CUSTOMER ORIENTED COMBINED APPROACH IN FLEXIBILITY MANAGEMENT AND AN APPLICATION IN READY TO WEAR SECTOR

(ESNEKLİK YÖNETİMİNE MÜŞTERİ ODAKLI BÜTÜNLEŞİK YAKLAŞIM VE HAZIR GİYİM SEKTÖRÜNDE BİR UYGULAMA)

by

Deniz YENSARFATİ, B.S.

Thesis

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

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Deniz YENSARFATİ
İstanbul, January 7th, 2011

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LIST OF SYMBOLS

AHP : Analytical Hierarcy Process

FAHP : Fuzzy Analytical Hierarcy Process

QFD : Quality Function Deployment

WTO : World Trade Organization

R&D : Research and Development

IS : Information System

CR : Consistency Ratio

TFN : Triangular Fuzzy Number

HoF : House of Flexibility

HoQ : House of Quality

ERP : Enterprise Resource Planning

CRM : Customer Relationship Management

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ABSTRACT

Today, the competition in the textile and ready to wear sector has increased significantly due to the ascending globalization. It has become quite difficult to adapt to the market conditions and to sustain profitability at the same time. The environment of the sector is dynamic because of the technological developments, customer behavior, government policies and similar changing factors, in this environment there are plenty of inconsistencies and risks and both internal and external changes occur frequently. Due to these conditions, the structure of the textile sector fluctuates. It is necessary to align to the sector needs and conditions to be able to survive in the sector.

Nowadays, textile and ready to wear sector consists a great share in Turkey's manufacturing capacity. When the development of the Turkish textile sector is evaluated, it will be seen that the total export volume and the share of the ready to wear sector in this volume have increased significantly in the recent years. Today, many Turkish manufacturers present their brands to several markets. Turkey is a good candidate for further developments and to stand out in the sector because of its advantages such as geographical position, production capacity and capability, speed to adapt new technologies, accordance to fashion trends. In spite of these advantages, Turkey does not possess sufficient capital to become a brand and the country image does not support this goal.

In this thesis, as the strategy to be competitive and to have profits, it is proposed that the firm should acquire capabilities to be flexible in its processes and to keep up with the internal and external changes. A decision making model has been constructed using fuzzy analytical hierarchy process (FAHP) and house of flexibility (HoF) derived from quality function deployment (QFD). The purpose of this model is to enable the valid evaluation of the flexibility types and system factors and the right selection of the

flexibility portfolio which will satisfy the customer needs of the targeted high consumer segment. It is not possible for a firm to be flexible in all of its processes. Eventually, there exist certain flexibility types which the company should lean into and invest more than the others. These flexibility types should be selected according to the company requirements that are based on the customer expectations. Consumers have plenty of options to choose from many ready to wear brands. There are many studies in the literature regarding how the customers perceive the brands and the factors which affect product selection.

Firstly, based on these works, the customer needs in the targeted customer segment are designated. These needs are grouped under two categories as emotional and social value/satisfaction and physical and functional value/satisfaction. For this study, the selected customer needs are high quality, product alignment with trends, comfortable and convenient, design, product variety at the store, convenient price, marketing activities, service and brand awareness. It is not possible to satisfy all of the customer expectations; however, these needs are ranked via FAHP to attain maximum customer satisfaction. In the application FAHP has been selected due to the fact that it is one of the best decision making methods incorporating the fuzziness and vagueness within the decision makers' preferences, as in the case of the selected problem. While conducting the research, five Turkish consumers in the targeted segment have filled in the questionnaire and the results of the questionnaire shows that the customers give more importance to emotional and social value/satisfaction than physical and functional value/satisfaction. For the customers in this segment, the joy of purchasing and owning a luxury ready to wear product is very significant. The first four criteria are namely brand awareness, design, high quality and alignment to trends. They constitute 86% of the weights. The common trait in all of these customer needs is that the owner of this luxury product will attract attention in the society and will attain self confidence.

In the next phase of the application, the flexibility types that will correspond to the customer needs are evaluated, in other terms, the customer needs are reduced into company needs. The flexibility types that can satisfy the customer needs are discussed with the experts and based on the literature review and the expert opinions the following flexibility types are selected: in the manufacturing flexibilities product-mix flexibility,

new product flexibility, volume flexibility, machine flexibility, workforce flexibility and delivery time flexibility and in the management flexibilities design flexibility, market flexibility, information system flexibility, logistics flexibility, spanning flexibility, strategic flexibility and R&D flexibility. Using HoF which flexibility types satisfy customer requirements and up to what extend are evaluated. First five flexibility types, namely design, new product, market, spanning and R&D flexibilities consists majority of the weight. Later on in the application, a second house is modeled where the flexibility levers are segregated into system factors. System factors picked up from the literature with the experts' aid are raw material, business development, creative team, supply chain, product development, organization structure, technology, system capacity, information systems, workforce, R&D and retail and marketing systems.

In the conclusion, the results of the combined approach are discussed and future work that can develop and improve the current study is denoted.

RESUME

De nos jours, la concurrence dans le secteur du textile et du prêt-à-porter augmente de plus en plus à cause de la globalisation mondiale. Il est devenu assez difficile de s'adapter aux conditions du marché et de maintenir la rentabilité en même temps. L'environnement du secteur est dynamique à cause des développements technologiques, du comportement des clients, des politiques gouvernementales et des autres facteurs qui changent avec le temps et à cet environnement, il y a beaucoup d'incohérences et de risques et les changements internes et externes se produisent fréquemment. La structure du secteur change sous ces conditions. Il est nécessaire d'être en harmonie avec les besoins du secteur et ses conditions pour pouvoir survivre.

Aujourd'hui, le secteur du textile et du prêt à porter forme une grande partie de la capacité de fabrication de la Turquie. En évaluant le développement du secteur, on peut voir que le volume total des exportations et la part du secteur du prêt à porter dans ce volume ont augmenté considérablement ces dernières années. Aujourd'hui, de nombreux fabricants turcs présentent leurs marques à plusieurs marchés. Grâce aux avantages comme la position géographique, la capacité de production et le pouvoir, la vitesse de s'adapter aux nouvelles technologies, l'importance donnée aux tendances de la mode, la Turquie est un bon candidat pour des développements ultérieurs et de se démarquer dans le secteur. En dépit de ces avantages, la Turquie ne possède pas suffisamment de capital pour devenir une vraie marque et l'image du pays ne supporte pas cet objectif.

Dans ce mémoire, pour être compétitif et pour avoir de grands profits dans le secteur, la stratégie proposée est d'assurer la flexibilité dans les processus et de fournir une compétence pour pouvoir suivre les changements internes et externes. Un modèle de prise de décision a été construit en combinant le processus de hiérarchie analytique floue (FAHP) et la maison de flexibilité (HoF) derivé du déploiement de fonction de

qualité (QFD). Le but de ce modèle est de permettre l'évaluation des types de flexibilité et de facteurs du système et de choisir la meilleure portefeuille de la flexibilité qui satisfera le plus les besoins des clients cibles dans l'application.

Pour une entreprise, il n'est possible d'être flexible dans tous les processus. Sûrement, il existera des types de flexibilité que l'entreprise doit attirer l'attention et doit investir plus que les autres. Ces types de flexibilité doivent être choisis selon les besoins de l'entreprise basés sur les attentes des clients. Aujourd'hui, les consommateurs ont beaucoup d'options de marques de prêt à porter. Il existe de nombreuses études dans la littérature sur la perception des marques des clients et sur les facteurs qui influent la sélection des produits.

Tout d'abord, les besoins des clients sont choisis pour le segment de la clientèle ciblé en se basant sur la revue de littérature. Ces besoins sont regroupés sous deux catégories : valeur/satisfaction émotionnelle et sociale et la valeur/satisfaction physique et fonctionnelle. Pour cette étude, les besoins des clients sélectionnés sont la qualité, la conformité avec les tendances, l'état confortable et pratique, la conception, la variété des produits à la boutique, le prix convenable, les activités de marketing, le service et la notoriété de la marque. Il n'est pas possible de satisfaire toutes les attentes des clients, mais ces besoins sont classés en utilisant la méthode FAHP pour atteindre la satisfaction maximale du client. Dans cette application FAHP a été choisi puisqu'il est l'un des meilleures méthodes de prise de décision intégrant le flou et l'imprécision dans les préférences des décideurs, comme dans le cas du problème sélectionné. En effectuant la recherche, cinq consommateurs turcs dans le segment ciblé ont rempli le questionnaire et le résultat du questionnaire montre que les clients donnent plus d'importance à la valeur/ satisfaction émotionnelle et sociale que la valeur/ satisfaction physique et fonctionnelle. Pour les clients de ce segment, la joie d'achat et de possession d'un produit de prêt à porter luxe est la plus importante. Les quatre premiers critères sont notamment la notoriété des marques, le design, la qualité et la conformité avec les tendances. Ils constituent 86% du total. Le trait commun de tous ces besoins est qu'ils permettent au propriétaire d'attirer l'attention dans la société et de faire confiance en soi même.

Dans la phase suivante de l'application, les types de flexibilité qui correspondent aux besoins du client sont évalués, en d'autres termes, les besoins du client sont réduits en besoins de l'entreprise. Les types de flexibilité qui peuvent satisfaire les besoins des clients sont discutés avec les experts et en se basant sur la revue de la littérature et sur les avis des experts, les types de flexibilités sélectionnées sont les suivants: la flexibilité de mix-produit, la flexibilité de nouvel produit, la flexibilité de volume, la flexibilité de machine, la flexibilité de main-d'œuvre et la flexibilité de temps de livraison dans la catégorie des flexibilités de fabrication et la flexibilité de design, la flexibilité de marché, la flexibilité de système d'information, la flexibilité de logistique, la flexibilité d'harmonie, la flexibilité de stratégie et la flexibilité de R&D dans la catégorie des flexibilités de gestion. En utilisant la méthode HoF, on évalue quels types de flexibilité peut satisfaire les besoins des clients et de quel degré. Les 5 premiers types de flexibilité sont les flexibilités de design, de nouveau produit, de marché, d'harmonie et de R & D et ils composent la majorité du poids. Apres, une deuxième maison est formée où les leviers de flexibilité sont séparés en facteurs du système. Les facteurs choisis de la littérature avec l'aide des experts sont les matières premières, le développement des affaires, l'équipe de création, la chaîne logistique, le développement de produit, la structure organisationnelle, la technologie, la capacité du système, le système d'information, le système de R & D, la main-d'œuvre, et le système de détail et de marketing.

Dans la conclusion, les résultats de l'approche combinée sont discutés et les travaux futurs qui peuvent améliorer et développer cet étude son présentés.

ÖZET

Günümüzde artan küreselleşme ile birlikte, tekstil ve hazır giyim sektöründeki rekabet artmıştır. Değişen pazar koşullarına uyum sağlayabilmek ve aynı zamanda karlılığı sürdürebilmek çok zor hale gelmiştir. Teknolojik gelişim, tüketici davranışları, devlet politikaları gibi değişen faktörler yüzünden dinamik bir ortam oluşmaktadır, bu ortamda belirsizlikler ve riskler çoktur ve iç ve dış değişimler çok fazla yaşanmaktadır. Bu durumlara göre tekstil sektörünün yapısı da değişmektedir. Sektörde var olabilmek için sektör ihtiyaçlarına ve durumlarına ayak uydurmak gerekmektedir.

Bugün, tekstil ve hazır giyim sektörü Türkiye'nin üretim hacminde büyük bir oranı oluşturmaktadır. Türk tekstil sektörünün gelişimi değerlendirildiğinde, toplam ihracat hacminin ve hazır giyim sektörünün bu hacimdeki oranının geçtiğimiz yıllarda hızla arttığı görülmektedir. Günümüzde pek çok Türk üreticisi birçok pazara markasını sunmaktadır. Türkiye, coğrafi konum, üretim kapasitesi ve kabiliyeti, yeni teknolojileri adapte etme hızı ve moda trendlerine uyum sağlama gibi avantajları sebebiyle sektörde daha fazla ilerlemeye ve öne çıkmaya adaydır. Bu avantajlara rağmen, Türkiye küresel bir marka olmak için gerekli sermayeye sahip değildir ve ülke imajı bu hedefi desteklememektedir.

Bu tezde önerilen strateji, firmanın rekabet edebilmesi ve karlı olabilmesi için, süreçlerinde esnekliğin ve iç ve dış değişimlere hızlıca ayak uydurabilecek yetkinliklerin sağlanmasıdır. Bulanık analitik hiyerarşi yöntemi (FAHP) ile kalite fonksiyon göçerimi (QFD) yönteminden geliştirilmiş esneklik evi (HoF) yöntemi kullanılarak bir karar verme modeli oluşturulmuştur. Bu modelin ana amacı, esneklik ve sistem faktörleri değerlendirmesinin doğru biçimde yapılmasını ve hazır giyim sektöründeki örnek firmanın hedeflediği üst segmentteki müşteri ihtiyaçlarını karşılayacak en doğru esneklik portföyünün seçilmesini sağlamaktır.

Bir firmanın tüm süreçlerinde tam olarak esnek olması mümkün değildir. Her firmanın daha fazla önem vermesi ve yatırım yapması gereken esneklik tipleri olacaktır. Bu esneklik tipleri müşteri ihtiyaçlarını temel alan firma gereksinimlerine bağlı olarak seçilmelidir. Günümüzde tüketiciler için birçok hazır giyim markası seçeneği bulunmaktadır. Literatürde hazır giyim sektöründe tüketicilerin markayı algılaması, tüketicilerin ürünleri seçerken dikkat ettikleri faktörler üzerinde birçok çalışma yapılmıştır.

İlk olarak, bu çalışmalar temel alınarak, hedef müşteri segmentindeki müşterilerin ihtiyaçları belirlenmiştir. Bu müşteri ihtiyaçları duygusal ve sosyal değer/tatmin veya fiziksel ve fonksiyonel değer/tatmin kategorileri altında gruplanmıştır. Bu çalışma için seçilen müşteri ihtiyaçları yüksek kalite, ürünün trendlere uygunluğu, rahat ve kullanışlı olması, tasarımı, mağazada ürün çeşitliliğinin bulunması, uygun fiyat, pazarlama aktiviteleri, hizmet ve marka bilinirliliğidir. Tüm müşteri isteklerini karşılamak mümkün değildir fakat maksimum düzeyde müşteri memnuniyeti oluşturabilmek için müşteri istekleri FAHP kullanarak sıralandırılmıştır. Burada FAHP, ele alınan problemde de var olan, karar vericinin tercihlerinde mevcut olan bulanıklık ve belirsizliği de değerlendirmeye katan en iyi karar verme metotlarından biri olduğu için tercih edilmiştir. Araştırmada, hedef segmentteki beş Türk tüketici anket sorularını cevaplamıştır, anket sonuçları tüketicilerin ana kriterler olarak duygusal ve sosyal değere/tatmine fiziksel ve fonksiyonel değerden/tatminden daha fazla önem verdiğini göstermiştir. Bu segmentteki müşteriler için lüks hazır giyim ürünü satın almanın ve bu ürüne sahip olmanın verdiği mutluluk çok önemlidir. Listedeki ilk dört kriter, marka bilinirliği, tasarım, yüksek kalite ve trendlere uygun olmaktır. Tüm ağırlığın yüzde 86'sını oluşturmaktadır. Tüm bu müşteri ihtiyaçlarında ortak olan özelliklik, kişinin bu kıyafete sahip olarak toplum içinde dikkat çekmesi ve kendine güveninin sağlanmasıdır.

