Fuzzy cognitive mapping has been widely used in studies. Researchers traditionally have worked on observable and measurable events, but people's decision making process do not happen in an objective world. In reality, this decision making process is a subjective process. With the help of cognitive mapping, a new understanding is developed to this subjective world (Klein and Cooper, 1982). By this study, customer satisfaction criteria with the quality of logistics services will be specified by use of fuzzy cognitive mapping.

Within the proposed structure of this study, customer satisfaction criteria will be determined and evaluated for proposing a guide to logistics managers. This study aims to identify what the index of customers' satisfaction with the quality of logistics service is. Specifically, this study can help the companies and especially logistics managers to understand customers' expectations with the logistics services and to increase customer satisfaction by efficiently concentrating on these expectations.

By reviewing the literature, it is observed that the customer satisfaction evaluation has been a subject for many researchers for years. Also, this customer evaluation studies mainly focus on the operations. Moreover, various studies built models for evaluating the customer satisfaction with the logistics services in order to provide a guideline for logistics experts over years. On the other hand, positive and negative relationships exist between customer satisfaction criteria in logistics services. Proposed methodology of this study, FCM is a method which takes into consideration of these positive and negative relationships. Moreover, FMCG is known as one of the most competitive industry with its very fast changing structure every day. This study brings together the customer satisfaction evaluation in logistics services and FCM methodology in FMCG industry. Hence, this will be a novel approach for the literature. This study will be an applicative guideline for companies operates in FMCG industry to assess their own performance and for retailers to evaluate the service they get. Therefore, this thesis presents a mutual guiding light and contributing the literature by that.

The rest of this thesis is organized in the following way. Section 2 provides key concepts of the study. Section 3 explains the proposed methodology in detail and Section 4 gives application steps. Finally, Section 5 presents the conclusion.

2. KEY CONCEPTS

2.1. Logistics Service

Logistics service can be generally defined as the total process of the planning, shipment, warehousing and distribution of the things from the first manufacturer to the last consumer. In other words, managing of the transportation process of things between different points for meeting customer expectations can be defined as logistics service (Christopher, 1998).

Primary objective of the logistics is ensuring the flow of the right products to the right destinations with the correct price and cost and in the proper conditions in line with the 7R principle. Principles are given below:

- Right product
- Right quantity
- Right quality
- Right time
- Right place
- Right information
- Right cost

Logistics objectives can be accomplished by companies with the activities given below (Coyle et al., 2002).

- Transportation
- Warehousing
- Packaging of goods

- Managing and controlling stocks
- Managing orders
- Production planning
- Purchasing
- Customer service providing
- Collecting returns

2.2. Customer & Customer Satisfaction

In the literature, the term customer presents the person who buys a service or product, while a user of this product of service is defined as consumer (Applebaum, 1951).

Customer satisfaction can be described by the evaluation of customers' feelings, emotions and psychological statements. A service or product can provide positive or negative feelings for a customer, and these feelings are defined as customer satisfaction (Barnes et al., 2004). Quality of a product or service, price and of course all other marketing inputs can directly affect customer satisfaction (Bonner and Nelson, 1985). Moreover, when customer satisfaction is ensured with the quality of services and products provided, it can create an important opportunity for companies to benefit and get more profit from repeat purchases of customers (Parasuraman et al, 1988).

This study is applied for evaluation of a retailer's satisfaction with the logistics services provided by a supplier in FMCG industry. In fast moving consumer goods industry a customer is considered as the retailer who buys manufacturers/suppliers' products and services and who is responsible for delivering them to consumers through stores. Within the context of this study, while mentioning the customer, from now on a retailer will be the main subject instead of a person who actually does shopping of a product from retailer's stores. With this approach, a third term should be explained in order to better explain the study. *A shopper* is the person who actually buys the products from retailer's stores. Customer, consumer and shopper terms are explained in detail in Figure 2.1.

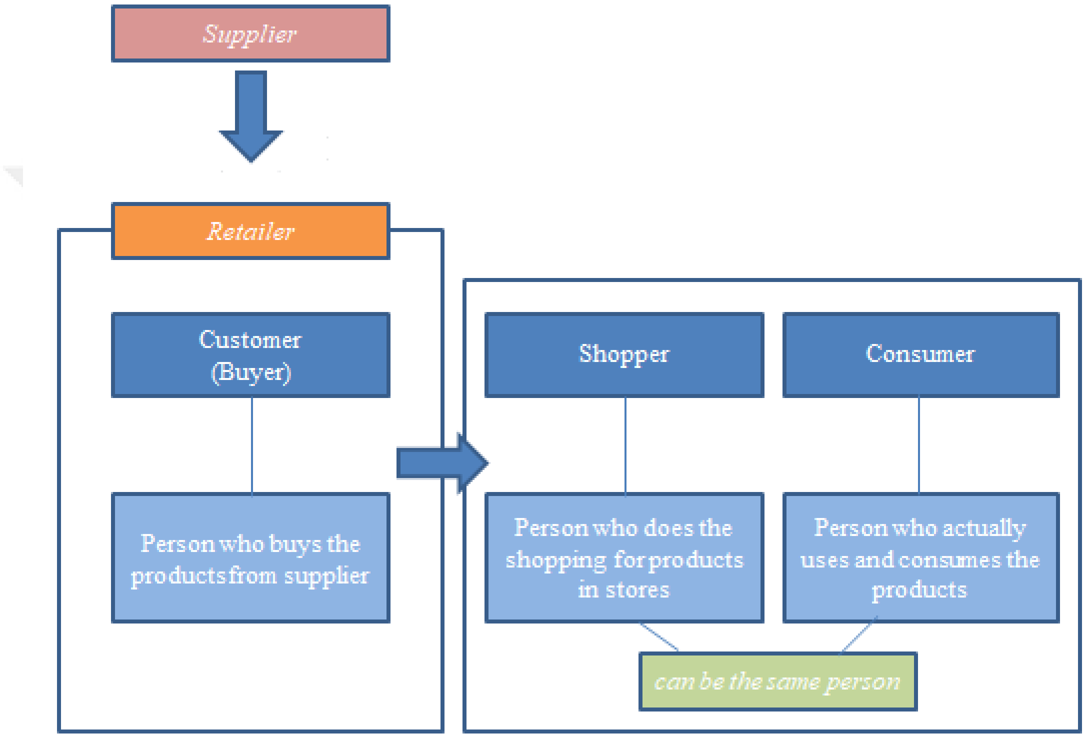

Figure 2.1: Customer- Shopper- Consumer Framework

2.3. Customer Satisfaction with Logistics Services

Customer satisfaction with logistics services can only be provided in the event of meeting and confirming the expectations and the needs of customers during all logistics service processes. In the contrary case, customers are dissatisfied with the services provided. Customers' expectations can be fulfilled in a positive or negative way as seen on Figure 2.2. When the difference between customer expectations and received logistics services by them increases, customer satisfaction, or quite the opposite, dissatisfaction gains more strength (Nedeliakova et al., 2015).