Uygulamanın bir sonraki adımında, müşteri ihtiyaçlarını karşılayabilecek esneklik tipleri değerlendirilmiştir, başka bir ifadeyle müşteri ihtiyaçları firma ihtiyaçlarına indirgenmiştir. Müşteri ihtiyaçlarını karşılayabilecek esneklik tipleri uzmanlar ile paylaşılmış ve literatür taraması ve uzman yorumları ile birlikte şu esneklik tipleri öne çıkmıştır: üretim esneklikleri gurubunda ürün çeşitliliği esnekliği, yeni ürün esnekliği,

hacim esnekliği, makina esnekliği, iş gücü esnekliği ve teslim zamanı esnekliği, yönetim esnekliği grubunda tasarım esnekliği, pazar esnekliği, bilgi sistemleri esnekliği, lojistik esnekliği, uyum esnekliği, stratejik esneklik ve ar-ge esnekliği. HoF kullanılarak hangi esneklik tipinin hangi ölçekte müşteri ihtiyaçlarını karşılayabileceği değerlendirilmiştir. İlk beş esneklik tipi olan, tasarım esnekliği, yeni ürün esnekliği, pazar esnekliği, yayılma esnekliği ve ar-ge esnekliği tüm ağırlıkların büyük bir bölümünü oluşturmaktadır. Uygulamada daha sonra ikinci bir ev modellenmiş ve esneklik kaldıraçları sistem faktörlerine ayrıştırılmıştır. Uzmanlar yardımı ile literatürden seçilen sistem faktörleri hammadde, iş geliştirme, yaratıcı takım, tedarik zinciri, ürün geliştirme, organizasyon yapısı, teknoloji, sistem kapasitesi, bilgi sistemleri, iş gücü, ar-ge ve perakende ve pazarlama sistemleridir.

Son olarak bu bütünleşik yaklaşımın sonuçları tartışılmış ve yapılan çalışmanın iyileştirilmesi ve geliştirilmesi için yapılabilecek gelecek çalışmalardan bahsedilmiştir.

1. INTRODUCTION

Textile and ready to wear industry plays a significant role in the economic progress of the developing countries and it is one of the first sectors where the industrialization has started. In today's world, ready to wear sector gains importance more and more each day. The overall economy of the global textile and ready to wear sector is approximately 360 billion dollars and 200 billion dollars of this economy belongs to the ready to wear sector's trade. Major participants of the ready to wear sector are USA, EU and Japan. Although these three exporters conduct business in all over the world, their main suppliers are the countries in the Yellow Sea Region (China, South Korea, Taiwan and Indonesia) and several other Far East countries such as India, Pakistan, Sri Lanka and Bangladesh. Since 2005, the quota limitations regarding the global textile and ready to wear sector trade have been abolished and this has triggered an extensive competitive environment [1].

From Turkey's perspective, ready to wear and apparel industry has a significant share in the country's overall export volume. The country can be stated as successful in this sector and this is due to the geographical closeness to the markets, advantages in raw materials and production, possessing a young working population, contract production chances, etc. However, the firms in the sector do not have the required capital to become globally known brands and the reputation of the country does not support the improvement of the sector image. There are a few globally known Turkish brands and they should have structured strategies to be successful in their target markets.

Today, consumers have plenty of options regarding whom to purchase the ready to wear goods. There exist several studies in literature on the customer perception of the brand and the major factors of brand selection. Brand name, production location, price, originality, style, service quality can be listed as the main elements that affect the

customers' purchase decision. As one can imagine, for the success in the target customer segments, it is crucial to respond to the consumer needs some that are listed above. Textile sector is a dynamic environment where internal and external changes occur frequently, competitiveness is high and uncertainty and risks always exist. For the firms that are keen to follow the fashion trends one of the biggest problems is the fact that their products are seasonal. As a result, the production quantity should be as much as the total demand and only that amount of goods should be kept on the inventory. Due to the fact that the raw materials can be imported from far suppliers, production tact time being short but production period being long, etc. the order quantities should be very well planned. Excess raw materials and the products that are late to be sold in the current season will perish their value in the next season and will be used or sold in lowered prices.

In a dynamic environment where the customer expectations change frequently, firms are supposed to be flexible on their processes and they should develop abilities to adapt to internal and external changes quickly so that they can handle or mitigate the effects of these issues. Flexibility is a necessity to remain competitive and profitable. In literature, the concept of flexibility is investigated extensively and it has been defined on several studies. In this study, flexibility is defined as the ability to cope with changing circumstances or instability caused by the environment and it is characterized as a response to external uncertainty [2, 3]. There exists many flexibility types and because of the fact that a company cannot be flexibility in every concept/process, it should lean on the certain types which will fulfill required customer needs.

The purpose of this study is to evaluate the customer needs of a Turkish company in the ready to wear sector and then to designate the flexibility types and system factors, details of flexibility types, which will fulfill the customer requirements. Firstly, the customer needs should be ranked according to their priorities. In fact this is a decision making problem and Analytical Hierarchy Process (AHP), a multi-criteria decision making methodology which is a technique developed by Saaty and is one of the most commonly used methods in the literature, can be proposed as the method for customer need ranking. Although it is an easy approach to rank the alternatives, in this case the

experiences and judgments of the users are in fact linguistic and vague, and this method cannot fully grasp the evaluation patterns of the decision makers. For handling both the complexity of the group decision making process and the fuzziness of the evaluation, in this application Fuzzy Analytical Hierarchy Process (FAHP) is proposed which is a much better technique representing user preferences in quantitative data improved via use of fuzzy set theory [4, 5]. Secondly, the required flexibility types should be determined and they should be detailed down to system factors. House of Flexibility (HoF) application can be used to find out the flexibility types that will meet the customer needs. In this application, Olgaher and West's [6], house of flexibility work is taken as a basis.

The organization of the thesis is as follows: In Chapter 2, brief information regarding the Turkey's textile and ready to wear sector is provided and by literature review needs of the Turkish consumers are investigated. In the next chapter, an extensive literature review is conducted on definition of flexibility, flexibility management and flexibility types. In Chapter 4, background information on the FAHP and HoF is given. Then the company whose data has been used in the application is presented and numerical illustrations are provided. Finally in Chapter 6, the conclusions drawn from this study and the possible future work are emphasized.

2. TEXTILE AND READY-TO-WEAR SECTOR

The purpose of this chapter is to explain the reason behind selecting textile and especially ready to wear sector in Turkey through pointing out the importance and the position of the sector and then to explain the customer expectations. Firstly, general information on the Turkish textile sector is provided supported by the industry data. The advantages of Turkey that play role in making the sector so significant, the disadvantages that slow down the positive progress of the sector despite the advantages and the future threats are detailed down. In the second part of this chapter, the customer expectations on the ready to wear goods are stated via literature review.

2.1. REVIEW ON THE SECTOR IN THE WORLD AND TURKEY

Textile production in Turkey goes back to the times of the Ottoman Empire; in 16th and 17th centuries it has been a widely developed industry and textile has been the main source of the overall industrial activities till the fall of the empire. During the first decades of the Turkish Republic, namely 1923-1962, the governments have invested on both the public and the privately owned textile facilities to increase the country's production capacity. The rich cultivation of cotton as the main source of supply has helped this sector to develop extensively on the succeeding years and this also provided support for the development of the ready-to-wear sector and apparel industry. On 1990's, with the high export performance textile sector has gained 11% share on the country's total export volume. According to the statistics of the World Trade Organization (WTO) on 2003, Turkey has been the tenth country in the world with 3.1% market share and second in the EU countries with 4.8% market share. A table is provided below (Table 2.1) which shows Turkey's foreign trade volume (in million dollars) in between the years 2007-2009 and the share of the ready-to-wear sector with

respect to the overall foreign trade volume. In here, the significant role of the ready-to-wear sector is worth recognition [7, 8].

Table 2.1 Turkey's Overall vs. Ready-to-Wear Sector Foreign Trade

	Turkey's Overall Foreign Trade (million $)		**Turkey's Ready-To-Wear Sector's Foreign Trade (million $)**		**The Percentage of Ready-To-Wear Sector to Overall Foreign Trade (%)**	
	Export	**Import**	**Export**	**Import**	**Export**	**Import**
2007	107.272	170.063	15.563	1.517	14,51	0,89
2008	132.027	201.964	15.235	2.118	11,54	1,05
2009	102.139	140.869	12.857	2.017	12,59	1,43

In general, the foreign trade information on sector reports are provided in four groups: agriculture products, mine products, industrial products and other products. From the table provided below (Table 2.2), it can be seen that total export of industrial products constitutes 79% of Turkey's total export volume and ready-to-wear sector constitutes 10,3% of Turkey's total export volume in 2008 [9].

Table 2.2 Turkey's Export Volume for Main Sectors

	Million Dollars			**% Change**		**% Share**		
Sector	**2006**	**2007**	**2008**	**07/06**	**08/07**	**2006**	**2007**	**2008**
Iron and Steel	7.239	9.586	16.842	32,4	75,7	8,5	8,9	12,8
Chemicals (Plastic, pharmaceutical)	3.923	4.739	6.122	20,8	29,2	4,6	4,4	4,6
Other Semi Finished Products (Paper, carton)	7.569	9.669	12.252	27,7	26,7	8,8	9	9,3
Machinery and Transportation Vehicles	26.487	34.251	39.147	29,3	14,3	31	31,9	29,7
Woven Products	7.596	8.950	9.407	17,8	5,1	8,9	8,3	7,1
Ready-To-Wear	12.052	13.886	13.590	15,2	-2,1	14,1	12,9	10,3
Other Products (Shoe, brown good)	4.460	5.926	6.896	32,9	16,4	5,2	5,5	5,2
Total Export of Industrial Products	**69.326**	**87.007**	**104.256**	**25,5**	**19,8**	**81**	**81,1**	**79**
Total Export	**85.535**	**107.272**	**132.027**	**25,4**	**23,1**	**100**	**100**	**100**

On the following table (Table 2.3), Turkey's top twenty export countries in the ready-to-wear sector are listed, as seen Germany is at the top of the list in 2007, 2008 and 2009 [10].

Table 2.3 Turkey's Top 20 Export Countries

COUNTRY	2007 ANNUAL ($)	2008 ANNUAL ($)	2009 ANNUAL ($)	2008/09 % CHANGE	TOTAL SHARE %
Germany	3.179.847.352	3.716.705.781	3.224.452.830	-13	25,1
England	2.618.959.760	2.082.149.687	1.792.019.382	-14	13,9
France	1.053.967.139	1.120.028.204	1.021.742.699	-9	7,9
Spain	949.602.488	966.209.255	954.276.373	-1	7,4
Italy	771.977.555	829.456.007	657.477.335	-19	5,3
Holland	1.046.210.642	1.023.469.630	642.135.041	-37	5
Denmark	520.976.534	477.426.646	401.322.049	-16	3,1
USA	799.862.210	548.044.638	351.245.601	-36	2,7
Belgium	274.618.195	289.636.762	318.022.413	10	2,5
Sweden	298.859.194	297.853.517	264.763.846	-11	2,1
Iraq	88.936.355	134.606.295	205.482.875	53	1,6
Greece	218.328.273	232.623.851	177.682.288	-24	1,4
Austria	160.697.638	191.415.709	172.730.846	-10	1,3
Algeria	146.140.739	137.628.959	169.644.315	23	1,3
Russia	239.444.594	260.774.419	146.488.113	-44	1,1
Istanbul Airport Tax Free Region	168.551.136	155.345.206	123.589.372	-20	1
Switzerland	134.958.575	151.427.316	117.490.722	-22	0,9
Chec Republic	103.622.217	105.675.286	114.912.703	9	0,9
Romania	125.381.142	170.578.445	113.978.732	-33	0,9
Kosovo	12.662.031	101.156.956	110.818.066	10	0,9
Sum of the First 20 Countries	**13.453.603.769**	**12.992.212.569**	**11.098.275.601**	**-15**	**86,3**
Turkey's Ready to Wear and Apparel Export	15.563.491.645	15.234.868.195	12.856.658.483	-16	100
Total Share of the First 20 Countries %	86	85	86		

Next table (Table 2.4) presents Turkey's top twenty import countries in the ready-to-wear sector in the years 2007, 2008 and 2009 [11].

Table 2.4 Turkey's Top 20 Import Countries

COUNTRY	2007 ANNUAL ($)	2008 ANNUAL ($)	2009 ANNUAL ($)	2008/09 % CHANGE	TOTAL SHARE %
P.R.C.	244.747.264	350.503.463	579.393.248	65	28,7
Bangladesh	160.086.955	341.333.605	417.409.327	22	20,7
India	110.842.801	164.055.618	135.855.160	-17	6,7
Italy	147.384.254	172.622.911	111.014.719	-36	5,5
Sri Lanka	30.333.927	58.636.975	62.740.055	7	3,1
Vietnam	32.418.308	70.631.055	54.795.200	-22	2,7
Pakistan	39.212.317	56.074.635	52.977.598	-6	2,6
Indonasia	57.170.554	81.348.217	46.132.573	-43	2,3
Spain	39.787.577	48.057.227	44.297.292	-8	2,2
Morocco	34.011.157	42.918.142	38.715.032	-10	1,9
Malasia	94.300.857	116.832.177	35.012.787	-70	1,7
Egypt	12.073.693	30.186.335	32.818.365	9	1,6
Germany	37.052.571	45.370.986	32.241.911	-29	1,6
Hong-Kong	65.970.874	65.305.125	25.595.046	-61	1,3
Portugal	23.206.843	26.736.276	21.972.565	-18	1,1
England	30.188.388	28.603.931	19.900.586	-30	1
Bulgaria	21.564.505	24.255.918	18.967.342	-22	0,9
France	26.282.527	30.122.037	17.667.154	-41	0,9
Moldova	5.209.858	16.860.980	17.437.011	3	0,9
Romania	20.339.155	20.535.250	15.052.683	-27	0,7
Sum of the First 20 Countries	**1.232.184.385**	**1.790.990.863**	**1.779.995.654**	**-1**	**88,3**
Turkey's Ready to Wear and Apparel Import	1.516.184.385	2.117.836.346	2.016.564.317	-5	100
Total Share of the First 20 Countries %	81	85	88		

The export volumes in the ready-to-wear and apparel industry in the first half of 2009 and 2010 are compared on the following table (Table 2.5), it is the second industry with an increase of %12,5 subsequent to the automotive industry [12].

Table 2.5 Turkey's Export Volumes in Ready-to-Wear and Apparel Industry

	2009 January-July	2010 January-July	Change %
Turkey's Overall Export (in 1000$s)	56.778.185	64.238.856	13,1
Ready-To-Wear and Apparel Industry (in 1000$s)	**7.423.719**	**8.348.497**	12,5
Ready-To-Wear and Apparel Industry's Share on the Overall Export (%)	13,1	13,0	
Industry Exports (in 1000$s)	**44.587.011**	**52.736.806**	18,3
Ready-To-Wear and Apparel Industry's Share on the Industry Exports (%)	16,6	15,8	

Out of the 8.3 billion dollars of ready-to-wear and apparel industry export, 6.7 billion dollars of it has been made to the EU countries on the first seven months of 2010 [12].

There are many factors which have enabled Turkey to become a leading figure in the textile sector. First of all, the country is situated at a very important geographical location, considering the distance to the main textile markets including the EU region, it is one of the closest textile exporting countries. Due to this closeness, transportation times are short and this brings competitive advantage in an environment where agility and rapidity are must. Fashion is a sector which demands very fast response to the customer needs and Turkey as a very close neighbor to the EU region and targeting the close neighbors as the main markets can supply the demands in less than four weeks. On the contrary, Asian rivals can supply ready-to-wear products in no less than two or three months.

Secondly, Turkey has advantages regarding the plentiful supplies and the production capabilities. With an annual average of 900,000 tons of cotton production, the country is the 6th biggest cotton producer on the World; furthermore, plenty of artificial and synthetic fibers are produced in Turkey. There are many rapid and qualified production

facilities and the industry is integrated from the lace to the end product. Besides the geographical closeness, plentiful supplies and the production capacities, Turkey possesses highly educated and young workforce that can meet the increasing HR demand of the sector. As an example to the vast workforce potential, the amount of the blue collar workers is approximately 2 million in the country.

Turkey has been part of the EU Customs Union since 1996 and besides that, has signed many free trade agreements with other countries such as EFTA, Israel, Romania, Macedonia, Croatia, Bosnia Herzegovina, Morocco, Palestine, Syria and Tunisia. Furthermore, Turkey's liberal trade politics and the benefits provided to foreign investors attract a lot of attention and capital. Turkey is a fast learning county regarding the adoption of new technologies and responsiveness to fashion trends. There is a profound infrastructure and an international expertise in the textile sector which bring advantage to generate and support good Turkish brands. If the leading fashion trends on the world are discovered soon and applied in production, then the textile sector will gain many opportunities to expand its export volume.

Although Turkey has many advantages in the textile sector as stated above, there exist many issues and problems in the industry. The industry's reputation is diminished due to the production of fake goods in the country. This problem prevents the success of Turkish companies' branding efforts and branding culture has not developed as fast as the industry's expansion rate. The production is mainly conducted via contract manufacturing where the customers have defined the production preferences. Most of the native manufacturing companies do not possess the sufficient capital to promote, advertise and expand their brands. Whereas multinational companies invest a lot of capital to develop their brands and they conduct global campaigns. They get to rent shop floor at a cheaper cost in shopping malls compared to the native companies in Turkey. As it can be seen from the table below (Table 2.6), production cost is the second highest item succeeding the supply cost [13].

In the production of textile goods, energy is one of the biggest cost items and due to the fact that the energy unit cost is high in Turkey, this brings disadvantage in the global

competition. Firms cannot generate long term plans and strategies due to the fact that the cost items stated above (supply, workforce and energy) fluctuate and increase drastically during the downturns of the national economy. Furthermore, the changeability and unpredictability of government policies create risks for this sector. Besides these issues, ready-to-wear goods can even be produced on small facilities so approximately 50% of the economy generated in this sector is not officially declared.

Table 2.6 Cost Share in Textile Production

Cost Items	Woven Ready-To-Wear Sector Turkey Average	Knitting Ready-To-Wear Sector Turkey Average	Sock Turkey Average	Turkey Average
Main Supply (%)	43	44	55	47
Second Supplies and Accessories (%)	12	11	5	10
Workforce (%)	29	30	22	27
Finance and Depreciation (%)	3	6	8	6
Other Costs (%)	12	9	11	10
Total (%)	100	100	100	100

There are many threats concerning the future of Turkey's ready-to-wear sector such as: economical instability, not finding methods to decrease workforce cost, the harsh competition environment generated by Far East and Asian countries, the probability of emergence of strong Far East brands, the increase of competition in new marketing channels, decrease in the transportation costs.

Although Balkan countries such as Romania can be stated as rivals in contract manufacturing and developed countries such as France and Italy are competitors to originate brands and lead the fashion industry, in reality Far East countries are the main competitors in export. The most prominent rivals are China and India which have very

low workforce cost and high production capacities. In January 2005, volume limitations on textile trade have ended which enabled China and India to dominate foreign markets with their goods. In today's global world, it is evident that Turkey cannot compete with China and India on the low quality goods segment. Turkish manufacturing firms should develop competencies to get strong in the free trade environment, work on branding activities, and invest on R&D and organizational structure. If these precautions are not taken into consideration, then the 20 billion dollar ready-to-wear and apparel industry's export volume might be at risk in the near future.

2.2. CUSTOMER NEEDS IN THE SECTOR

There exist many studies in literature regarding the brand perception and shopping habits of the consumers.

In the fashion sector, the concept of value for the consumers can be expressed both on tangible and intangible terms [14]. Tangible attributes are physical parameters such as type, color, size, length, texture and pattern, whereas intangible attributes can be described as subjective sense and feeling that include silhouette, occasion and fashion trend [15].

According to the interviews conducted with experts by AC Nielsen Research Company, Turkish consumers shopping habbits on ready-to-wear and apparel industry are explained below [16].

Most of the Turkish consumers are not well educated compared to the European consumers to understand the supplies of the purchased good and they are more sensitive about the price. The brand dependency is very low and similar to other Meditarenean neighbors Turkish consumers care about product variety and creativity in design. Religion and regional diversification are two important traits and the shopping preferences and habits of the Turkish consumers in different regions should be evaluted seperately. In daily life, majority of the Turkish consumers do not care about the origins of the goods and they do not even know the nationality of the brands. However,

due to nationalism, in special cases like political crisis consumers become sensitive and quit purchasing the goods of a certain country for some time. Some consumers do not prefer Far East ready-to-wear goods for they do not think that these products are of good quality. On the other hand, some consumers choose Italian and Franch brands for the counter reason, they feel that these brands possess high quality.

Wearing thinner clothing (t-shirts sales have increased during the winter season), increase in the comfort aspect of fashion, putting on globally known brands, keeping up with the latest fashion trends, etc. are elements of local and global fashion styles. In near future, it is expected that customers will get more educated on wearing heathier products, the popularity of technological clothes will increase and multifunctional clothes will be prefered where the life cycle of these fashionable products will be shorter.

AC Nielsen Research Company has conducted market investigation in Istanbul, Ankara and İzmir regarding ready-to-wear goods' consumer habits for the Turquality Project in 2007 [17]. It has been seen that most of the consumers decide on what to purchase at the store while shopping. They are influenced by the preferences of their friends and the advertisements and movies on TV. Most important criterion to choose a cloth is its price; this is followed by purchasing a brand or doing a casual shopping. The brand concept signifies longer usability, an identity, a stunning look, a pride of wearing a quality good, originality. Thus the functionality of the clothes and the pattern of the cloth are also significant. Women care about the tailoring of the cloth and a product of a known brand is acknowledged to be a better cloth, whereas young customers do casual shopping more compared to other segments.

Regarding the perception of the brand concept, the interviewees have been interrogated further. They listed quality, unique design, service, attractiveness, brand and price balance (there exists a prejudice on thinking that low price means defective goods), brand awareness, trendy, warranty to change, usability as part of the brand image. Quite contrary to what is expected, they have not listed the design as a component of the brand. Luxury goods are defined as products with very high prices and original designs.

For a known brand, consumers do not care about which county the production has been made, because the manufacturing firm gives global warranty and support. If the brand is no name, then consumers choose the goods of Italy or France compared to China and India. Foreign brands are preferred by high socio economic segments; however, a native brand which exports to other countries and produces successful goods is preferred also. Not so many products made of polyester, lycra or nylon are purchased because they are thought to be unhealthy; whereas, cloths made of satin and silk are admired, however, they are not favored in daily clothing [16, 17].

The results of the market investigation point out the following shopping habits of the Turkish consumers. 84% of the interviewees believe that the optimum prices can be located on the end season outlets, succeeded by 37% thinking that optimum prices are in the stores where multiple brands are sold. In the investigation, it has been seen that the shopping malls are preferred by majority of the consumers because everything that the consumers are looking for can be purchased on the malls due to product variety and that it is fun to spend time on the malls. 34% of the interviewees have stated that they purchase quality goods from the chain or brand stores where they can rely on the firm and the product excellence. About 10% of the consumers visit not so distant stores on the avenues, because they are used to purchase goods from the same stores not too far from home [16, 17].

Another study conducted by Ayhan Görgülü [18] point out the fact that Turkish consumers primarily care about the goods design and esthetic, if these attributes are suitable then the consumer looks at the price tag. Before the purchase, an informal evaluation is made to compare the quality of the cloth and the price to be paid. In this evaluation, how the product is presented, the packaging, how green the product is are also significant measures. In order to evaluate the good, the consumer controls the information tag and looks at its attributes.

Again from the research conducted by AC Nielsen Company, the sector experts have agreed on the fact that need, beauty/fashion, the urge to own brand clothes, the wish to

wear different clothes compared to the peers, the influence of media on preferences, functionality in hobbies and pricing do affect the shopping habits [16].

In general, it can be stated that if a manufacturing firm is targeting majority of the consumer segments, then it uses mass media such as newspapers, magazines and advertisement billboards. Only global and rich firms use TV as a sales channel and they become sponsors to TV shows and series. Radio advertisements are used during promotional campaigns and internet emerges as a new marketing channel but there is some time till this medium matures [16].

There exist some attributes which have somewhat less influence on the shopping habits compared to the items listed above. These are the visibility/invisibility of the brand logo, accessories of the cloth, product being non-iron, anperspirant, non staining, not itching or not needing dry cleaning, the color options, product being well-made so that it does not worn out soon, product fitting on the body so that it shows the person thinner but hides the body curves, etc. It is obvious that some of these attributes can only be observed once the product is purchased and worn for some time so these are less influential on the purchase but more important for the brand satisfaction [16, 17].

Lastly, consumers are asked to define the ideal product using keywords and phrases. They have expressed the ideal product as being different from equivalents, having multiple model/design options (with/without pockets, loose/tight fitting, with/without décolleté), supplied with quality cloth and thread, getting post-sales support, being purchased with extra accessories in case of worn out, having sufficient information on the tag about the content of the cloth and how to clean it [16, 17].

On Da Silvaa et al's work [19] regarding the international trade in textiles between Portuguese exporters and British retail buyers, it has been stated that cost, work quality, delivery time, responsiveness to requests, innovative ability and good design ideas are important criteria for the exporters to sell their textiles in the British retail market.
Russian Business Consulting firm have conducted an interview with the customers in 2008 in the 15 cities of Russia about shopping habits. The results of this study shows

that the preferences of the customers are shaped according to the manufacturing firms' loyalty card and promotion activities, the location of the stores, whether the brand is famous and trustworthy or not, the product variety in sizes, being able to find accessories at the same store matching with the product to be purchased, pricing policy and store's interior and exterior decoration [20].

To conclude with, in a recent study on the logistics and supply chain management in luxury fashion retail in Italy, critical success factors are asserted by the retail companies as product quality, style and design, country of origin, emotional appeal, brand reputation and creation of a lifestyle. Product quality is considered both for product compliance with the standards and premium manufacturing quality. Products with superior material quality should also appeal to the customer emotions. Product origin such as a label of "Made in Italy" is a significant attribute and means a lot to the consumers. Furthermore, premium service should be provided by the sales personnel so that customers will appreciate the shopping experience and will visit the store frequently. Customers should feel that he/she is part of the brand aura while shopping and wearing the products which are differentiated from other goods and brands. In this study, it is also expressed that in the luxury segment high quality products must be guaranteed so sourcing of the raw materials and production phasing are critical. Specialized suppliers should be preferred developing good and long term relationships. Significant production phases should never be outsourced and should be conducted internally where there is full control [21].

3. LITERATURE SURVEY ON FLEXIBILITY

As seen on the previous chapter, textile sector plays a significant role in the Turkish manufacturing industry and Turkey has many advantages compared to its rivals. However, the country stands out with its manufacturing capabilities. It should satisfy the needs of the target segment consumers in order move forward in becoming a brand. In the prior section, customer expectations are determined by conducting literature review. In this chapter, flexibility is proposed for Turkish firms to satisfy customer needs and to progress in becoming a brand by utilizing its advantages. A general cadre is drawn with the help of the literature review regarding what flexibility is, its significance, flexibility needs of the firms and flexibility types.

3.1. FLEXIBILITY DEFINITIONS

In literature, the concept of flexibility is investigated extensively and it has been defined on several studies. In this section of the thesis, the flexibility definitions from earlier studies are provided.

Mascarenhas [22] is noted as one of the oldest studies on this topic and defines flexibility as the ability of a manufacturing system to cope with environmental variations. Gerwin [23] defines flexibility as ability to respond effectively to changing circumstances. Later, Cox [24] includes the time aspect into the flexibility concept and states it as quickness and ease with which plants can respond to changes in market conditions. Sethi and Sethi [25] explain flexibility as adaptability of a system to a wide range of possible environments. Then, Ramasesh and Maliyakal [26] include the financial aspect, stating flexibility as the ability of a manufacturing system to generate high net revenues consistently across all conceivable states of the nature in which is may be called function. Nagarur [27] expresses flexibility as the ability of the

manufacturing system to cope with changes such as product, process, load, and machine breakdown.

Gupta and Somers [28] define it as the ability to cope with changing circumstances or instability caused by the environment. Newman *et al.* [29] characterize flexibility as a response to external uncertainty. Hyun and Ahn [30] propose to divide the external dimension into reactive and proactive strategies. An adjustment or a response is described proactive when the firm uses the knowledge to impose changes in the environment, such as: responding to customer requests efficiently by incorporating its supplier's new technology to add value to the product portfolio. On the other hand, an adjustment or a response is said to be reactive when the firm copes with changes imposed in the environment by external forces, such as incorporating a new feature to its product soon after a competitor does [31]. Gerwin [32] represents flexibility in four strategies: "adaptive" (defensive or reactive use to accommodate unknown uncertainty); "redefinition" (proactive use to raise customer expectations and gain competitive edge); "banking" (defensive use to accommodate known types of uncertainty); and "reduction" (the use of long term contracts, total quality management) [33]

In short terms, flexibility means the ability to adapt to changing conditions using the existing set and amount of resources; however, in long terms, it measures the ability to introduce new products, new resources and production methods, and to integrate these into the existing production system [34]. Groote [35] states that flexibility is a property of technology in which it can be used as a hedge against diversity of the environment. Upton [36] splits flexibility into two: internal flexibility and external flexibility. In this study, internal flexibility is defined as what the firm can do (competencies) and external flexibility is stated as what the customer sees (capabilities). Upton [36] states that in order to enable flexibility in a manufacturing facility the managers have to decide on certain issues. They should know what needs to change or be adapted to, what is the time horizon for change or adaption and what elements of flexibility are important for their firm. Van Dijk [37] views flexibility as an enabler of the shift from one mix of products and processes to another mix with little penalty in time, cost or performance [38].

Viswanadham and Raghavan [39] list the important performance measures of business processes as: lead time, customer service, dependability, cost, quality, flexibility, capacity and asset utilization. On their literature survey flexibility is defined as a system's capability to cope effectively with a wide range of environmental changes and internal variations without deterioration in system performance in terms of cost, quality, lead time and on-time delivery. Flexibility also requires the managements of subsystems in the supply chain like automation hardware, software, people, organization structure, suppliers, customers, distribution channels, and factory floor control systems. Besides the flexibility, other important performance measures on this work are worth recognition. Lead time reduction can be maintained by eliminating the unnecessary or redundant work, the quality of the customer service must be increased to meet the customer needs on time with the right quantity of products, reliability of product delivery can be boosted by managing dependability and eliminating machine failures, worker absenteeism, etc. Cost cutting strategies should be applied while meeting the quality requirements of the customers and assets should be utilized effectively and efficiently depending on the peak production volumes and low demand seasons. Flexibility management involves the management of company resources such as hardware, software, production lines, employees, organization structure, suppliers, distribution channels and customers to react to changes in the production parameters like time, cost, quality, etc.

Wiendahl and Hemandez [40] partition the flexibility concept into two: modifiability and versatility. Modifiability requires the adaptation of production systems to changing environment needs by changing the structure, character and number of resources of the production system. Versatility describes only the adaptation of production systems within the given available resources and organizational structure [41]. Zhang et al. [42] detail uncertainty as the increasing variety of customer expectations with respect to cost, time, organizational disruptions or performance losses. Bernardes and Hanna [31] state that flexibility is a change management issue which seeks proactive solutions to expected situations. Erol Genevois and Gürbüz [33] view flexibility as the capability of adaptation to change. On their terms, it is a firm’s strategic asset not only to adapt the changes in the environment but also to leverage the environment for better performance.

There exist several studies on differentiating certain concepts from flexibility. Backhouse and Burns [43] and Wadhwa and Rao [44] conclude that agility is dealing with unknown situations whereas flexibility corresponds to managing known issues. Bernardes and Hanna [31] believe that agility, flexibility and responsiveness are not really synonyms; they use prior studies as reference and state that responding quickly and flexibly to the environmental changes and meeting emerging challenges require responsiveness, rapidly reconfiguring the whole system requires agility and changing the current status of the system with respect to the existing configuration needs flexibility. On the other hand, Stanev et al. [41] state that elasticity, agility, adaptability and sensitivity are synonyms for flexibility.

3.2. NECESSITY FOR FLEXIBILITY

In today's fast changing global business environment, firms cannot survive in the market unless they respond to internal and external changes quickly. Intense foreign competition, rapid technological developments, mass-production capabilities, shorter product life cycles and lead times force the manufacturing firms to be flexible in all their processes [31, 32, 42, 45]. Furthermore, customers are less predictable in their behavior of purchasing [46]. They expect the up most from the suppliers: low cost, high quality, low defect rate, high product variety, on-the-spot delivery and maintenance without irritants. Many researches propose flexibility as a solution to adapt to these conditions and gain competitive advantage in the market with regard to dynamic set of customer requirements.

Viswanadham and Raghavan [39], propose flexibility as a tool to cope with uncertainties such as resource variations in human and machine; design and demand changes for products; technological innovation like implementing a new hardware or software; socio-political changes like deregulation. Resource changes might occur due to machinery break up or employee absenteeism. Customers might come up with planned and unplanned design changes, and they might even ask the early transferred lots to be replenished. In some cases for some products, the technology evolves so fast that the manufacturing firm might need to develop new competencies to produce better

and novel products. Lastly, regulations and legislations can have positive or negative effect on the socio-political environment of the firm and the management should cope with these uncertainties.