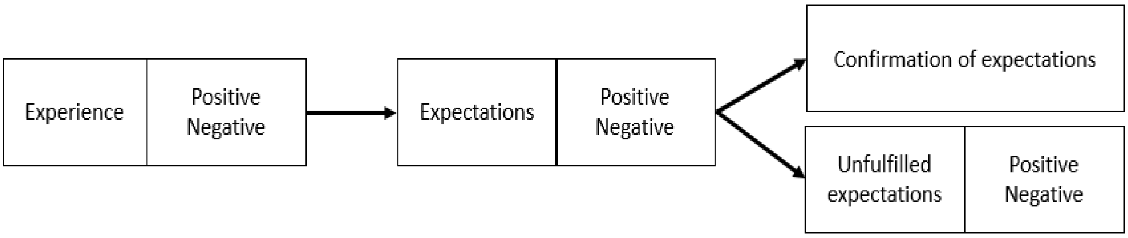

Figure 2.2: Customer Satisfaction or Dissatisfaction

Quality of the logistics services can be observed as a result by comparing customer expectations and fulfillment level of these expectations. During the recent years, companies enormously started to focus on improving their logistics capabilities and service levels in order to gain competitive advantage on the market (Daugherty et al., 1998).

Building the strong logistics service strategy ensures a strong competitive advantage for all companies. This strategy creates a route to follow for companies to achieve their objectives despite the fact that increasing competition, fast changing market situations and customer behaviors. Moreover, strong built logistics strategy is crucial for a long term relationships with customers and is purely and simply applicable through satisfying the customers (Albrecht and Zemke, 1985).

2.4. Customer Satisfaction Criteria

The perceived quality of logistics services depends on various variables. These variables may affect the customer satisfaction positively and also negatively. All of these variables and principles which have importance on evaluation process are called criteria.

In order to select the most suitable and appropriate criteria for this study, academic studies which are related to customer satisfaction evaluation in logistics are reviewed deeply. These criteria are discussed in depth interviews with the two logistics experts in mentioned FMCG Company who are responsible from customer service and logistics processes and teams of all trade. With the help of literature survey and experts' guidance, nine main customer satisfaction criteria were selected to conduct this study. The definition for each selected criteria is given below with mentioning the related studies.

- **Product Quality**

It refers to the quality and durability of the shipped products and their packaging. The product quality was identified as one of the main logistics capabilities to provide value to the customers by various researchers. Lambert and Burduroglu (2000) proposed "quality and durability of packaging" as a criterion which affects the logistics performance of a supplier of fast moving consumer products according to the survey conducted. Gustafsson (2006) included "physical product quality" in criteria of study by several interviews and a questionnaire which was made in order to identify logistics service requirements for satisfying the customers in sawmills industry. Hayes and Pisano (1994), Moraes and Lacombe (1999) and Gustafsson (2002) also presented studies which include product quality as one of the criteria affecting customer satisfaction with the logistics services in their studies. Ahmet and Kangari (1995) proposed quality as one of six client satisfaction factors in their study which presents an evaluation for construction industry.

- **Product Accuracy**

In this study, delivering the right products with right amount is identified as product accuracy. Mentzer et al. (1999) states that the delivering ordered amount of the correct product at the right shipment place at the time indicated in the proper conditions at the agreed price with the correct information was crucial to build customer satisfaction. Seth et al. (2006) and Gustaffson (2003) also include product accuracy into their studies as one of the criteria affecting customer satisfaction with the logistics services.

- **Complete Delivery**

Lorenz and Lounela (2011) mentioned complete delivery as of the criteria affecting the customer satisfaction. It refers to the high case fill rate on normal reorders and promotional orders of the customers. As supplier’s fill rate depends on products’ availability in supplier’s warehouse, in several studies this criterion was named as out-of-stock avoidance (Forslun, 2003).

- **Time**

It represents the shipment of the ordered products on promised lead time and also speed in deliveries. Fawcett and Fawcett (1995) indicate that quick delivery capability is essential for a company to reach higher logistics operations performance. Loya et al. (2015) emphasized the importance of time factor on customer satisfaction in their study.

Christopher (2005) and Forslun (2003) also include time in their studies for evaluating the customer satisfaction. Tang et al (2003) presents timeliness of service as one of the customer satisfaction factor out of total twenty nine satisfaction factors for consulting firms.

- **IT Capability**

In this study, IT capability of a company represents advanced usage of tracking and tracing systems, its systems' speed, and implementation of electronic data interchange (EDI) systems. Customers can take advantage of company's advanced IT capabilities. IT capabilities are one of the most important factors in any organization (Gil et al., 2007). Jharkharia and Shankar (2007) mentions that the strong IT capability is essential for fulfilling the customer expectations.

- **Responsiveness**

In this thesis, responsiveness refers to companies' capability of finding solutions for unforeseen problems and unexpected events and also capability of correcting mistakes quickly. Baki et al. (2009) defines responsiveness as an ambition for helping customers and providing services in their study which proposes a hybrid model for evaluate the logistics services quality.

- **Flexibility**

It represents the logistics service providers' flexibility to special or non-usual requests in operations and deliveries. Flexibility of a company in logistics services can define as the ability of responding to changing customer needs quickly and effectively (Autry et al, 2008). Meiduté et al. (2014) include flexibility in their study as one of the criteria and mention that the power of flexibility provides competitive advantage for service providers.

- **Coordination**

In this thesis, coordination capability refers to having informative and reliable human sources as contact person for customers in the logistics teams and also having alignment between teams in all processes. Nollet et al. (2012) include coordination as one of the criteria affecting customer satisfaction with the logistics services. Anderson and Norman (2002) indicate that the coordination is essential for achieving common goals between suppliers and customers.

- **Cost**

Optimizing costs is one of the most important logistics capabilities for delivering to the customers' superior value and services and very frequently used as a satisfaction factor in logistics literature. In this thesis, cost refers to offer special discounts for full pallet or full truck shipment, handling service for shipped products and optimizing trade terms for customers. Lynch (2000) describes the cost factor as the total cost of logistics outsourcing and indicates that the cost should be at the minimum level in any processes. Hayes and Pisano (1994) include cost in their studies for evaluating the customer satisfaction with the logistics services provided. Seth et al. (2006) indicates in their study that a reasonable cost point affects the customer satisfaction with service quality. Ahmet and Kangari (1995) proposed cost as one of six client satisfaction factors in their study which presents an evaluation for construction industry.

3. METHODOLOGY

3.1. Cognitive Maps

A cognitive map is presented as s graphic representation of a decision maker's commentaries as a structural frame work about a specified situation. The concept was firstly introduced by Edward Tolman in 1948 as a mental image of an environment (Downs and Stea, 1975).

Axelrod (1976) is the first scientist who introduce Cognitive maps (CMs) as a tool to make decisions in social and political sciences. CMs are also used by researchers in the field of strategic planning, forecasting and research and development.

Weighted, functional and signed graphs are some of the different types of CMs. The binary relations are utilized in crisp (conventional) CM. CMs have a reasonable approach to speak to causal connections, they permit users to quickly contrast their mental thinking and reality, they transform assessments less demanding, and they advance better approaches for considering the issue being assessed (Ross, 2010).

3.1.1.Concepts and Causalities

Concepts and causal relationships are the two sorts of components for building a CM. Concepts are denoted by nodes, Cx, where x = 1,2,…,N.

A concept variable is named a cause variable when it's located at an arrow's origin point, though an effect variable is defined as a concept variable at the end of this arrow.

For example, an arrow from C_h to C_i represents that the cause variable C_h affects the effect variable Ci. A simple CM which comprises four concepts is given in Figure 3.1.

Arrows speak to the positive or negative causalities between concept variables. For example, an arrow from C_h to C_i which has a negative sign shows that causal relationship of C_h on C_i is negative. In this manner, increase of C_h brings about decrease of C_i (Ross, 2010).

3.1.2. Cycles and Paths

A path from a concept variable to another, from C_h to C_k, meant by P(h,k), is an array of the considerable number of nodes associated by edges between the first node (C_h) and the last node (C_k). A path that has an edge from the ending point to the origin is named a cycle (Ross, 2010).

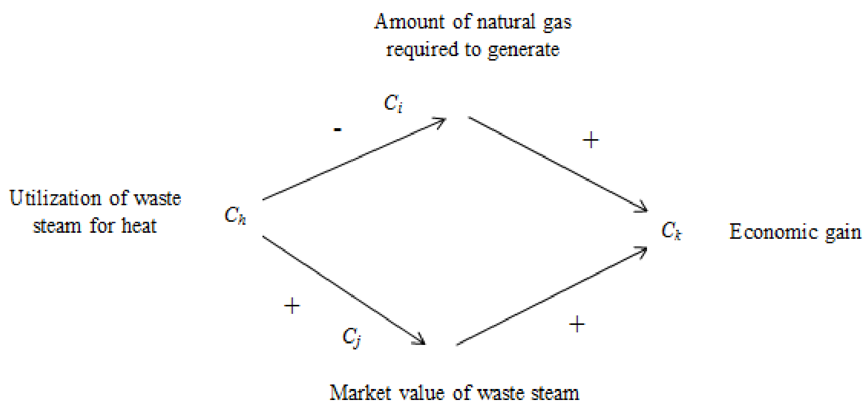

Figure 3.1: An example of a crisp cognitive map (Kosko, 1986)

3.1.3. Indirect Effect

The indirect effect which is represented by I (h, k), starts from C_h and reaches to C_h,), is the result of the causalities of the path between Ch and Ck (Axelrod, 1976).

In the event that a path has also a few negative edges, then it presents the positivity of the indirect effect. On the other hand, if the path has both negative and positive edges at the same time, so the indirect effect is negative.

3.1.4. Total Effect

T (h, k) is the combination of all indirect effects between C_h and C_k is named as the total effect of C_h on C_k (Axelrod, 1976). The total effect stands positive, in the case of all the indirect effects are positive. Quite the contrary, in the case of the negativity of all indirect effects, then total effect stands negative too. Furthermore, when indirect effects stand negative and positive dispersedly, so it means the combination is indeterminate (Kosko, 1986).

A complex CM, which has an extraordinary number of paths and concepts, will be most likely a possibility to be indeterminate. Figure 3.1 demonstrates the cause variable C_h's total effect on the effect variable C_k Since there are positive and also negative indirect effects at the same time on these paths, so the total effect is indeterminate in this case (Ross, 2010).

3.2. Basic Notions of Fuzzy Logic

3.2.1. Information and Uncertainty

Just a little part of the information for a normal issue may be viewed as assured or as deterministic. The information with no obliviousness, ambiguity, imprecision or chance is not available in real life. Uncertain information, which can go up against a wide range of structures, emerges as a result of complexity and the inability to quantify sufficiently or absence of knowledge (Ross, 2010).

3.2.2. Fuzzy Sets and Membership

Researchers have to determine the kind of uncertainty in a particular issue to choose a reasonable technique to infer the uncertainty. Fuzzy sets are quite proper to give a scientific way keeping in mind the end goal to indicate vagueness and fuzziness in systems (Ross, 2010).

Fuzzy sets give a more helpful purpose for the development of a theoretical structure which parallels in numerous regards than the system utilized in ordinary sets. Basically, this kind of structure gives a characteristic method for managing.

The membership function includes the mathematical presentation of a set's membership. The interval is as follows.

$$\mu_{\tilde{A}}(x) \in [0,1] \tag{2.1}$$

Where $\mu_{\tilde{A}}(x)$ alludes to the degree of membership of element x in fuzzy set $\tilde{A}$ (Ross, 2010).

Example membership function of a crisp set is presented in Figure 3.2 and Figure 3.3 sets an example of a fuzzy set.

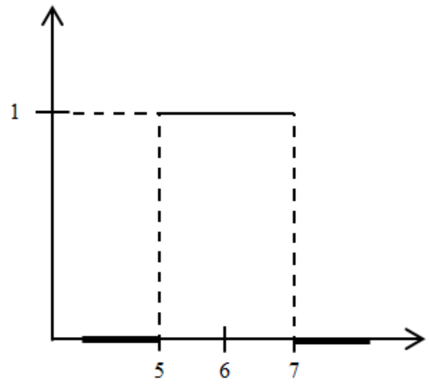

Figure 3.2: Membership function for a crisp set (Ross, 2010)

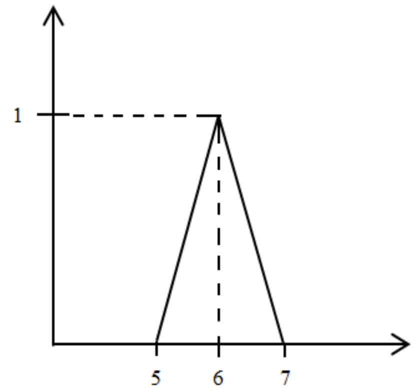

Figure 3.3: Membership function for a fuzzy set (Ross, 2010)

3.2.2.1. Fuzzy Sets

For a universe X, which is discrete and finite, a fuzzy set A∼ is denoted as follows (Ross, 2010).

$$\tilde{A} = \left\{ \frac{\mu_{\tilde{A}}(x_1)}{x_1} + \frac{\mu_{\tilde{A}}(x_2)}{x_2} + \ldots \right\} = \left\{ \sum_i \frac{\mu_{\tilde{A}}(x_i)}{x_i} \right\} \quad (2.2)$$

For a universe continuous and not finite X, notation for a fuzzy set A∼ is as follows (Ross, 2010).

$$\tilde{A} = \left\{ \int \frac{\mu_{\tilde{A}}(x)}{x} \right\} \quad (2.3)$$

3.2.2.1.1. Definitions of Fuzzy Sets

Definition 1:

A normal fuzzy set is a fuzzy set with a function of membership has minimum one element *x* in the universe with a value of membership that is equivalent to unity (Ross, 2010)

Definition 2:

A fuzzy set with a function of membership does not have any *x* element in the universe with a value of membership that is equivalent to unity, is named as a subnormal fuzzy set (Ross, 2010).