Regarding how flexibility can increase the efficiency of the supply chain Zhang et al. [47] assert that flexibility should be established throughout the value chain of the manufacturing firm. As a result, firms can introduce new products quickly, support rapid product customization, shorten manufacturing lead times and costs for customized products, improve supplier performance, reduce inventory levels, and deliver products in a timely manner [42].

Looking from the customer expectations' perspective Erol Genevois and Gürbüz [33] list the reasons firms should be flexible as: the need to make design changes quickly, when competitors introduce new models and customers start switching supply sources; to focus on volume flexibility, when large customers reduce inventories and their demand rates become volatile; more flexible product mixes, when importers or domestic competitors start offering multiple quality and price levels; to respond quickly and supply the new products/services, when the customer tastes change quickly. Flexibility is needed to satisfy the customer demand with respect to delivery on time to the right location in required quantity of the right mix of products with the most suitable price.

Regarding financial aspect and profitability, as Hill [48] provides detailed information, effective manufacturing management is not just about technology management, it is configuring the entire manufacturing system to increase the firm's competitiveness and net profit. There are several studies namely Swamidass and Newell [49] and Vickery et al. [50] that find significant positive relationships between manufacturing flexibility and financial performance and Gupta and Somers [51] that find significant positive relationships between manufacturing flexibility and growth performance, which also exists in Vickery et al. [50].

3.3. FLEXIBILITY TYPES

In literature there are many studies regarding how flexibility is categorized and detailed down to many types. In this section of the thesis, a brief summary of the earlier views is provided for background information. Following this literature survey, the frequently mentioned flexibility types are defined comprehensively, giving examples from prior studies. Lastly, a table outlining the distribution of the flexibility types in literature is presented for better top-down view.

Mandelbaum [52] characterize flexibility in two parts: action flexibility, where system can respond to change when an outside intervention occurs and state flexibility where a system responds to change with its existing attributes/dynamics. Slack [53] models flexibility in two layers: system and resource. System flexibility refers to the manufacturing tasks in terms of product, mix, volume and delivery flexibility. Resource flexibility corresponds to different groups of flexibility which facilitate manufacturing tasks. Combination of the studies conducted by Browne et al. [54], Gupta and Goyal [2] and Sethi and Sethi [25] points out eleven types of flexibility: machine, material handling, operation, process, product, routing, volume, expansion, program, production and market flexibility. In Beach et al.'s [55] analysis, the first three of the eleven types are considered as basic system components and the remaining eight types apply to the manufacturing system as a whole. This study provides a diagrammatic interrelationship of these flexibilities (Figure 3.1). In summary it is stated that flexibility can be classified according to how it is perceived (internal vs. external) and over what time scale it is considered (long term vs. short term).

Suarez et al. [56] propose a matrix structure where four flexibility types (mix, new product, volume and delivery time) are matched according to need factors (product strategy, competitor behavior, product demand characteristics, and product life cycle) and source factors (production technology, production management techniques, human resources, relationship with subcontractors, suppliers and distributor relationships, product design, and accounting and information systems). Chambers [57] lists types of

flexibility according to corporate or market strategy, or via the market requirement defined by order-winning criteria [6].

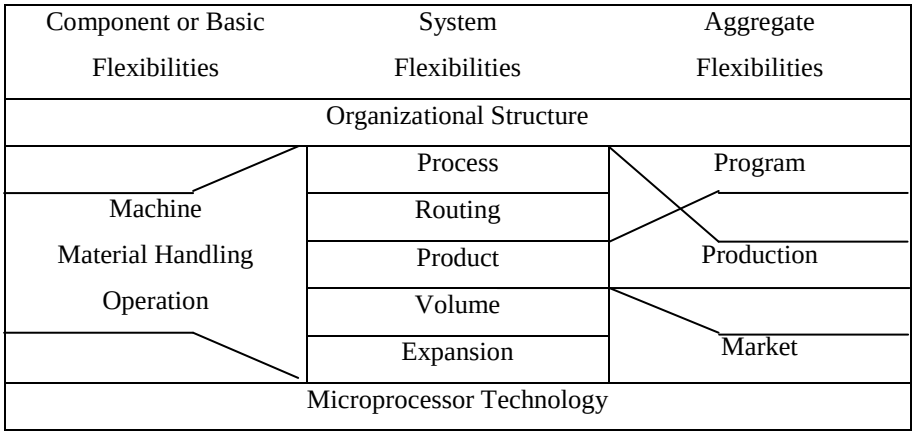

Figure 3.1 Linkages between the various flexibilities

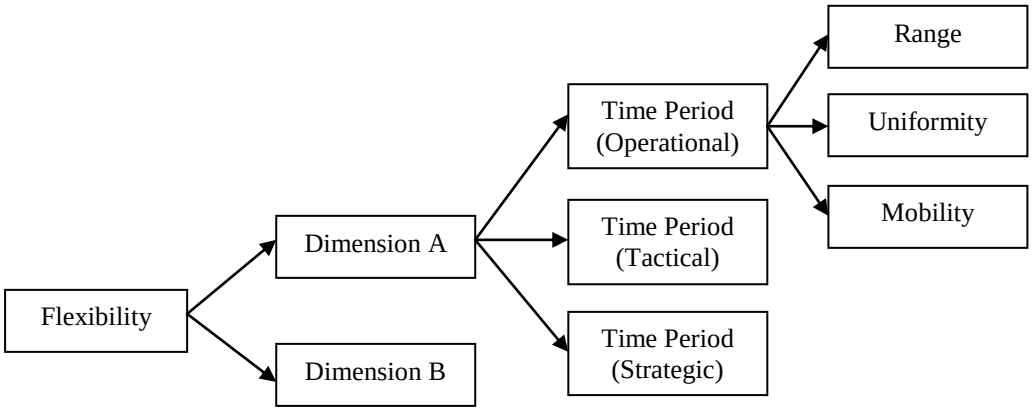

Figure 3.2 Flexibility framework reproduced from Upton

In Upton's [36] work, flexibility is divided into a number of smaller dimensions which can be then defined in time period (operational, tactical and strategic) with respect to range (scope of the flexibility dimension), mobility (ability to transit within the range) and uniformity (the indifference in performance of possible locations within the range) [55]. Upton's segmentation of flexibility types is presented in the figure above (Figure 3.2).

Benjaafar and Ramakrishnan [45] state that the manufacturing system flexibility depends on product and process flexibilities. Product flexibility is split into operation, sequencing and processing flexibility. Process flexibility is drilled down to processor, mix, volume, layout and component flexibility. Furthermore, processor flexibility is divided into five: machine, material, fixture, tooling and labor. Lastly mix flexibility is categorized according to the time span as short, medium or long term.

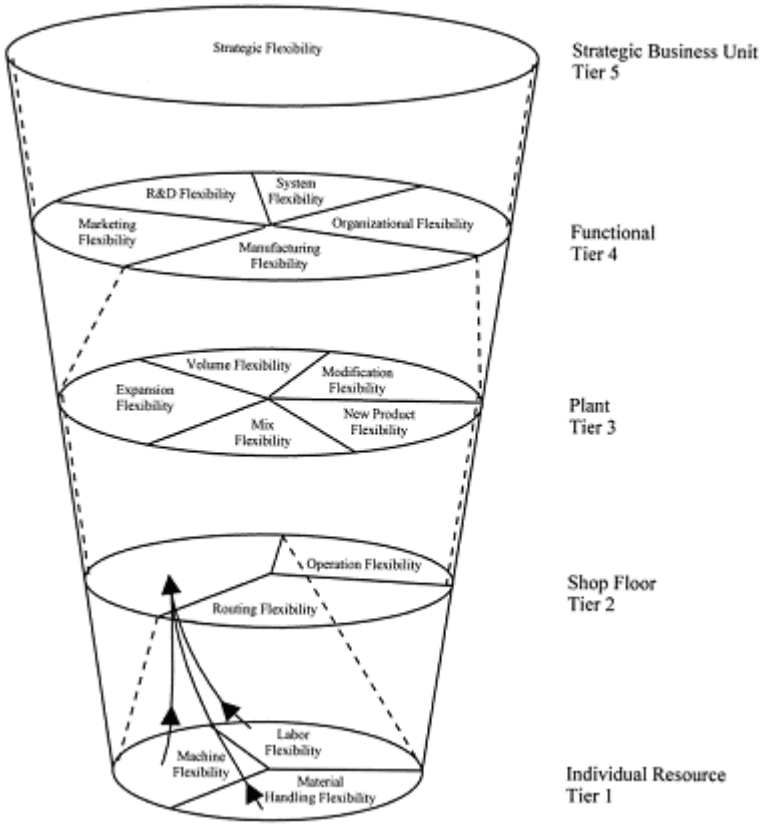

Figure 3.3 Hierarchy of flexibility dimensions

Koste and Malhotra [58] define four elements of flexibility: range-number (R-N), range-heterogeneity (R-H), mobility (M), and uniformity (U). Ten flexibility dimensions (machine, labor, material handling, routing, operation, expansion, volume, mix, new product, modification) mainly discussed in literature are matched with these four elements (Figure 3.3). Lastly, a hierarchy of flexibility dimensions is constructed, including several more flexibility dimensions, in 5 tiers (individual resource, shop floor,

plant, functional, strategic business unit). According to their study, machine, labor and material handling flexibility are situated at the base level on the individual resource tier. On top, lies the shop floor layer which requires operation and routing flexibilities. These two tiers support the plant level where expansion, volume, mix modification and new product flexibility are needed for competitive advantage. Above the plant level, there exists the functional tier constructed by R&D, system, organizational, manufacturing and marketing flexibility which represent the main functions of the firms. Above all of these, strategic business unit is located by the strategic flexibility constituent. In their study two flexibility types are mentioned which are not so frequently emphasized in literature, namely material handling and market flexibilities. Material handling refers to the ability to move different part efficiently on the facility sections and market flexibility is defined as the ability to adapt to a changing market.

D'Souza and Williams [59] explain manufacturing flexibility in two categories and four dimensions. Two categories are externally driven flexibility dimensions that are volume and variety flexibility and internally driven flexibility dimensions which are process and material handling flexibility. The two flexibility dimensions, variety flexibility and materials handling flexibility should be detailed down because they are not involved extensively in manufacturing flexibility literature. Variety flexibility refers to the ability of the manufacturing system to produce a number of products and to introduce new products. Whereas materials handling flexibility represents the ability of effective material delivery to the required manufacturing process.

De Treville et al. [60] define three layers of flexibility: Strategic Flexibility: How organizations perceive and interpret their environment; Tactical Flexibility: Concerns defining and measuring flexibility, as well as the translation of flexibility at the strategic level into the technologies, systems, and structures required to realize such flexibility; Operational Flexibility: Being technically or theoretically capable of varying the process is only the first step toward achieving flexibility.

Besides these categorizations, there are various studies mentioning only several flexibility types without any classification. Emphasizing on this research is important to point out which types are more frequent and worth specifying in this thesis.

In the earliest study, Browne et al. [54] split the flexibility concept into eight: routing, machine, process, product, volume, expansion, operation, and production flexibility. Later on, Malhotra and Ritzman [61], Gupta and Somers [28] and Nandkeolyar and Christy [62] emphasize machine, labor, and material handling flexibility which provide a base for the development of higher-level flexibility dimensions. Chen et al. [63] list product, process, volume and mix flexibility as the major types of flexibility. Dixon [64], Suarez et al. [65, 66] and Upton [67, 68] discuss mix, new product, and modification flexibility for they provide competitive importance in the market place. Viswanadham and Raghavan [39] state that four types of flexibility exist: mix, volume, new product and delivery time. These flexibilities depend on product technology, product management techniques, relationship with suppliers and distributors, human resource management and product design. Routing, delivery time and new product flexibilities are explained in detail from the supply chain perspective where routing refers to generating new transportation routes, delivery time flexibility means changing delivery time according to customer demands and new product flexibility can be maintained only by designing and marketing brand new products simultaneously. Parker and Wirth [69] provide taxonomy of dimensions of comparison for flexibility types (machine, process, product, routing, volume, expansion, operation). Then a correlation matrix is constructed in between flexibility types. Fogliattao et al. [38] list 11 types of flexibility in manufacturing: product, mix, delivery, production, volume, expansion, process, program, routing, machine, labor. How these flexibilities affect the capability of the manufacturing system are discussed and the measures to evaluate the effect are stated. It is concluded at that the choice of the most appropriate flexibility depends on the competitive strategy of the firm, different types of variety and uncertainty that exist in the internal and external environments and the manufacturing process configuration of the production system. Zhang et al. [42] define manufacturing flexibility as the ability of the organization to manage production resources and uncertainty to meet various customer requests. Furthermore they list six sub-constructs

of manufacturing flexibility as machine, labor, material handling, routing, volume and mix. Shuiabi et al. [70] define 11 dimensions of flexibility: machine, material handling, operation, process, product, routing, volume, expansion, program, production and marketing. According to Gong and Hu [71], flexibility can be classifies as machine flexibility, routing flexibility, product flexibility, market flexibility, structural flexibility, and manufacturing-system flexibility. Lastly Erol Genevois and Gürbüz [33] list the types of flexibility as volume, product mix, new product and design flexibilities.

Several flexibility types are defined comprehensively below and examples from prior studies are provided:

Volume flexibility is defined as the ability to change the level of output of a manufacturing process. It shows the competitive potential of the firm to increase production volume to meet rising demand and to keep inventory low as demand falls [72]. It ensures profitable operation at different production volumes [33]. In order to be volume flexible, production line should have small setup time to produce and deliver the products in small batches. Volume flexibility is significant especially in volatile markets [39].

Product mix flexibility is adopted to deal with uncertainty about the products that will be demanded by customers at a particular period [33]. In today's mass production environment, it is a difficult mission both to produce in mass numbers and become product mix flexible, producing different products during the same planning period [32]. Considering the elements of a supply chain, product line should be extendable and capable of changeovers, warehouses and transportation should be able to handle different sizes, shapes and installation requirements to accomplish product mix flexibility. It also directs the producer to work with many suppliers and establishing a multi-supplier environment is difficult to deal with. Information sharing, sustaining a unified quality in products, reducing changeover times, etc. all need a lot of care, time and effort. Furthermore, producing a variety of products means more production planning, control, forecasting and leftovers. Human resource and programmable equipment are the two important issues in mix flexibility [39].

New product flexibility is defined as the ability of a system to add or substitute new products to the product mix [33]. It is a necessity in technology intensive markets. Several new products should rapidly be designed and marketed simultaneously and a cross-functional team should be in charge of all the operations to control time-to-market, customer satisfaction, patenting, navigation through regulatory agencies, etc. [39]. A variety of new, innovative products is needed to be launched with minimal disruptions and loses [67, 73]. As Clark and Fujimoto [74] point out, it boosts the manufacturability of products by simplifying their structure and facilitating process improvements. Recent literature emphasizes at least two important issues for the management of product development: set-based product conceptualization (product concept flexibility - CF) and rapid prototyping (product prototype flexibility - PF). CF allows firms to originate a variety of different product concepts and PF facilitates a firm to create multiple working models of a product [75].

A firm is described as strategically flexible if major changes in the environment can be recognized as soon as they occur and precautions are taken as soon as possible to halt the negative effects of these changes [76].

Design flexibility is defined as the ability to change the design of a product very economically and quickly [33].

Materials flexibility is the ability of the manufacturing system to accommodate uncontrollable variations in the materials and parts being processed [32].

Delivery time flexibility is defined as the ability of a system to reduce the order-to-delivery time. If the manufacturer can reduce or expand the delivery time as per customer requirements according to the rush orders and delayed shipment requests then the firm is considered delivery time flexible. In this type of flexibility rescheduling, excess capacity in all resources, low variation in lead time, quick change-over times are important factors [39].

Expansion flexibility requires expanding the system capacity as needed, easily and modularly. Information system flexibility demands an agile IS where a major change will not be required in the systems to support requirements of the supported business processes [76].

Wang and Chuu [77] mention value chain flexibility which encapsulates product development, manufacturing, logistics and spanning flexibilities that deals with satisfying customer needs effectively and efficiently. With the aid of value chain flexibility, firms can introduce new products quickly, shorten the time to market, decrease the production costs, improve the relations with the suppliers, reduce the level of inventory carried and satisfy customer needs.