Definition 3:

If the elements of a fuzzy set $\tilde{A}$, have a relation between them such that z > y > x, which specifies that $\mu_{\tilde{A}}(y) \geq \min[\mu_{\tilde{A}}(x), \mu_{\tilde{A}}(z)]$, so fuzzy set $\tilde{A}$ is called as convex fuzzy set (Ross, 2010).

Definitions 4:

When $\tilde{A}$ is a convex normal fuzzy set, then $\tilde{A}$ is said to be a fuzzy number (Ross, 2010).

3.2.2.2. Definitions of Membership Function

Definition 1:

The core of a membership function includes components x such that $\mu_{\tilde{A}}(x) = 1$ (Ross, 2010).

Definition 2:

The support of a membership function includes components x such that $\mu_{\tilde{A}}(x) > 0$ (Ross, 2010).

Definition 3:

The boundaries of a membership function comprises of components x such that $0 < \mu_{\tilde{A}}(x) < 1$ (Ross, 2010).

Definition 4:

The crossover points of a membership function involves elements x such that $\mu_{\tilde{A}}(x) = 0.5$ (Ross, 2010).

3.2.3. Defuzzification

The transformation process of a fuzzy quantity to a crisp quantity is called defuzzification (Ross, 2010).

3.2.4. Defuzzification to Crisp Sets

Let $\tilde{A}$ is a fuzzy set, A_λ is a lambda-cut set, where $0 \leq \lambda \leq 1$. A_λ, which is called as the *lambda* (λ)-*cut* (or *alpha-cut*), is a crisp set $\tilde{A}$, where $A_\lambda = \{x | \mu_{\tilde{A}}(x) \geq \lambda\rangle\}$ (Ross, 2010).

3.2.5. Defuzzification to Scalars

Numerous methods of defuzzification have been introduces to the literature by researchers in recent years. Four principle methods, summarized and proposed by Ross (2010), are given as follows.

- ***Max membership principle:***

$$\mu_{\tilde{A}}(z^*) \geq \mu_{\tilde{A}}(z), \qquad \text{For all } z \in Z, \tag{2.4}$$

Where z^* is the defuzzified value.

- ***Center of gravity (COG):***

$$z^* = \frac{\int \mu_{\tilde{A}}(z).z \quad dz}{\int \mu_{\tilde{A}}(z)\, dz}, \qquad (2.5)$$

Where $\int$ refers to an algebraic integration.

- ***Weighted average method:***

$$z^* = \frac{\sum \mu_{\tilde{A}}(\bar{z}).\bar{z}}{\sum \mu_{\tilde{A}}(\bar{z})}, \qquad (2.6)$$

Where $\sum$ refers the sum and $\bar{z}$ refers to the gravity center.

- ***Mean max membership principle:***

$$z^* = \frac{a+b}{2} \qquad (2.7)$$

3.3. Fuzzy Cognitive Maps

3.3.1. Indeterminacy

An indeterminate crisp CM may be found by presenting a numerical weighting, nevertheless, by using computers and conceptual efforts (Kosko, 1986).

In the case of the causal edges are weighted positive or negative, the product of these weights on related path is the indirect effect, and the sum of these products stands for the total effect.

While calculating the total effect, the problem of indeterminacy is removed with the help of this weighting framework. Nevertheless, causal discrimination needs to be more sensitive. Decision makers, who are building the CM, may not be able to handle this sensitivity.

Creating CM with crisp numbers brings on insufficiency for decision makers and may end up with discrepancies. Various numbers can be found by same decision makers or various decision makers on separate days. However, FCM provides the opportunity for expressing the causal links with linguistic variables instead of numerical terms (Ross, 2010)

3.3.2. FCM Methodology

FCM were initially portrayed by Bart Kosko (Kosko, 1986), who used FCM as a way to convert cognitive maps from qualitative to processable. Contrary to other cognitive mapping methods, FCMs empower a solution for complex decision systems and the determination of system instabilities, contrary to other CM approaches. (Jetter and Kok, 2014)

FCM captures causal information in cognitive maps form, also implements neural network calculation to refine those models and investigate the results as a causal knowledge-based multi-step method.

Fuzzy numbers or linguistic variables were integrated to model to find out causal relationships among concepts by Taber and Kosko (Kosko, 1986; Taber, 1994).

FCM elements, nodes and weighted edges, can be representing in a graphic. Edges are marked to comprehend the heading of causality and associate the hubs. Causality direction, positivity, negativity or nullity of the causal relationship is determined with the help of signed edges which connect the nodes (Büyükavcu et al., 2016).

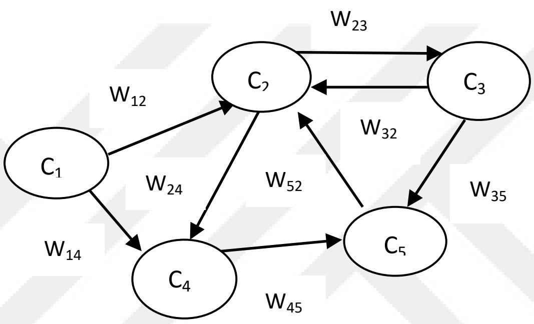

Figure 3.4: Graphical representation of FCM (Büyükavcu et al., 2016)

Concept sets are represented by $C = \{C_1, C_2, ..., C_n\}$ and edges (C_j, C_i) indicate how concept C_j causes concept C_i. The weight of these causality links places in the interval [-1,1] or may be proposed with linguistic variables for example: “negatively strong”, “zero”, “positively strong”, etc. The representation and method’s application steps are given in Figure 3.4 and Figure 3.5, respectively.

Figure 3.5: Application steps of FCM

The direction of causal links among concepts is represented by w_{ji}. In the case of $w_{ji} > 0$, so concepts C_j and C_i has a positive cause-effect relationship. When $w_{ji} = 0$, concepts C_j and C_i have no causality. Additionally, the direction of causal links presents which concept causes the other, C_j or C_i. The value determined for weight w_{ji} represents the power of causal relations between concepts. For example, as seen on Figure 3.4, concept C_1 can cause an increase or decrease effect on concept C_4 with w_{14}. These values of concepts are calculated by using the iterative formula below.

$$A_i^{(k+1)} = f\left(A_i^{(k)} + \sum_{\substack{j \neq i \\ j=1}}^{N} A_j^{(k)} w_{ji} \right) \tag{2.8}$$

The term k indicates the number of iteration, and $A_i^{(k)}$ presents the value of concept C_{ii} w_{ji} represents the connections weight among concepts C_j and C_i and f is an initial function.

The activation levels are updated in FCM in synchronization for all concepts. The activation level of concept C_i is represented by A_i^t, time is denoted by t. The vector $A^t = \left[A_1^t, A_2^t, ..., A_n^t \right]$ is the vector that proposes the state of the FCM at t, n denotes the concepts numerically. For each concept, there is an initial and a final vector, this vector refers a state at the initial and the last step, respectively. Determining this final vector is the main objective of FCM method by providing the each concept’s value (Büyükavcu et al., 2016).

3.3.3. Literature Survey of FCM

In recent years, FCMs have become a remarkable research topic. FCM methodology was widely used by the researchers to make analysis of causal systems on many different areas such as management, manufacturing, tourism, transportation, medicine, energy etc. For this study, an FCM literature survey was conducted on “Emerald”, “Science Direct”, “Springer”, “Taylor and Francis” and “Web of Science” databases by using “Fuzzy cognitive map” and “multi-criteria decision making” keywords. As the result of this literature survey, scientific articles published between 2011 and 2018 are given in the Table 2.1 and specified according to their research areas.

In manufacturing sector, FCM has been used for solving complex problems. Zhao et al. (2014) used FCM methodology to build a flexible operational structure model in wind power industry to cope with complex environment circumstances. Chen et al. (2015) utilized FCM based approach for an estimation problem in elevator group control system to decrease electricity consumption. Azadeh et al. (2015) conducted a case study in Iran to evaluate the leanness degree of an organization by using FCM methodology. Vidal et al. (2015) used FCM method to improve the eco-design strategy in Spanish ceramic industry by using a data survey. Zhang et al. (2016) proposed an FCM methodology to show the effect of risk criteria in oil and gas production plants. Dursun et al. (2018) proposed FCM methodology to evaluate performance of suppliers in the textile industry.

FCM has been also utilized in agricultural industries. Papageorgiou et al. (2011) made a research on yield forecasting in cotton production with the help of FCM method. Furthermore, Papageorgiou et al. (2013) also used FCM for apple field prediction. Jayashree et al. (2015) categorized production levels due to different climatic conditions in coconut yields in India by using FCM method. Natarajan et al. (2016) proposed FCM methodology to categorize sugarcane yields in India.

Information and management systems have been also a subject area for FCM methodology. Büyüközkan & Vardaloğlu (2012) analyzed the elements that ensure a better way for implementing a forecasting strategy in retail industry by using FCM approach. Sharif et al. (2012) built a model for evaluating the criteria affecting risk and cost of reverse third-party logistics providers depending on their information systems and then validated this model by using FCM method. Irani et al. (2014) applied FCM method for evaluating the information systems investment. Baykasoglu and Golcuk (2015) also proposed a combined FCM model with utilizing a Strengths, Weaknesses, Opportunities, and Threats (SWOT) to select strategy. Dias et al. (2015) performed a study to understand the interaction between management systems and users by using FCM method. Kang et al. (2016) proposed a FCM method to show the direct and indirect influences of environment management systems on system's performance.

Besides, FCM method was also preferred by researchers on tourism and transportation. Kardaras et al. (2013) presents a FCM methodology to find dealing ways for customers' choices and expectations from tourism web pages design. Leon et al. (2014) determined and evaluate the factors affecting people's transportation preferences by using FCM approach. Kayikci & Stix (2014) analyzed the collaboration criteria for structuring a collaborative transport system in fast moving consumer goods industry by using FCM based model. In addition to these studies, Shang et al. (2018) presents a hybrid method based on FCM model to impute missing traffic data.

Another application area of FCM methodology is energy sector. Kyriakarakos et al. (2014) preferred FCM for the reginal planning of renewable energy sources in real investments on Crete Island. In another study, FCM was used for forecasting the minimum number of elevators to decrease the electricity consumption (Chen et al., 2015a). Olazabal & Pascual (2016) proposed a FCM approach to find different methods for increasing decarbonisation level of the energy system in Bilbao. Mpelogianni and Groumpos (2018) studied a FCM model for solving the energy consumption issue of the construction industry.

In addition to all these, FCM methodology is one the most frequently used medical research area method. Lee et al. (2012) determined and evaluated the criteria affecting the dental implant process by implementing FCM method. Giabbanelli et al. (2012)

made the observation of obesity's psychological elements with the FCM approach. Froelich et al. (2012) used FCM for the early identification of prostate cancer. Büyükavcu et al. (2016) made also research on oncologic area and combined FCM and fuzzy inference system to indicate breast cancer risk factors.

Table 2.1: FCM Literature survey with search areas

Research Area	**Year**	**Author(s)**
Agriculture	2011	Papageorgiou et al.
	2013	Papageorgiou et al.
	2015	Jayashree et al.
	2016	Natarajan et al.
Energy	2014	Kyriakarakos et al.
	2016	Olazabal & Pascual
	2015	Chen et al.
	2018	Mpelogianni & Groumpos
Information and Management Systems	2011	Maio et al.
	2012	Büyüközkan & Vardaloğlu
	2012	Sharif et al.
	2014	Irani et al.
	2015	Ahmadi et al.
	2015	Ahmadi et al.
	2015	Baykasoglu & Golcuk
	2015	Dias et al.
Manufacturing and Production	2014	Zhao et al.
	2015	Azadeh et al.
	2015	Chen et al.
	2015	Vidal et al.
	2016	Zhang et al.

	2018	Dursun et al.
Medical	2012	Froelich et al.
	2012	Giabbanelli et al.
	2012	Lee et al.
	2016	Büyükavcu et al.
Tourism and Transportation	2013	Kardaras et al.
	2014	Leon et al.
	2014	Kayikci & Stix
	2015	Lee & Lee
	2018	Shang et al.

4. APPLICATION OF THE PROPOSED METHODOLOGY

In the application part of the thesis, a FCM approach is utilized for proposing an evaluation model for customer satisfaction with the logistics services quality. The study takes point of departure from the logistics operations between a global fast moving consumer goods (FMCG) company based on the manufacturing and distribution of personal care products and retailers as its customers who deliver its products to consumers. FCM methodology is used to be employed because of the absence of neat numbers and due to need of the use of linguistic variables or fuzzy numbers, and the presence of cause-effect relationships among concepts in customer satisfaction with the quality of logistics services provided. The application steps are given in Figure 4.1.

For the application of the proposed method, steps are implemented on two big global companies in order to demonstrate customer satisfaction evaluation. One of them is operating in FMCG industry globally and Turkey operation is responsible from distributing their products to the consumers via its customers. And the other one is also a global chain retailer which also operates as one of the biggest retailer in Turkey. FMCG Company is the category leader in terms of market share in all categories they exist and retailer has almost seven hundred stores all over Turkey. While reaching the highest distribution of all products in the portfolio is the main objective for this FMCG Company, retailer aims to offer a rich portfolio to its shoppers whenever they want and wherever they need. Therefore, flawless logistics services processes are essential for both companies.