Routing flexibility is the ability of the supply chain to produce and deliver to the customer through alternate routes or performing each function (manufacturing, warehouse facilities, etc.) on more than one location. Efficient scheduling is a must for routing flexibility [39]. Rerouting flexibility is described as the ability to change the sequence of steps in the production process through which the product must progress [32].

Changeover flexibility is the ability of the system to adapt to changes in the production process [32].

Modification flexibility is defined as the ability of the system to incorporate design changes into a specific product [32].

Spanning flexibility facilitates the organization of different process departments or groups which will take part in product design, production, and delivery processes [78].

Process flexibility is defined as the ability to produce different products with minimal delay. A manufacturing system has the expansion flexibility if the production system can be expanded easily and modularly when needed [78].

Operational flexibility is maintained when for a given part of the product the sequence of manufacturing operations can be changed easily without any interference [78].

Program flexibility is stated to be the ability of the manufacturing system to run a long period of time unaccompanied [55].

Market flexibility refers to the ease of adaptation to changing market environments [55]. Market flexibility involves the ability to have a high market share and international presence [76].

Logistics flexibility aids the transfer of materials from one site to another in a manufacturing environment [78].

Flexibility responsiveness is the ability to adjust emphasis on the above flexibility dimensions given changes in the internal or external environment [32].

Flexibility types mentioned in the literature are listed in the table below dating from present to past (Table 3.1).

Table 3.1 Flexibility Types in Literature

Flexibility Types	**Mentioned in**
Volume	[33], [72], [70], [77], [38], [42], [55], [58], [69], [39], [45], [51], [79], [67], [32], [80], [63], [81], [56], [82], [53], [83], [84], [54], [85], [86].
Product Mix	[33], [72], [77], [38], [42], [6], [58], [39], [45], [67], [32], [63], [64], [81], [56], [87], [25], [53].
New Product	[33], [58], [39], [64], [81], [56], [25]
Design	[33], [67].
Delivery	[38], [39], [81], [56], [53].
Routing	[70], [38], [42], [55], [58], [69], [51], [67], [45], [88], [89], [87], [25], [90], [54], [91], [86].
Machine	[70], [38], [42], [55], [58], [69], [45], [51], [67], [45], [28], [62], [89], [61], [25], [90], [54].
Product	[70], [38], [55], [69], [45], [67], [63], [53], [83], [84], [90], [54], [91], [85], [86].

Table 3.1 continued Flexibility Types in Literature	
Flexibility Types	**Mentioned in**
Program	[70], [38], [55], [51], [67].
Labor	[38], [42], [58], [45], [67], [92], [28], [62], [61], [93].
Long Term	[45], [67]
Action	[67], [32]
Short Term	[45] , [67]
Operation	[70], [55], [58], [69], [67], [25], [54].
State	[67]
Expansion	[70], [38], [55], [58], [69], [28], [67], [25], [90], [54], [85].
Process	[70], [77], [38], [55], [69], [45], [51], [67], [63], [53], [83], [84], [90], [54], [91] , [86], [52].
Modification	[77], [58], [32], [64].
Production	[70], [38], [55], [50], [45], [51], [79], [53], [83], [49], [84], [90], [54], [86], [52].
Material Handling	[70], [77], [42], [55], [58], [45], [51], [32], [28], [62], [87], [61], [25].
Marketing	[70], [55], [51].
Changeover	[77], [45] , [32].
Rerouting	[77], [32].

3.4. READY-TO-WEAR SECTOR'S FLEXIBILITY DEMAND

Textile sector is a dynamic environment where internal and external changes occur frequently, competitiveness is high and uncertainty and risks always exist. In order to cope with all these issues, the textile firms are supposed to be flexible. They can only gain competitive advantage by promoting their brands and differentiating their products from the rivals'. This differentiation can be via direct product attributes such as quality, trendiness, design as well as managerial aspects like service, brand awareness, etc. Due to the fact that fashion trends change very swiftly, successful textile firms need to develop flexibility responsiveness to adjust to internal and external changes [32].

In this sector, the products are manufactured seasonally and usually the seasons are separated into two as spring-summer and fall-winter. A product for the winter season will not likely be sold in the spring so planning and agility are important. The product life cycles are fast and competition is drastic. Flexibility enables the firms to design new clothes and respond to customer needs as soon as possible even in the current season. Materials used in the production might be sourced from the country where the production will be conducted or they can be sourced from distant countries. Material import from faraway countries such as China or India to Europe might take as much as 150 days which should be taken into consideration. Owing to this information, the first material orders should be given in accordance with the planned production volumes and the possibility of change in the customer orders.

Although the production phases for the textile goods might be identical, the processing of the materials is very divergent. Each model's process flow is projected separately and the production is done according to this flow. There can be processes like embroidery, drawing or procedures special for the model within the flow which might slow down the production. Due to the fact that timing is so essential, the firm should adapt to such changes in the production and should not fall back on the planned schedule.

The products might be sold in different countries to customers with diverse shopping preferences; as a result, it is likely to face a trouble in a portfolio of several markets. Because of a local or global economic crisis or another issue, the customer demand might decrease. Similarly, the majority of a season's collection may not be liked by the target segment so the firm might be in loss for that season in that market. Firm should be open to the customers' feedbacks and should target the upmost customer satisfaction. A wholesale customer might close down his business which means no sales to that customer onwards. On the contrary, another wholesale customer might be increasing the number of stores in his chain which means a boost on the demand. The firm should be able to adapt to such changes in demand by changing its production volume.

4. METHODOLOGY AND BACKGROUND

As mentioned in the first chapter, textile and ready to wear sector is one of the fastest growing sectors in Turkey and this industry is very important for the country's economy due to its large share in exports. However, there exist many uncertainties and risks in the sector which make it quite difficult to respond to the customer needs and the ones that satisfy the customer needs become sector leaders.

To provide a quick solution to deal with all of these issues, flexibility is proposed. As discussed in the previous chapter, there are several flexibility types and it is not possible for a firm to meet all of them. For that reason, firstly the firm should designate the expectations of the target segment customers. Later on, these customer needs should be ranked according to their value, flexibility types that will fulfill these needs should be determined and then these flexibility types should be detailed down to system factors. For this purpose, as the methodology, a decision making model is developed by combining FAHP and HoF.

The objective of this section is to define the reasons for selecting FAHP and HoF; later on the methods are introduced.

4.1. FUZZY ANALYTIC HIERARCHY PROCESS (FAHP)

For handling both the complexity of the group decision making process and the fuzziness of the evaluation, fuzzy analytical hierarchy process (FAHP) is selected. The most suitable AHP form for the specific problem type in this study, Chang's extent analysis method is demonstrated. In this section, firstly the AHP methodology then the fuzziness, due to the fact that FAHP incorporates it, are explained. Later on, the selected AHP form is defined.

4.1.1. Introduction to Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a multi-criteria decision making methodology developed by Thomas Saaty in 1980 [94], while he was conducting research projects in US Arms Control and Disarmament Agency. It was established due to the fact that there existed no simple, easy to implement method for complex decisions at that time. Since the development of this methodology, AHP has been used widely in many decision making problems not just in the defense sector but for business, government, social studies, R&D and other domains because it is a simple and powerful tool [95].

4.1.1.1. Brief Methodology Review

It enables the design of the decision making problem in a hierarchical structure, so that the relationship between the goal, criteria and the alternatives are clearly defined and distinguishable. The processing of a decision problem via AHP consists of the following steps: hierarchically structuring the complex problem, conducting pair-wise comparisons of the sub-criteria, criteria and alternatives, weighing the pairs and checking the consistency of the evaluations [96].

1. Problem Definition: At this step, the decision making problem is defined and the experts decide whether the problem is suitable to be modeled by AHP or not. This decision can be made by verifying that the elements involved in the AHP model can be compared quantitatively.
2. System Observation: With AHP methodology a complex multi-criteria decision problem is decomposed into a hierarchy of goal, criteria, sub-criteria and alternatives. In order to decompose the problem into several levels in details, the system should be observed extensively.
3. Decomposition of the Decision Problem: The decision making problem is separated into a hierarchy of goal, criteria, sub-criteria and alternatives. Any mistake or understatement at this stage might cause imprecise formulation of the model and this will not reflect the reality of the system. Hierarchy is a tree like design, at the top lays the goal (Figure 4.1). Under the goal, the main criteria for decisions are placed and

under each criterion its sub-criteria are listed. At the bottom, the alternatives are put [95].

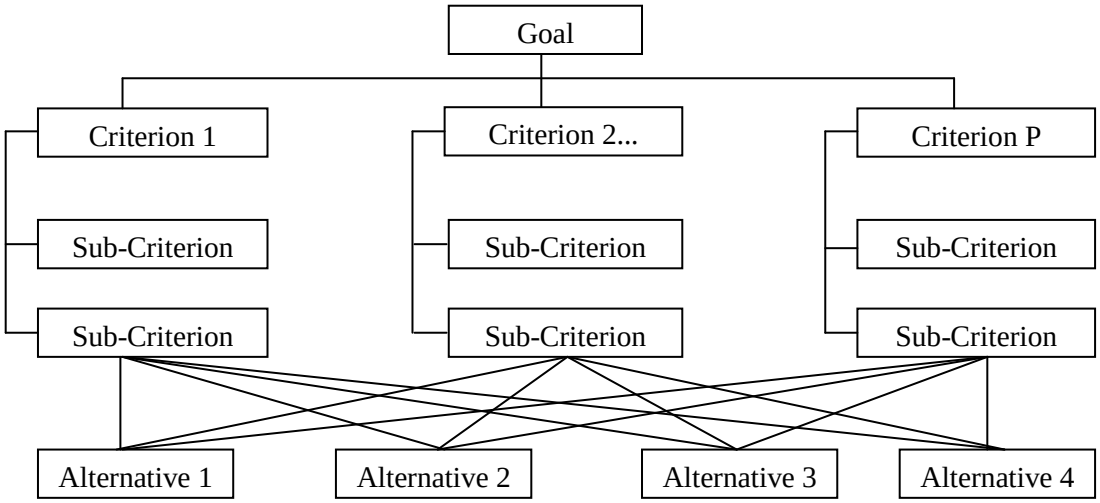

Figure 4.1 Generic hierarchic structure of AHP

4. Priority Assessment: Following the decomposition of the decision making problem, the comparative priorities of the sub-criteria at the same level are determined [95]. At this point Saaty's fundamental scale of absolute numbers is used for pair-wise comparison (Table 4.1).

Table 4.1 Fundamental Scale for Comparison of Alternatives

Option	**Numerical value(s)**
Equal	1
Marginally strong	3
Strong	5
Very strong	7
Extremely strong	9
Intermediate values to reflect fuzzy inputs	2, 4, 6, 8
Reflection dominance of second alternative compared with the first	Reciprocals

For each pair wise comparison table, consistency index – an indicator which points out the fact that an unbiased evaluation has been made – is calculated. This calculation is explained following the AHP steps.

5. Synthesis: Similar to priority assessment of sub-criteria, the weights are scaled up to the criteria and the comparison of the alternatives for each criterion is made to calculate the final ratings of the alternatives.

4.1.1.2. Consistency Ratio

Consistency Ratio (CR) is calculated to evaluate the consistency of the decision maker judgments. If the judgments are found to be inconsistent, then they should be reviewed.

1. Calculation of the Eigenvector: There exist many methods to find the eigenvector. In this application the following method is used. Entries in each row of the matrix are multiplied and the n^{th} root of this product is calculated. The n^{th} roots are added and their sum is used to normalize the eigenvector values.

2. Calculation of λ_{max}: The matrix of judgments is multiplied by the eigenvector to obtain a new vector that corresponds to $A\omega$. According to the AHP theory $A\omega=\lambda_{max}\omega$, so estimates of λ_{max} can be calculated by dividing each component of $A\omega$ by the corresponding eigenvector value. The estimate for λ_{max} is the mean of these values.

3. Calculation of Consistency Index (CI): It is calculated with the following formula.

$$CI=\frac{\lambda_{max}-n}{n-1} \tag{4.1}$$

4. Calculation of Consistency Ratio: It is calculated with the following Formula, in here RI corresponds to the index of consistency for random judgments derived from Saaty's work. In the following table RI value for each order of random matrix is provided (Table 4.2.).

$$CR = \frac{CI}{RI} \tag{4.2}$$

Table 4.2 RI Values for Random Matrix

Order of Random Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Saaty states that the CR is acceptable if it is lower than 0.10. If CR exceeds this value, then the evaluation should be reviewed and improved [97].

4.1.1.3. Advantages and Disadvantages of AHP

As a method of multi criteria decision making methods, AHP encompasses the following advantages:

- It eases the modeling of complex problems and it is also very easy to understand the modeling theory behind the method where there are only a few axioms.
- It is applicable to most of the decision making problems and is widely applied in many domains with the use of many software to solve AHP models.
- Due to the fact that the people who will apply this method to their decision making problems may come from different backgrounds and domains, it is an advantage that the method is simple and easy to use.
- In many cases, a decision is given by a group of people or executives and it is an opportunity to be able to use AHP in group decision making problems. It should be noted that even if the group is very small in number it is likely that every decision maker will point out different issues on every sub-criteria and will have different preferences. When AHP is applied on a group decision making problem, it avoids the long discussions on each sub-criteria and the overall results are discussed which is beneficial for all.

- AHP allows the evaluation of not only the main criteria but the sub-criteria that constitute these so it enables an extensive and an overall assessment for the whole problem
- Both the tangible and intangible preferences are taken into consideration which underlines the fact that AHP is a method in which knowledge, experience, beliefs, thoughts and foresight are combined for a better decision making.
- When the problem is modeled via AHP methodology the issues that have never questioned related to the problem before arise which empowers the decision making process. It encourages a process of learning, debate and revision.
- Due to the fact that a pair-wise comparison is simplier for decision makers compared to one by one evaluation, AHP is a preferred method.
- With the aid of many software tools (Expert Choice, and even MS Office Excel), the pair-wise comparisons can be conducted not only by words (equal important, better, etc.) but by numerical terms (1, 9, 1/5) and graphics.

Limitations and disadvantages of AHP methodology:

- Due to the complexity of the model defined, finding the results for each alternative might become a time consuming and exhausting process.
- When a criterion or a sub-criterion is added or subtracted from the model, the evaluation should be conducted once more which is a time-taking process.
- Pair-wise comparison might lead to inconsistencies due to mistyping preferences, not concentrating on the evaluation process, AHP not being suitable for the specific problem, not calculating the consistency index which might give reference to bias evaluation.
- A suitable hierarchical model should be constructed prior solving the problem by AHP.
- AHP is an evaluation tool where decision makers reflect subjective thoughts, as result the outcome of a model solution can never be stated as “totally valid”.
- As the number of levels or the elements in each hierarchy increase, the number of pair-wise comparison increase drastically. It might take more time to

construct and evaluate the model compared to less structured decision making methods.

Due to the limitations in the Analytic Hierarchy Process, in the application of this study Fuzzy Analytic Hierarchy Process is suggested. In order to understand this methodology, the foundations of the fuzziness concept are provided in the following section.

4.1.2. Fuzziness

In real life, the decision making problems consist of complexity in several levels. Due to the fact that preferences cannot be expressed in numerical terms very clearly, evaluation with linguistic values is a more realistic approach. It is difficult to limit boundaries of the linguistic values so they involve fuzziness and vagueness.

The fuzzy set theory is a mathematical theory designed by Zadeh [98] in 1965 to model the vagueness or imprecision of human cognitive processes [99]. It is a theory of classes with unsharp boundaries where vague data can be represented on fuzzy terms. Since then, Zadeh's theory has been applied to variety of domains that involve decision making with imprecise or incomplete information. In this section, general information on fuzziness is provided for the better understanding of the methodology [100, 101].

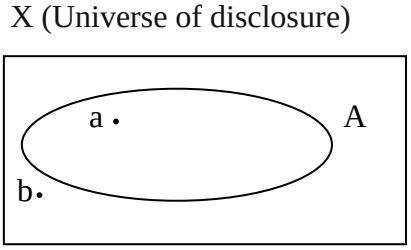

Figure 4.2 Classical Set Representation

A classical set is defined with crisp boundaries, an example is given in Figure 4.2, where the limits are clearly drawn to show which elements belong and which elements

do not belong to the set. On the other hand, fuzzy set is described by vague, ambiguous or incomplete properties as it can be seen in Figure 4.3.