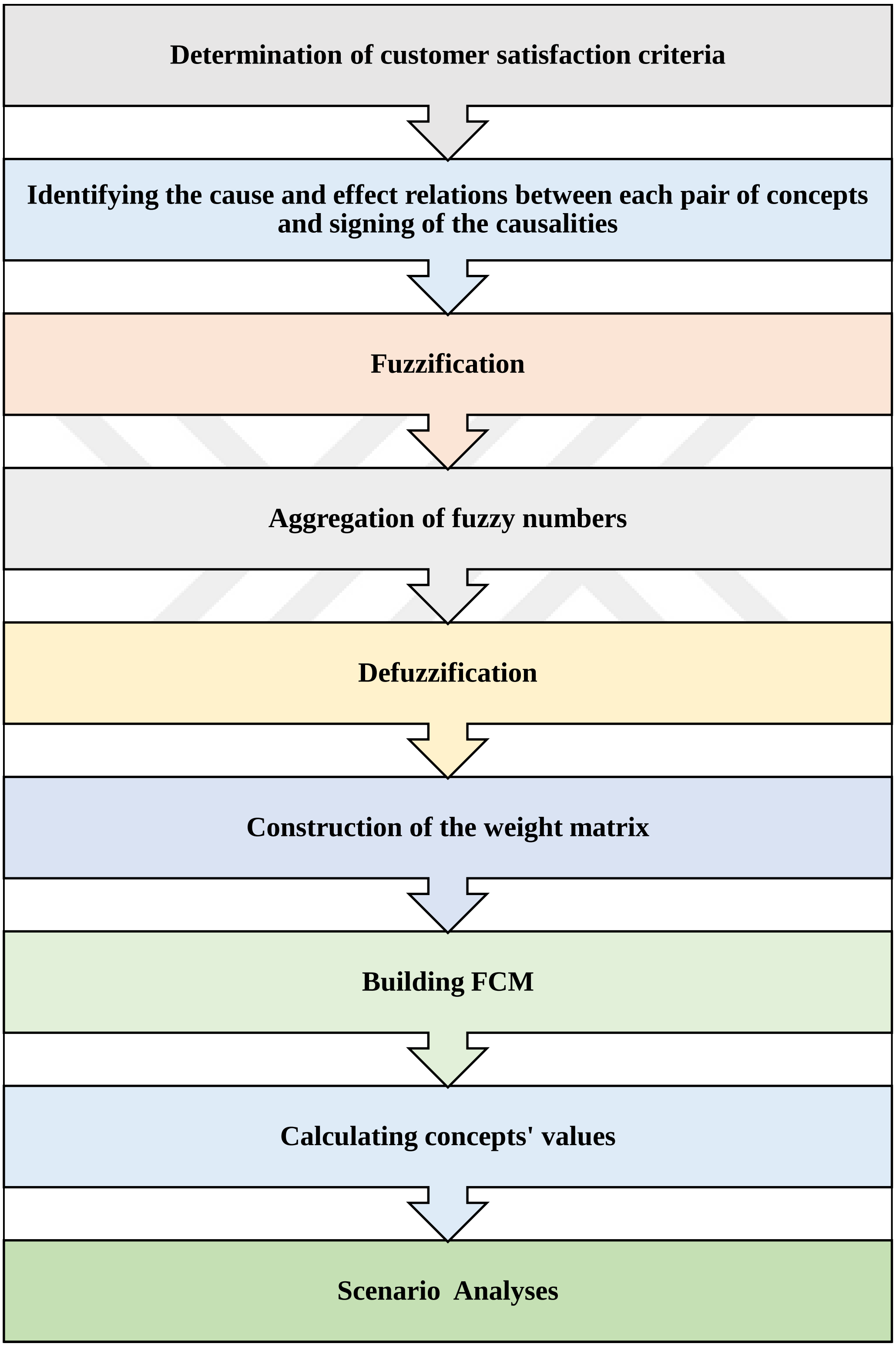

Figure 4.1: Application steps of the study

4.1. Determination of Customer Satisfaction Criteria

In order to provide an evaluation framework, customer satisfaction criteria with the logistics services are determined and listed in Table 4.1. These customer satisfaction criteria are chosen thanks to a deep literature survey and with the guidance of two different experts who are responsible from leading the customer services and logistics operations and team in mentioned FMCG Company.

Table 4.1: Customer Satisfaction Criteria

Label	**Concept**
C_1	Product Quality
C_2	Product Accuracy
C_3	Complete delivery-case fill
C_4	Time
C_5	IT Capability
C_6	Responsiveness
C_7	Flexibility
C_8	Coordination
C_9	Cost

4.2. Identifying the Cause-Effect Relationships

The satisfaction criteria which were determined with the help of a deep literature survey and experts' guidance are sent to three different decision makers. All of these decision makers decide the positivity, negativity or nullity of causal relationships. One of them is Customer Development Manager and the other is Customer Services and Logistics Manager in the related FMCG Company, whereas the other decision maker is Category Development Specialist in a multinational retailer company which is one of the customers of this FMCG Company. The copy of the matrix prepared by the experts is given in Table 4.2, and the matrices of sign filled by three decision makers are given in Table 4.3, Table 4.4, Table 4.5, respectively.

Table 4.2: The copy of the matrix sent to decision makers

	C1		C2		C3		C4		C5		C6		C7		C8		C9	
C1																		
C2																		
C3																		
C4																		
C5																		
C6																		
C7																		
C8																		
C9																		

C1	Product Quality	**C4**	Time	**C7**	Flexibility
C2	Product Accuracy	**C5**	IT Capability	**C8**	Coordination
C3	Complete Delivery	**C6**	Responsiveness	**C9**	Cost

Table 4.3: The matrix of sign according to the Decision Maker 1

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1		+	+			+	+	+	
C_2			+			+	+	+	
C_3		+							+
C_4			+					+	
C_5		+	+	+		+	+	+	
C_6				-	+			+	-
C_7				-	+	+		+	-
C_8					+	+			
C_9				-	+				

Table 4.4: The matrix of sign according to the Decision Maker 2

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1			+						
C_2			+						
C_3		+							+
C_4						+			
C_5		+	+	+		+	+	+	
C_6				-	+		+	+	-
C_7				-		+		+	-
C_8		+	+	+		+	+		+
C_9			+			-	-		

Table 4.5: The matrix of sign according to the Decision Maker 2

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1					+				-
C_2	+		+			+			-
C_3									
C_4						+		+	
C_5	+	+	+	+		+	+	+	
C_6				-				+	
C_7			-	-		+			-
C_8		+		+					
C_9	+		+						

4.3. Fuzzification

The degree of causalities is determined by three decision makers by using linguistic variables. Afterwards these linguistic variables are converted to related fuzzy numbers. In this thesis, nine different linguistic terms are used in order to identify the degree of causalities. These terms are negatively very strong, negatively strong, negatively medium, negatively weak, zero, positively weak, positively medium, positively strong, and positively very strong and denoted as nvs, ns, nm, nw, z, pw, pm, ps, pvs and vs, respectively.

The functions of membership for these linguistic variables are given in Fig. 3.2. They are presented as $\mu_{nvs}, \mu_{ns}, \mu_{nm}, \mu_{nw}, \mu_{z}, \mu_{pw}, \mu_{pm}, \mu_{pm}, \mu_{ps}, \mu_{pvs}$. Linguistic variables determined by decision makers are given in Table 4.6, Table 4.7 and Table 4.8.

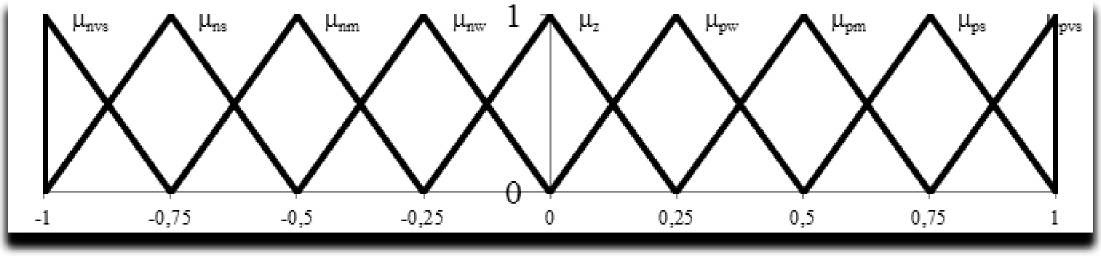

Fig 3.2: The nine membership functions corresponding to each fuzzy term of effect

Table 4.6: The matrix of power of causalities by using linguistic variables according to the Decision Maker 1

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1		ps	ps	z	z	pw	pw	pw	z
C_2	z		pvs	z	z	ps	ps	pvs	z
C_3	z	pw		z	z	z	z	z	pvs
C_4	z	z	pm		z	z	z	ps	z
C_5	z	ps	ps	ps		pvs	pvs	pvs	z
C_6	z	z	z	nm	pw		z	pm	ns
C_7	z	z	z	ns	pvs	ps		pm	ns
C_8	z	z	z	z	pw	pm	z		z
C_9	z	z	z	nw	pw	z	z	z	

Table 4.7: The matrix of power of causalities by using linguistic variables according to the Decision Maker 2

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1		z	pvs	z	z	z	z	z	z
C_2	z		pvs	z	z	z	z	z	z
C_3	z	pvs		z	z	z	z	z	pvs
C_4	z	z	z		z	pvs	z	z	z
C_5	z	pvs	pvs	pvs		pvs	pvs	pm	z
C_6	z	z	z	ns	pw		pm	ps	nm
C_7	z	z	z	ns	z	pm		pvs	ns
C_8	z	pvs	ps	pvs	z	ps	ps		pw
C_9	z	z	pvs	z	z	nvs	nvs	z	

Table 4.8: The matrix of power of causalities by using linguistic variables according to the Decision Maker 3

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1		z	z	z	pm	z	z	z	ns
C_2	pm		ps	z	z	ps	z	z	nm
C_3	z	z		z	z	z	z	z	z
C_4	z	z	z		z	ps	z	ps	z
C_5	pm	pvs	pvs	pvs		pm	pm	ps	z
C_6	z	z	z	nvs	z		z	pvs	z
C_7	z	z	nm	nvs	z	pvs		z	nw
C_8	z	ps	z	pvs	z	z	z		z
C_9	ps	z	pm	z	z	z	z	z	

4.4. Aggregiation of Fuzzy Numbers

Firstly, interrelationships are determined by decision makers. Afterwards, following step is to indicate the causal links for these interrelations. By using MAX aggregation method, which is involved in MATLAB Fuzzy Toolbox, a fuzzy set is created from the fuzzy numbers of decision makers.

4.5. Defuzzification Process

The numerical value of w_{ij} is calculated with the help of COG defuzzification method, which is also involved in MATLAB Fuzzy Toolbox, from a fuzzy set acquired with MAX aggregation method mentioned above. The formulation for the method is as indicated as follows (Ross, 2010).

$$z^* = \frac{\int \mu_{\tilde{A}}(z).z \quad dz}{\int \mu_{\tilde{A}}(z)\, dz} \tag{3.1}$$

4.6. Construction of the Weight Matrix

The weight matrix for satisfaction criteria is given in Table 4.9. This matrix is constructed with aggregation and defuzzification processes, which are mentioned above.

Table 4.9: The weight matrix according to three decision makers' opinions

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1	0,00	0,37	0,45	0,00	0,25	0,13	0,13	0,13	-0,37
C_2	0,25	0,00	0,80	0,00	0,00	0,37	0,37	0,32	-0,25
C_3	0,00	0,31	0,00	0,00	0,00	0,00	0,00	0,00	0,32
C_4	0,00	0,00	0,25	0,00	0,00	0,45	0,00	0,37	0,00
C_5	0,25	0,80	0,80	0,80	0,00	0,65	0,65	0,65	0,00
C_6	0,00	0,00	0,00	-0,67	0,13	0,00	0,25	0,67	-0,40
C_7	0,00	0,00	-0,25	-0,80	0,32	0,67	0,00	0,39	-0,80
C_8	0,00	0,45	0,37	0,32	0,13	0,40	0,37	0,00	0,13
C_9	0,37	0,00	0,39	-0,13	0,13	-0,32	-0,32	0,00	0,00

Afterwards, in degree, out degree, centrality indices are calculated. In degree values are the summation of values for each column numbers of the weight matrix, out degree values are the summation of values for each row numbers of the same matrix and centrality means the summation of the in degree and out degree values. These indices are calculated and given in Table 4.10.

Table 4.10: Indices

Label	Concept	In degree	Out degree	Centrality
C_1	Product Quality	0.87	1.82	2.70
C_2	Product Accuracy	1.93	2.37	4.30
C_3	Complete delivery-case fill	3.31	0.64	3.95
C_4	Time	2.72	1.07	3.79
C_5	IT Capability	0.95	4.59	5.54
C_6	Responsiveness	2.99	2.12	5.11
C_7	Flexibility	2.10	3.24	5.33
C_8	Coordination	2.54	2.17	4.70
C_9	Cost	2.27	1.66	3.93

4.7. Calculating concepts' values

In this section of the application, FCMapper Software is used for computing each customer satisfaction factors' values, by taking into consideration the weighted arcs by formulation (2.7)

The value of a concept Ci, Ai is calculated by taking into consideration the effect of the related concepts C_j on the related concept C_i. The activation level of concept C_i at time t is denoted by A_i^t for each concept. The vector $A^t = [A_1^t, A_2^t, \ldots, A_n^t]$ gives the state of the FCM at time t.