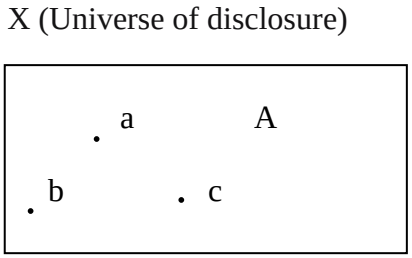

Figure 4.3 Fuzzy Set Representation

A fuzzy set is a class of objects with a continuum of grades of membership that is characterized by a membership function denoted by ($\mu_A(x)$) meaning that the x element has the right to belong to the set A. Each object is assigned a grade of membership ranging between 0 and 1, as the value converges to 1 the condition of belonging to the set is better obtained. A tilde "~" symbol is placed above a set to define it as a fuzzy set [101].

A fuzzy set consists of elements which have varying degrees of membership in the set, whereas in a crisp set, the membership of the elements is 1 only if they are fully, or complete members of the set. These elements which have incomplete memberships might belong to several fuzzy sets. A fuzzy set can be shown as such when the universe of disclose, X, is discrete and finite:

$$\underset{\sim}{A} = \left\{ \frac{\mu_A(x_1)}{x_1} + \frac{\mu_A(x_2)}{x_2} + \ldots \right\} = \left\{ \sum_i \frac{\mu_A(x_i)}{x_i} \right\} \tag{4.3}$$

When the universe of disclosure is continuous and infinite, then the fuzzy set $\underset{\sim}{A}$ can de denoted as:

$$\underset{\sim}{A} = \left\{ \int \frac{\mu_A(x)}{x} \right\} \tag{4.4}$$

In both of the notations, the numerator in each term is the membership value of the fuzzy set $\underset{\sim}{A}$ related to the delimiter provided below the horizontal line. In Figure 4.4 membership function for a sample fuzzy set is provided.

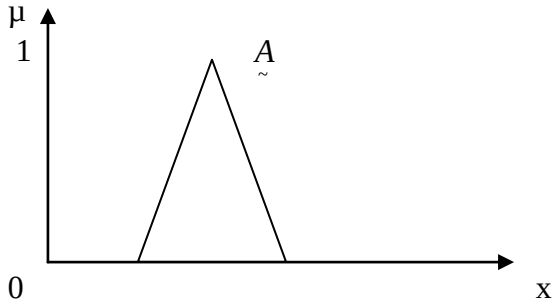

Figure 4.4 Membership function for a sample fuzzy set

The "+" signs in the first notation represent the aggregation or collection operator and not simple addition. In the second notation, integral sign is used to show the continuous function theoretic aggregation operator for the continuous variables.

Several operations can be defined for the fuzzy sets. Assuming that there exist three fuzzy sets $\underset{\sim}{A}$, $\underset{\sim}{B}$ and $\underset{\sim}{C}$ on the universe X, union, intersection and complement set-theoretic operations for these sets can be written as:

Union: $\mu_{\underset{\sim}{A} \cup \underset{\sim}{B}}(\mathrm{x}) = \mu_{\underset{\sim}{A}}(\mathrm{x}) \vee \mu_{\underset{\sim}{B}}(\mathrm{x})$ (to acquire the maximum value) (4.5)

Intersection: $\mu_{\underset{\sim}{A} \cap \underset{\sim}{B}}(\mathrm{x}) = \mu_{\underset{\sim}{A}}(\mathrm{x}) \wedge \mu_{\underset{\sim}{B}}(\mathrm{x})$ (to acquire the minimum value) (4.6)

Complement: $\mu_{\underset{\sim}{\bar{A}}}(\mathrm{x}) = 1 - \mu_{\underset{\sim}{A}}(\mathrm{x})$ (4.7)

The Venn diagrams for these set-theoretic operations are provided below (Figure 4.5, 4.6, 4.7) :

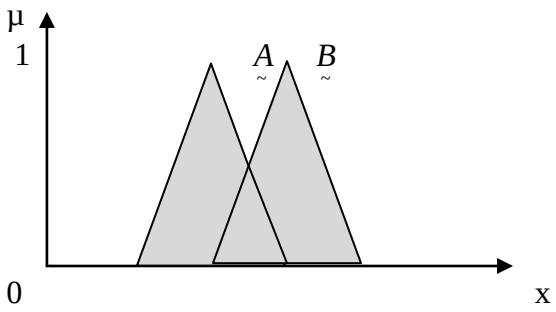

Figure 4.5 Union of fuzzy sets $\underset{\sim}{A}$ and $\underset{\sim}{B}$

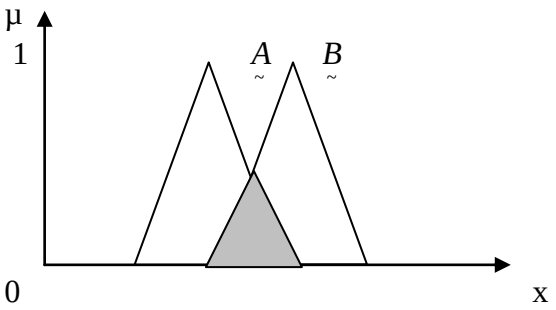

Figure 4.6 Intersection of fuzzy sets $\underset{\sim}{A}$ and $\underset{\sim}{B}$

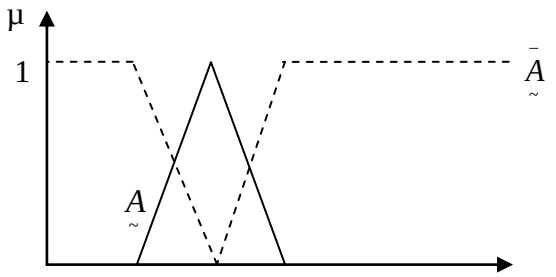

Figure 4.7 Complement of fuzzy sets $\underset{\sim}{A}$

De Morgan's principles for classical sets also hold true for the fuzzy sets as can be seen from the expressions below:

$$\overline{\underset{\sim}{A} \cap \underset{\sim}{B}} = \bar{\underset{\sim}{A}} \cup \bar{\underset{\sim}{B}} \tag{4.8}$$

$$\overline{\underset{\sim}{A} \cup \underset{\sim}{B}} = \bar{\underset{\sim}{A}} \cap \bar{\underset{\sim}{B}} \tag{4.9}$$

All other operations are defined similarly for the fuzzy sets except the excluded middle axioms, they are defined as:

$$\underset{\sim}{A} \cup \bar{\underset{\sim}{A}} \neq X \tag{4.10}$$

$$\underset{\sim}{A} \cup \bar{\underset{\sim}{A}} \neq \varnothing \tag{4.11}$$

Because fuzzy sets follow the same properties of the crisp sets and the membership values of a crisp set are a subset of the interval [0,1], crisp sets can be stated as a special type of fuzzy sets. As a result, the frequently used properties of the crisp sets can be modified for the fuzzy sets as:

Commutativity:

$$\underset{\sim}{A} \cup \underset{\sim}{B} = \underset{\sim}{B} \cup \underset{\sim}{A} \tag{4.12}$$

$$\underset{\sim}{A} \cap \underset{\sim}{B} = \underset{\sim}{B} \cap \underset{\sim}{A} \tag{4.13}$$

Associativity:

$$\underset{\sim}{A} \cup (\underset{\sim}{B} \cup \underset{\sim}{C}) = (\underset{\sim}{A} \cup \underset{\sim}{B}) \cup \underset{\sim}{C} \tag{4.14}$$

$$\underset{\sim}{A} \cap (\underset{\sim}{B} \cap \underset{\sim}{C}) = (\underset{\sim}{A} \cap \underset{\sim}{B}) \cap \underset{\sim}{C} \tag{4.15}$$

Distributivity:

$$\underset{\sim}{A} \cup (\underset{\sim}{B} \cup \underset{\sim}{C}) = (\underset{\sim}{A} \cup \underset{\sim}{B}) \cap (\underset{\sim}{A} \cup \underset{\sim}{C}) \tag{4.16}$$

$$\underset{\sim}{A} \cap (\underset{\sim}{B} \cup \underset{\sim}{C}) = (\underset{\sim}{A} \cap \underset{\sim}{B}) \cup (\underset{\sim}{A} \cap \underset{\sim}{C}) \tag{4.17}$$

Idempotency: $\underset{\sim}{A} \cup \underset{\sim}{A} = \underset{\sim}{A}$ *and* $\underset{\sim}{A} \cap \underset{\sim}{A} = \underset{\sim}{A}$ (4.18)

Identity: $\underset{\sim}{A} \cup \varnothing = \underset{\sim}{A}$ *and* $\underset{\sim}{A} \cap X = \underset{\sim}{A}$ (4.19)

$\underset{\sim}{A} \cap \varnothing = \varnothing$ *and* $\underset{\sim}{A} \cup X = X$ (4.20)

Transitivity: If $\underset{\sim}{A} \subset \underset{\sim}{B}$ *and* $\underset{\sim}{B} \subset \underset{\sim}{C}$, *then* $\underset{\sim}{A} \subset \underset{\sim}{C}$ (4.21)

Involution: $\underset{\sim}{\overline{\overline{A}}} = \underset{\sim}{A}$ (4.22)

The definition of a fuzzy number is provided below.

Let M $\in$ F(R) be called a fuzzy number if:

1) exists $x_o \in R$ such that $\mu_M(x_o) = 1$.
2) For any $\alpha \in [0,1]$,

$A_\alpha = [x, \mu_{A_\alpha}(x) \geq \alpha]$ is a closed interval. Here F(R) represents all fuzzy sets, and R is the set of real numbers [5].

In short for a normal and convex fuzzy set, if an α cut set is a closed interval then it is defined as a fuzzy number. A fuzzy set that has a membership function degree of 1 or above is defined as normal fuzzy set. In other terms:

$\underset{\sim}{A}$ is stated to be normal $\leftrightarrow \max \mu(x) = 1, \quad x \in X$

Convex fuzzy set is defined as such: In case when x$\in$[a,b] then $\mu_{\underset{\sim}{A}}(x) \geq \mu_{\underset{\sim}{A}}(a) \wedge \mu_{\underset{\sim}{A}}(b)$.

In the following figure normal and abnormal fuzzy sets are sketched (Figure 4.8) :

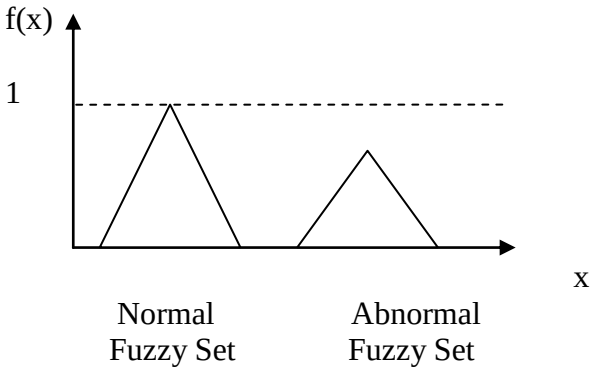

Figure 4.8 Normal and abnormal fuzzy sets

The next figure is provided to distinguish convex and concave fuzzy sets (Figure 4.9):

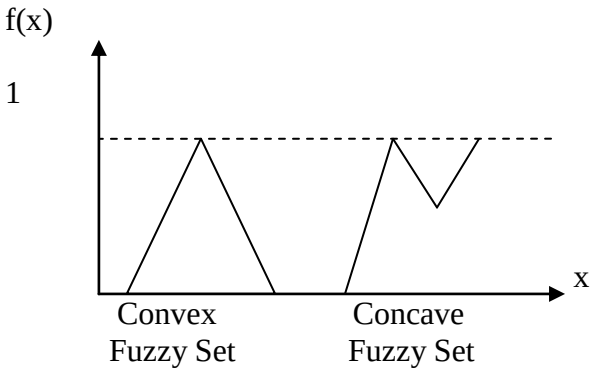

Figure 4.9 Convex and concave fuzzy sets

4.1.3. FAHP Methodology

When the advantages and the constraints of the AHP methodology are considered with respect to the other decision making methods, AHP is preferred as the method for the application. At this point the most suitable AHP version should be selected according to the problem type because different AHP versions exist with several constraints and conditions. FAHP has been proposed as the best decision making method for the problem in this application because it incorporates the vagueness and the uncertainty in

decision makers' judgments regarding the tangible and intangible preferences with fuzzy numbers. It is a better approach compared to the crisp pair-wise comparison in the conventional AHP where imprecise information may lead to misjudgments. A boundary value is defined for each evaluation compared to the crisp and single value in AHP and this boundary covers the mistakes which might be the result of verbal and numeric mismatch. AHP is a methodology conducted based on the subjective perception of the decision maker where missing information for one criterion or sub-criterion might postpone the decision making process, FAHP includes the possibility of not having information on one criterion or sub-criterion. Fuzzy approach defines a holistic decision making process where fuzzy pair wise comparisons will define the vague preferences more rationally.

FAHP consists of many forms, in this paper Chang's [102, 5] extent analysis method has been applied because the processing is relatively easier and it takes less time to compute the results compared to the other FAHP approaches. It more significant for the decision maker to understand the problem rather than to struggle to solve it while handling uncertainty and imprecision so Chang' simple methodology is preferred [103]. The processing steps of Chang's extent analysis method are very similar to the steps of the classical AHP methodology so it is a simple approach. On the contrary, it involves several disadvantages: Chang's method can only be used by triangular fuzzy numbers and if null values are assigned to the importance weight of some criteria then these criteria will be neglected which will lead to not using this information in the evaluations. For further information on the defficiencies of Chang's method, Wang et al.'s [104] study can be investigated where they have examined three numerical examples and suggested improvement issues in this methodology.

Chang's extended analysis method has been applied in many domains such as education [105], defense [106], finance [107, 108, 109, 110], electronics [111], logistics [112, 113], human resources [114, 115, 116], maritime [117, 118], supply chain [119, 120, 103], energy [121, 122, 123, 124], transportation [125, 126], catering [127], health [128], manufacturing [129] , stone [130], information service [131], computer [132] .

Chang's extent analysis method uses triangular fuzzy numbers to decide on the final priority of different decision criteria in pair wise comparisons. At this point, brief information on triangular fuzzy numbers is provided as reference.

4.1.3.1. Triangular Fuzzy Numbers

In this application triangular fuzzy numbers (TFNs) have been used because they are convenient and simple to work with in computations, useful in representation and information processing in a fuzzy environment and are the most preferred in FAHP studies [107]. A triangular fuzzy number, $\tilde{M}$, is shown on the figure below (Figure 4.10).

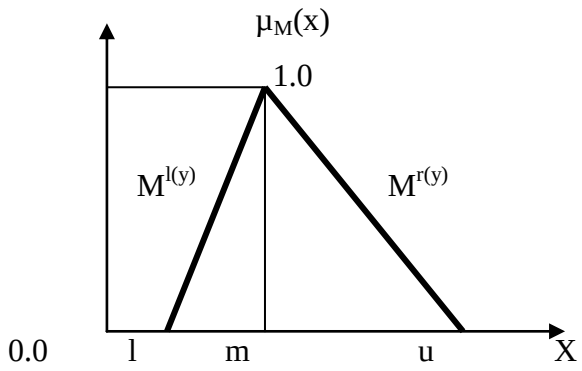

Figure 4.10 $\tilde{M}$ triangular fuzzy number

A TFN is denoted simple as (l/m, m/u) or (l, m, u) where these parameters l, m and u respectively denote the smallest possible value, the most promising value and the largest possible value that describe a fuzzy event [101].

A fuzzy number M on R is defined as a triangular fuzzy number if its membership function $\mu_M(x) : R \rightarrow [0,1]$ is equal to

$$\mu_{\mathrm{M}}(\mathrm{x}) = \begin{cases} \dfrac{x}{m-l} - \dfrac{l}{m-l}, x \in [l, m] \\ \dfrac{x}{m-u} - \dfrac{u}{m-u}, x \in [m, u] \\ 0, \qquad\qquad otherwise \end{cases} \qquad (4.23)$$

where $l \leq m \leq u$, l and u stand for the lower and upper value of support of M respectively, and m for the modal value. In here, triangular fuzzy number can be denoted by (l, m, u). The support of M is the set of elements $\{x \in R \mid l < x < u\}$. When l = m = u, it is a non-fuzzy number by convention.