In this thesis, the initial vector $A^0 = [1,1,\ldots,1]$ is activated by Formulation (2.7). By using Formulation (2.7) the values are terminated. The new vector, calculated by using this formulation iteratively, represents the first vector for the upcoming iteration. These vectors are continuously updated by utilizing Formulation (2.7) until positive or negative relationships among the concepts have reached the equilibrium point (Büyükavcu et al., 2016). The concepts' values for customer satisfaction criteria of this study are presented in Table 4.11.

Table 4.11: Concepts' Values

Label	**Concept**	**Concept Value**
C_1	Product Quality	0,62722
C_2	Product Accuracy	0,99104
C_3	Complete delivery-case fill	0,98072
C_4	Time	-0,79927
C_5	IT Capability	0,90746
C_6	Responsiveness	0,99555
C_7	Flexibility	0,99473

C_8	Coordination	0,99172
C_9	Cost	-0,97601

Table 4.11 indicates that two of the customer satisfaction criteria, time and cost, have negative impact on customer satisfaction with logistics services provided to customers. Increasing lead time decreases the quality of logistics services, whereas special discounts, which are given on special occasions such as, full pallet or truck shipment, provide higher customer satisfaction. Product accuracy, responsiveness, flexibility, coordination and complete delivery have positively very strong impact on customer satisfaction as seen on the table 4.11.

For reaching the concepts' values of customer satisfaction factors, criteria influencing the customer satisfaction with the logistics services are listed thanks to a deep literature survey and with the guidance of logistics specialists.

4.8. Scenario Analyses

Scenario 1:

A decrease of the power of complete delivery and case fill level as a factor, causes to an increase on the power of negativity of cost factor. The results of this scenario analysis are provided in Table 4.12. If the company's case-fill level decreases, several products will be out of stock on retailer's warehouse. Because of the second shipment which contains previous missing products, the cost will increase remarkably.

Scenario 2:

If the importance of quality and durability of the shipped products and their packaging increase for the customers, companies need to prioritize their customers' needs and pay more attention on their whole shipment processes. In order to reach flawless shipment processes and avoid damaged products during shipment, tracking and tracing systems' get much more importance. Since, the high level of IT capability provides high level of shipment quality, the power of IT capability factor is seen increased in this scenario. The resulting concepts' values according to the Scenario 2 are given in Table 4.12.

Scenario 3:

If the cost of logistics services isn't a constraint for a customer, in other words, if the value of the cost concept is equal to zero, major changes on the quality and time concepts' values occur. Since the companies operates with the pay for performance mind set in all decision processes, when the cost of logistics services does not exist in decision making process, quality of services received and on time shipment will be crucial for their satisfaction with the quality of logistics services. The results of this scenario analysis are provided in Table 4.12.

Scenario 4:

As mentioned in detail before, in this study flexibility of a company in logistics services represents the ability of responding to changing customer needs in quick and effective way. If the power of flexibility decreases, time will be the factor which affected the most as seen on Table 4.12.

Table 4.12: Scenario Analyses' Results

	No change	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Product Quality	0.62722	0.62304	**0.99000**	0.87619	0.62722
Product Accuracy	0.99104	0.98855	0.99341	0.99301	0.99073
Complete delivery	0.98072	**0.60000**	0.98663	0.99320	0.98501
Time	(0.79927)	(0.79906)	(0.79116)	(0.84319)	(0.56140)
IT Capability	0.90746	0.90710	0.92470	0.93868	0.88455
Responsiveness	0.99555	0.99555	0.99609	0.99208	0.99447
Flexibility	0.99473	0.99473	0.99533	0.99099	**0.70000**
Coordination	0.99172	0.99169	0.99268	0.99223	0.99103
Cost	(0.97601)	(0.98132)	(0.98185)	-	(0.96057)

5. CONCLUSION

Globalization of the economy brings increased competition for all companies. With the increasing number of choices, customers tend to change their behavior more quickly. The ability of accessing the goods and services faster with lower price points has become more and more important for the customers. Satisfying the customers with logistics capabilities in such a competitive market can really help out towards the achievement of upper-level performance and maintained competitive advantage and enhances market and financial performance. Therefore, understanding the customers' satisfaction factors would provide competitive advantage for companies.

In this thesis, FCM methodology is presented to evaluate customer satisfaction in logistics services provided by a fast moving consumer goods supplier by determining customer satisfaction criteria and the relationship between them as well.

FCM is an aggregation of fuzzy logic and cognitive mapping which can be defined as a graphical representation of the perception of a structured system. A FCM composes of factors and each factor presents the important elements of the mapped system. Strength of the causal relations between these factors is presented with the help of directed lines with fuzzy values for each of them. The effect of the factors on each other is calculated iteratively by using a method which is arising from neural network approach until the system stabilizes. In addition, FCM enables users to run different simulations and see the different results of possible scenarios. Also, when exact data are not available, decision makers can use fuzzy numbers or linguistic variables to determinate the power of relationships between pair of concepts with this method.

In this study, in order to identify the values of concepts of customer satisfaction factors, criteria affecting the customer satisfaction with the logistics services are listed through a deep literature survey and with the guidance of two logistics experts. Afterwards, nine criteria were identified and delivered to three different decision makers, one of them is Customer Development Manager and the other is Customer Services and Logistics Manager in the mentioned FMCG Company, whereas the other decision maker is Category Development Specialist in a multinational retailer company which is one of the customers of this FMCG Company. Decision makers presented their opinions. Then, they filled the given tables with the linguistic variables for indicating the power of causal links for each relationship. These linguistic variables are transformed into fuzzy numbers. With the help of MATLAB Fuzzy Toolbox, aggregation and defuzzification of these fuzzy numbers provided from decision makers were done with the help of MAX and center of gravity methods. The final weight matrix was built; outdegree, indegree and centrality values were calculated and provided. Concept values are calculated iteratively. Different scenario analyses are conducted and interpreted to better understand the effect of particular concepts.

Conclusions of the case study show that time and cost has negative impact on customer satisfaction. Increasing lead time decreases the quality of logistics services, whereas special discounts, which are given on special occasions such as, full pallet or truck shipment, provide higher customer satisfaction. Product accuracy, responsiveness, flexibility, coordination and complete delivery have positively very strong impact on customer satisfaction.

In sum, it is appeared that the most important customer satisfaction factors with the logistics services are shipment of the right products, logistics team’s capability to find solutions for unforeseen problems, their flexibility to special or non-usual requests in operations and delivery, coordination and complete delivery of all ordered products.

Moreover, this study can help the companies and especially logistics managers to understand customers’ expectations with the logistics services and to increase customer satisfaction by efficiently concentrating on these expectations and also can be a tool for self-evaluation.

In addition, this study combines the customer satisfaction evaluation in logistics services and FCM methodology. Hence, this will be a novelty for the literature. This study will be an applicative guideline for companies operates in FMCG industry to assess their own performance and for retailers to evaluate the service they get. Therefore, this thesis presents a mutual guiding light and contributing the literature by that.

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