In order to show the several triangular fuzzy number operations consider two triangular fuzzy numbers M_1 and M_2, $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$. Their operational laws are as follows:

1. $(l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$. (4.24)

2. $(l_1, m_1, u_1) \odot (l_2, m_2, u_2) \approx (l_1 l_2, m_1 m_2, u_1 u_2)$. (4.25)

3. $(\lambda, \lambda, \lambda) \odot (l_1, m_1, u_1) = (\lambda l_1, \lambda m_1, \lambda u_1)$, $\lambda > 0$, $\lambda \in R$. (4.26)

4. $(l_1, m_1, u_1)^{-1} \approx (1/u_1, 1/m_1, 1/l_1)$. (4.27)

4.1.3.2. Extent Analysis Method on FAHP

Let $X = \{x_1, x_2, \ldots, x_n\}$ be an object set, and $U = \{u_1, u_2, \ldots, u_m\}$ be a goal set. According to the Chang's extent analysis method, each object is taken and extent analysis is performed for each goal respectively. M extent analysis values for each object can be obtained with the following signs:

$$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m, \; i = 1, 2, \ldots, n, \qquad (4.28)$$

where all the $M_{g_i}^{j}$ (j = 1, 2, …, m) are triangular fuzzy numbers.

Step1: Let $M_{g_i}^{1}$, $M_{g_i}^{2}$,…, $M_{g_i}^{m}$ be values of extent analysis of i[th] object for m goals. Then the value of fuzzy synthetic extent with respect to the i[th] object is defined as:

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \odot \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \tag{4.29}$$

where the multipliers in this formula are obtained by:

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{4.30}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \tag{4.31}$$

The reciprocal of the last multiplier is:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \tag{4.32}$$

Step2: The degree of possibility of $M_2 = (l_2, m_2, u_2) > M_1 = (l_1, m_1, u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min(\mu_{M_1}(x), \mu_{M_2}(y)) \right] \tag{4.33}$$

and x and y are the values on the axis of membership function of each criterion. This expression can be equivalently rewritten as:

$$V(M_2 \geq M_1) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_{1)}}, & otherwise \end{cases} \qquad (4.34)$$

where d is the highest intersection point μ_{M_1} and μ_{M_2} (Figure 4.11).

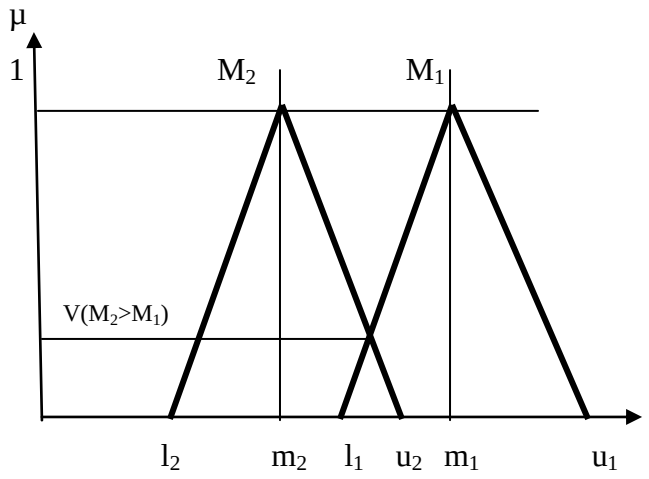

Figure 4.11 The intersection between M_1 and M_2

To compare M_1 and M_2; both values of $V(M_2 \geq M_1)$ and $V(M_1 \geq M_2)$ should be calculated [121].

Step3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers

M_i (i = 1, 2, 3, 4, 5, ……, k) can be defined by

$V(M \geq M_1, M_2, M_3, M_4, M_5, M_6, \ldots\ldots, M_k) = V[(M \geq M_1)$ and $(M \geq M_2)$ and $(M \geq M_3)$ and $(M \geq M_4)$ and …… and $(M \geq M_k)] = \min (M \geq Mi)$, i = 1, 2, 3, 4, 5, ……,k. (4.35)

Assume that $d'(A_i) = \min V(S_i \geq S_k)$

For k = 1, 2, 3, 4, 5, ……,n; $k \neq i$. Then the weight vector is given by:

$$W' = (d'(A_1), d'(A_2), d'(A_3), d'(A_4), d'(A_5), \ldots\ldots, d'(A_n))^T \quad (4.36)$$

where A_i = (i = 1, 2, 3, 4, 5, 6, ……, n) are n elements.

Step4: Via normalization, the normalized weight vectors are given in the following equation:

$$W = (d(A_1), d(A_2), d(A_3), d(A_4), d(A_5), d(A_6), \ldots\ldots, d(A_n))^T \quad (4.37)$$

where W is non-fuzzy numbers.

The opinions of the experts should be combined together for an overall evaluation. Fuzzy importance weights for control criteria according to the membership functions defined in the following table are denoted from each expert's questionnaire results. A triangular fuzzy number $\tilde{D}$ is obtained by putting together the experts' preferences.

$\tilde{D} = (n^-, n, n^+)$ where

$$n^- = \left(\prod_{t=1}^{s} l_t \right)^{1/s}, \forall \ t = 1, 2, \ldots, s \quad (4.38)$$

$$n = \left(\prod_{t=1}^{s} m_t \right)^{1/s}, \forall \ t = 1, 2, \ldots, s \quad (4.39)$$

$$n^+ = \left(\prod_{t=1}^{s} u_t \right)^{1/s}, \forall \ t = 1, 2, \ldots, s \quad (4.40)$$

and (l_t, m_t, u_t) is defined as the importance weight of the expert t.

Due to the fact that fuzziness concept affirms the reality that decision makers can have bias or inconsistency in their judgments, in Chang's extended FAHP, consistency ratio calculation is not conducted as can be seen in the applications in literature [133].

4.1.3.3. Sensitivity Analysis

FAHP methodology is based on the criteria hierarchy developed at the beginning of the problem definition phase; during the problem solution these criteria are evaluated. When a brand new alternative is included to the existing problem set, sensitivity analysis is conducted to inspect the change on other alternatives [134].

Sensitivity analysis for the FAHP evaluation is modeled as such:

A: goal, main criterion or sub-criterion
C_i: i^{th} alternative, main criterion, sub-criterion where i = 1,2, ..., n and j = 1,2,..., n
C_y: new alternative, main criterion or sub-criterion
l_{ij}: the lowest value of the pair wise comparison of the alternative, main criterion or sub-criterion on the i^{th} row and the alternative, main criterion or sub-criterion on the j^{th} column
m_{ij}: the most probable value of the pair wise comparison of the alternative, main criterion or sub-criterion on the i^{th} row and the alternative, main criterion or sub-criterion on the j^{th} column
u_{ij}: the highest value of the pair wise comparison of the alternative, main criterion or sub-criterion on the i^{th} row and the alternative, main criterion or sub-criterion on the j^{th} column
n: Number of alternatives, main criteria or sub-criteria
A general representation of the fuzzy evaluation matrix with the variables stated above is presented in Table 4.3.

Table 4.3 Mathematical Presentation of the Fuzzy Evaluation Matrix

Regarding A	C_1			C_2			.....			C_n		
C_1	1	1	1	l_{12}	m_{12}	u_{12}	...	...	...	l_{1n}	m_{1n}	u_{1n}
C_2	$1/u_{12}$	$1/m_{12}$	$1/l_{12}$	1	1	1	...	...	...	l_{2n}	m_{2n}	u_{2n}
.....	...	...	...	...	...	...	1	1	1	...	...	...
C_n	$1/u_{1n}$	$1/m_{1n}$	$1/l_{1n}$	$1/u_{2n}$	$1/m_{2n}$	$1/l_{2n}$	...	...	...	1	1	1

Table 4.4 Fuzzy Evaluation Matrix for the Goal, Main Criterion or Sub Criterion where the New Goal, Main Criterion or Sub Criterion Is the Best

Regarding A	C_1			C_2			.....			C_n			C_7		
C_1	1	1	1	L_{12}	m_{12}	u_{12}	...	...	...	l_{1n}	m_{1n}	u_{1n}	2/9	1/4	2/7
C_2	$1/u_{12}$	$1/m_{12}$	$1/l_{12}$	1	1	1	...	...	...	l_{2n}	m_{2n}	u_{2n}	2/9	1/4	2/7
.....	...	...	...	...	...	...	1	1	1	...	...	...	2/9	1/4	2/7
C_n	$1/u_{1n}$	$1/m_{1n}$	$1/l_{1n}$	$1/u_{2n}$	$1/m_{2n}$	$1/l_{2n}$	...	...	...	1	1	1	2/9	1/4	2/7
C_7	7/2	4	9/2	7/2	4	9/2	7/2	4	9/2	7/2	4	9/2	1	1	1

The matrix above is constructed with the assumption that the brand new alternative, main criterion or sub-criterion is definitely more significant than the existing alternatives, main criteria or sub-criteria (Table 4.4).

Table 4.5 Fuzzy Evaluation Matrix for the Goal, Main Criterion or Sub Criterion where the New Goal, Main Criterion or Sub Criterion Is the Worst

Regarding A	C_1			C_2			.....			C_n			C_7		
C_1	1	1	1	l_{12}	m_{12}	u_{12}	...	...	...	l_{1n}	m_{1n}	u_{1n}	7/2	4	9/2
C_2	$1/u_{12}$	$1/m_{12}$	$1/l_{12}$	1	1	1	...	...	...	l_{2n}	m_{2n}	u_{2n}	7/2	4	9/2
.....	...	...	...	...	...	...	1	1	1	...	...	...	7/2	4	9/2
C_n	$1/u_{1n}$	$1/m_{1n}$	$1/l_{1n}$	$1/u_{2n}$	$1/m_{2n}$	$1/l_{2n}$	...	...	...	1	1	1	7/2	4	9/2
C_7	2/9	1/4	2/7	2/9	¼	2/7	2/9	1/4	2/7	2/9	1/4	2/7	1	1	1

When it is assumed that the brand new alternative, main criterion or sub-criterion is definitely less significant than the existing alternatives, main criteria or sub-criteria, the matrix is established as such [134], (Table 4.5).

4.2. QUALITY FUNCTION DEPLOYMENT AND HOUSE OF FLEXIBILITY

In this section, QFD methodology and house of flexibility which is derived from this methodology are presented. House of flexibility is introduced based on the study conducted by Olhager and West [6]. QFD is an approach which defines customer needs in a structured way and transforms those into strategic plans. Thus, house of flexibility details down those needs into flexibility types. For that reason, it is proposed to rank the customer needs with FAHP and then convert them to flexibility types and more detailed firm needs via house of flexibility.

4.2.1. Introduction to QFD

The voice of the customer and the customer requirements are usually neglected in traditional production environments. QFD, a broad total quality management implementation, introduced by Yoji Akao in 1966, is a structured approach for defining customer needs and transforming those into strategic plans. In short, this methodology answers the questions to define required product qualities for the customer desires, to develop the functions the product will serve, to provide customer needs satisfactorily.

The name of the method expresses its sole purpose, it is satisfying customers (quality) by translating their expectations into a design and assuring that all organizational units (function) work together to systematically break down their processes into fine details which can be quantified and controlled (deployment) [135].

As stated previously Yoji Akao has developed the Quality Function Deployment with Katsuyo Ishihara of Matsushita Electric in 1965-1967. They defined it as "a method for developing a design quality aimed at satisfying the consumer and then translating the consumer's demands into design targets and major quality assurance points to be used

throughout the production stage.". A similar definition for the service domain can be generated as "a system and procedures to aid the planning and development of services and assure that they will meet or exceed customer expectations.".

According to Akao, with the destruction encountered in the World War II, Japanese companies could only copy and imitate the products of other countries. However, they have seen the fact that for competitive advantage unique and original goods were required. As a result, QFD was introduced in this environment where new product development was a necessity [136]. By 1972, the power and benefits of this approach has been demonstrated at the Mitsubishi Heavy Industries Kobe Shipyard [137] and in 1978 the first book on QFD was published by Mizuno and Akao in Japanese [138].

In this method, customers' needs are converted into substitute quality attributes at the product design phase for product benefits. Then these substitute quality attributes are deployed to the production activities so that necessary control and check points are established prior the start of the production. These two related objectives are the main drivers of the QFD and if they are met then a product which will satisfy the customers' needs and expectations will be designed. This methodology focuses on delivering value to the operations via prioritizing both spoken and unspoken customer requirements and optimizing operations and services to bring competitive advantage in the market. The close awareness on the customer needs turns out to deliver the products with the right specifications and functionalities and this approach tightens the customer loyalty which in return leads to a steady stream of cash flow.

Although QFD has been developed for the manufacturing industry, it has been discovered as a beneficial tool to design services by the service industries. Early applications of QFD in the service organizations go back to 1981 in Japan where a shopping mall, a sport complex and a retail store applied it to their processes. Then hotels, shopping centers, hospitals, airlines, movie theaters have adapted this approach for their customers [139].

4.2.2. QFD Methodology

QFD method consists of four phases. First phase is "Product Planning" where the House of Quality is built. Marketing department leads this phase where the customer requirements, competitive opportunities, product measurements, competing product measures, and the technical ability of the organization to meet each customer requirement are detailed down. It is significant to acquire qualified and realistic data from the customers at this stage. In the "Design Deployment" phase, the engineering department conducts part deployment. Product concepts are created with creative and innovative team ideas to find out the most important product parts to fulfill customer needs. Then the "Manufacturing Planning" stage, also called process planning, is conducted. In here, the manufacturing engineers design the flowchart of manufacturing processes and the target values for each process. Finally the "Production Planning" phase is carried on by the manufacturing and quality assurance departments where the production operations are planned. Risks are evaluated for the manufacturing processes, performance indicators are created.

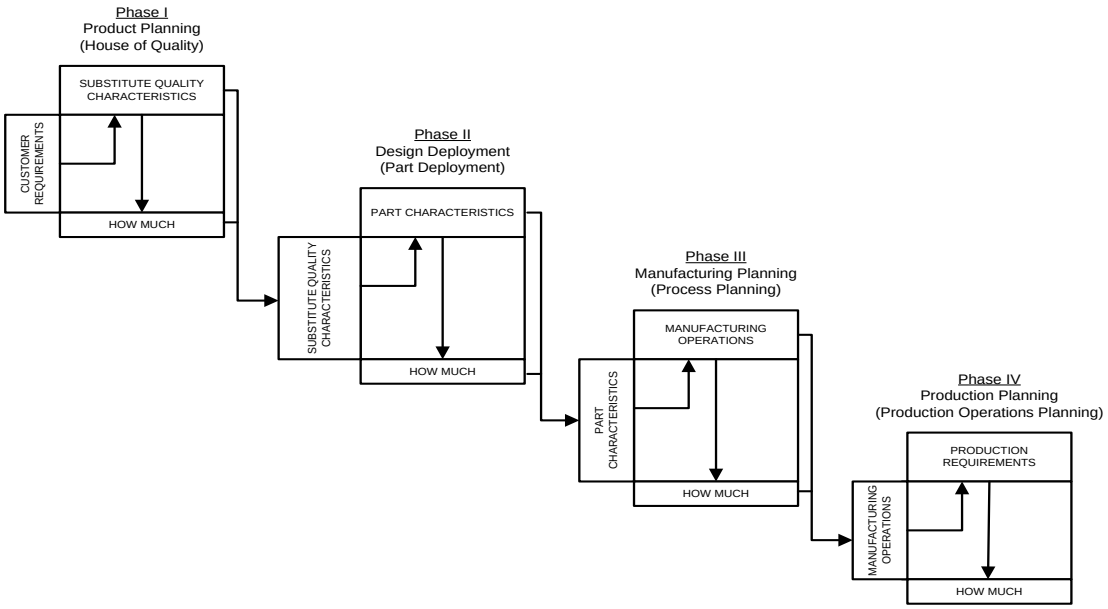

Figure 4.12 Four Phases of QFD

The four phases of QFD is provided above (Figure 4.12). The first phase of the QFD method, Product Planning, consists of 11 steps; each step is applied to fill in certain part of the following house of quality (Figure 4.13).

1. Customer Requirements – "Voice of the Customer": The target market segment is determined and the marketing team gathers the customer requirements for a product or service. Affinity Diagrams or Tree Diagrams are used to organize and evaluate this data.
2. Customer Importance Ratings (Priority): In a scale of 1 to 5, customers are asked to rate their product or service requirements. These rates are used later on in the relationship matrix.
3. Customer Rating of the Competition (Competitive Evaluations): Then the customers are inquired to compare the firm with its rivals with respect to the listed requirements. It is very important to point out the competitive advantage information on each requirement. Additional columns can be added to the customer rating column where information on sales opportunities, goals for continuous improvement, customer complaints, etc. can be gathered.
4. Technical Descriptors – "Voice of the Engineer" (Product Design Requirements): Product or service attributes are defined by the team of engineers to measure and benchmark the planned output.
5. Direction of Improvement: Team of engineers defines the direction of movement for each technical descriptor.
6. Relationship Matrix: Team evaluates the degree of relationship between the technical descriptors and customer requirements. The relationship can be verbally defined as weak, moderate or strong or numerically defined as 1,3 or 9.
7. Organizational (Technical) Difficulty: Design attributes are rated in terms of organizational difficulty.
8. Technical Analysis of Competitor Products (Technical Evaluations): Competitor technical descriptors are compared by the engineering team, some of this work might be through reverse engineering the customer products.

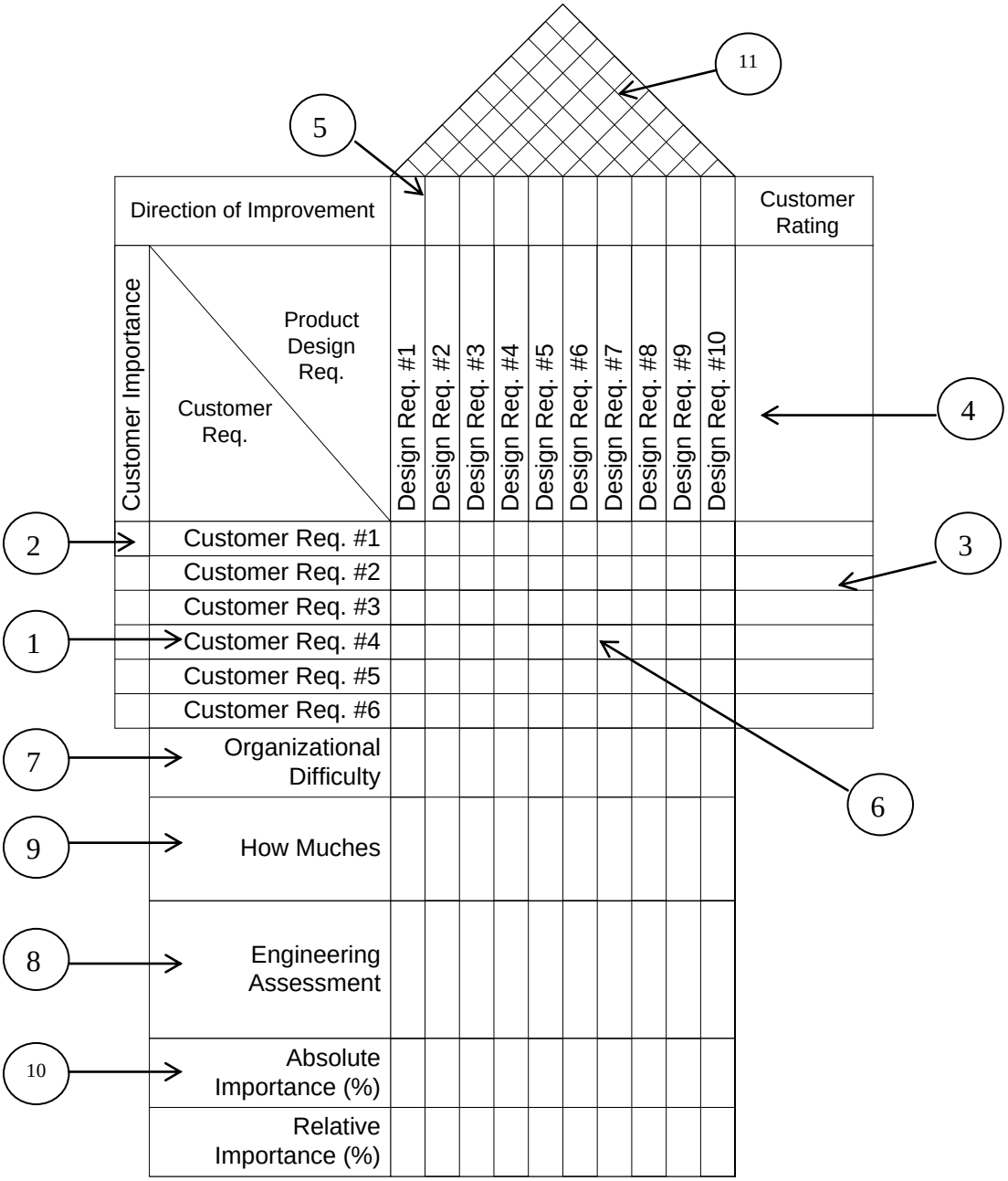

Figure 4.13 House of Quality

These steps are repeated for the last three phases of the QFD method. From the customer evaluations in the phase 1, it shifts to the evaluation of part characteristics by the engineering team in phase 2. Then the manufacturing planning is assessed in the process planning phase. At last production operations planning is conducted.

4.2.3. Advantages and Disadvantages of QFD

Strengths of the Quality Function Deployment

- QFD seeks out both spoken and unspoken customer requirements and maximizes positive quality (such as ease of use, fun, luxury) that creates value. Traditional quality systems aim at minimizing negative quality (such as defects, poor service).
- Instead of conventional design processes that focus more on engineering capabilities and less on customer needs, QFD focuses all product development activities on customer needs.
- QFD makes invisible requirements and strategic advantages visible. This allows a company to prioritize and deliver on them.
- This methodology is easy to use and apply to problems.
- QFD requires less time and resources to utilize.
- QFD reduces the designed products' time to market and it reduces the design changes. As a result, design and manufacturing costs will be lowered down for greater profits.
- As the quality of the products is improved the customer satisfaction will boost. Furthermore, once a product is developed via QFD methodology, the manufacturing firm will be in a good position to design next-generation product.
- QFD combines three powerful concepts into a single design process model: transition from customers' jargon to technical specifics, rational representations of linkages between the customer and the design and knowledge gained from a multifunctional and interactive design team.
- All of the organizational units focus on the product quality and customer satisfaction as a result the efforts are more focused and not wasted.
- Companies can easily make a trade-off between what the customer demands and what the company can produce to meet the demands.
- When client expectations are identified early, the uncertainty is minimized which decreases the risks.
- Design changes at the last minute are reduced.

Limitations of Quality Function Deployment

- Customer perceptions are found by market survey. If the survey is performed in a poor way, then the whole analysis may result in doing harm to the firm.
- The needs and wants of customers can change quickly nowadays. Comprehensive system- and methodical thinking can make adapting to changed market needs more complex.

Assumptions of Quality Function Deployment

- The market survey results are accurate.

Customer needs can be documented and captured and they remain stable during the whole process.

4.2.4. House of Flexibility

Olgaher and West [34] have conducted the house of flexibility application in the telecommunication sector for a manufacturing firm interested in manufacturing flexibility which was redesigning its manufacturing system. In their application house of flexibility is constructed parallel to the QFD's first phase, house of quality.

Table 4.6 The Steps which Build the HoF Relative to HoQ

Step	HoF	HoQ
1	Abilities – competitive priorities	Customer attributes
2	Relative importance – order winners/qualifiers	Relative importance
3	Customer perceptions	Customer perceptions
4	Flexibility characteristics	Engineering characteristics
5	Relationship matrix – linking abilities and flexibility	Relationship matrix
6	Correlation matrix	Correlation matrix
7	Objective measures, including competitor's visible performance	Objective measures, including competitor's products in technical terms
8	Target measures	Target measures

The customer requirements are evaluated with respect to flexibility types; similar steps like the house of qualities' are followed. House of flexibility steps equivalent to the ones in the house of quality method are provided in the Table 4.6 [34]. Similarly, Erol Genevois and Gürbüz [33] have worked on the automotive sector to determine the best flexibility levers' portfolio dealing with consumers' needs for flexibility in term of 5R (right place, right time, right quantity, right product, right price).

Based on the work of Olhager and West [34], house of flexibility model is applied to match these needs with the flexibility capabilities the firm can acquire. The steps below are followed to construct the house of flexibility:

First the customer requirements (competitive priorities) which are demanded by the firm are listed. These are the abilities which will make the firm win customer orders against the rivals. Then the customer importance for each requirement is designated by FAHP methodology. This is calculated by comparing customer needs with each other. Instead of the technical descriptors (engineering characteristics), flexibility types are situated on the columns. These flexibility types are selected by the multidisciplinary team while the literature has been reviewed. A relationship matrix is formed where this team judges which customer attribute impacts which flexibility type and to what degree. Later on, correlation matrix is filled in and the team members examine how flexibility types impact each other. Lastly, absolute and relative importance values are calculated.

5. A FLEXIBILITY BASED RAPID RESPONSE MODEL IN READY TO WEAR SECTOR

As stated in the previous chapters, ready to wear sector has a significant role in the Turkish economy. Although Turkey possesses many advantages to be successful in the textile sector, Turkish textile firms have not progressed quite a lot to become global brands. While textile sector holds a structure which is very variable and ambiguous, customers are less predictable in their behavior of purchasing and this leads to higher uncertainty and variability for the firms. The purpose of this study is to find out the best flexibility lever portfolio satisfying customer needs and providing a quick solution to deal with the uncertainties and the risks this company faces. Eventually with this, customer satisfaction will be maximized in the markets that the firms exist and this will be a step on becoming a brand. For this aim, flexibility is proposed as a solution. It is considered that firms which are flexible in their processes are the ones that have developed abilities to adapt to internal and external changes quickly.

At the initiation step, the customer needs are discussed with the experts of the case company based on the literature review conducted on the previous sections regarding customer needs. The most prominent customer needs in the high consumer segment are chosen. Then a questionnaire is prepared and the selected customer needs are evaluated with the participation of the five Turkish customers in the target segment. For handling both the complexity of the group decision making process and the fuzziness of the evaluation, fuzzy analytical hierarchy process (FAHP) is applied.

Subsequent the ranking of the customer needs, the house of flexibility model based on the work of Olhager and West [34], is applied to match these needs with the flexibility capabilities the firm can acquire. First, the flexibility levers are selected by the same experts with the help of the literature. The relative weights calculated in FAHP are used in the first house of flexibility as weights of the customer needs. Then, experts are asked

to evaluate the relationship in between the flexibility levers and the customer needs. Subsequent to the calculation of the first house, system factors are selected by the experts with the help of the literature. In the second house, the relationship in between the flexibility levers and the system factors are evaluated.

Then, the results and the applicability of the methodology to the real life are discussed with the experts.

5.1. COMPANY SUMMARY

The company whose data has been used in this application belongs to the women's ready to wear textile sector in Turkey. The first boutique has been established in Paris in 1999, at present the firm has showrooms in Paris, New York and Moscow, and more than 500 point of sales as stores and franchises in France, Turkey, Poland, Ukraine, Russia, etc. The company aims to operate in many markets to reach all of the women their brand appeals to, to strengthen their existence in the market and to increase the global brand awareness. Satisfying the customers' needs is their first target to reach the aims stated above.

The company designs the clothes for the women aged between 25-40, who are in the high segment and have high self esteem. On the stores, there are many goods ranging from accessories to shoes, outfits to dresses. This wide product variety is created so that when a customer visits the store, she can purchase all of her needs and she will not need to visit any other brand. With this product variety, customers are free to choose a product with any color, model and accessory, this freedom supports combining good with each other. From the company's point of view, the customer should be able find the shoes and/or the accessories that will fit with the clothes purchased from the store. She should not visit many stores, because shopping must give pleasure and not pain. The music played on the store, the decoration and shop window should support the overall shopping experience and should comfort the customers.

Although the firm has many stores in several countries, it sustains the boutique concept. Annually two collections are designed as spring-summer and fall-winter. Besides these two collections, on demand collections such as New Year, cocktail collections can be designed in addition. A general overview of operations in one season is presented below.

In order to present the brand, French and Italian designers are preferred. During the preparations for the new collection, many print, embroidery, tryout, research and development operations are conducted for the clothes and accessories. Goods in each season are divided into 6 capsules and each capsule consists of clothes with compatible and combinable colors and models. In fact, each capsule can be defined as a mini collection so that in a season although the same clothes are not maintained in every store, a similar ambiance is conserved. When the preparations for the new collection are over, head designer and his team deliver it to the showroom.

Retail and wholesale teams give orders for the collection in the showroom. According to these orders with a projection, raw material orders are given by the purchasing department. Depending on the raw material delivery dates, production plans are prepared and the design team provides information on the design and the models to the manufacturing team. Manufacturing operations are held in Turkey; cutting is done internally, sewing is outsourced. There exist many outsourced firms, the company chooses several outsourced firms for each model. When the manufacturing is over, marketing team conducts the delivery of the end goods with respect to the capsule concept and the sales projections. During the season, marketing activities and product changes are handled due to the sales. Usually small sized stores are opened to provide the feel of a boutique with attractive concepts and collections.

5.2. FAHP APPLICATION

Luxury ready-to-wear clothes appeal to many customers; although these are targeted for the A and B+ customer segments, other customer groups which cannot afford to buy expensive clothing are still interested in and from time to time purchase luxury goods.

In this work, the luxury product needs are categorized into two as:

Emotional & Social Value/Satisfaction: This refers to the concepts of self-expression, social evaluation of this self-expression, seeking for beauty, fashionability, sociability, etc. The customer should enjoy purchasing and owning the luxury good and should feel as part of the brand. This brand will express the customer's status/class in the society and will distinguish the owner from the others. Stability, positive feeling, satisfaction and trust are other emotional values customers seek while purchasing and owing a luxury product.

Functional & Physical Value/Satisfaction: This refers to the benefits the customer will gain by the product's physical functions and usage.

Customer expectations are selected based on the literature review presented in Chapter 3 and are as follows:

High Quality: The customers in the high segment are mainly interested in the quality of the clothing they will put on. According to them, the brand name and the first impression of the outfit designate the quality of the clothing. If the brand is not very well known, then how the cloth fits on the body and the fact that no defaults are seen while trying it on mean that it has high quality. Most of the customers are not well educated on the material of the cloth so their quality evaluations will probably lack this notion. On the other hand, for the firm the same criteria cannot be applied; the management team will state that their ready-to-wear cloth has high quality only if all of the supplies; even the snap, have the required quality standards. It is expected that the supplies have passed the quality tests and premium work has been applied during production. The content and quality of the main supply, the cloth, can be elusive to the customer and if majority of the cloth is made up of silk or Kashmir, this might be enough for the customer to believe that the product has high quality. In reality for the firm, the purity of the cloth, weaving frequency, the processes applied, etc. are significant to tailor high quality products.

Trendy: For the customers, a ready-to-wear cloth is trendy if similar brands or models are worn by celebrities, used in movies or advertised on magazines. If the customers visit fashion shows and see these products, then they will definitely think that the products are trendy and they will be likely to purchase it. Firm defines their cloth trendy if it is in accordance with the trends of the current season. Usually the most famous designers set the trends in the season such as color scale, models, the prominent product group, the content of the cloth, etc. Firms expect to produce clothes which will have similar traits/characteristics with the products of famous designers.

Convenient and Comfortable: Although customers wish to have an outfit which appeals nice, beautiful and modern they also like to be comfortable while wearing it. For the firm, this attribute can be attained only if the design department works aligned with the R&D department. R&D department should develop raw materials with respect to the requirements of the designers and modelists should produce the needed prototypes. Then these prototypes are tested according to how comfortable they fit on the models. For example clothes with embroidery might itch the skin so if the designer wants to come up with a product that has this type of cloth, then the R&D department should develop a two sided cloth which must avoid itching. Likewise, a product that does not require dry cleaning might be more convenient, contrary to silk, and this product might boost the sales.

Good Design: When customer purchases a luxury ready-to-wear product, she also purchases the design of the product. She should feel that this clothing has only been design for her, and not for anyone else. Although the perception of good design might change from customer to customer, in general it can be stated as the good combination of the supplies and the designed model. According to the firm, a good design is possible by selecting and hiring a good designer, this is an important criterion.

Product Variety: Customers want to find the product that they are looking for as soon as they enter the store. For the firm, a customer that has entered the store should buy at least one product and should not leave the store empty handed. In order to accomplish this, the product variety should be established and the customer must find what she is

looking for. Furthermore, customer loyalty will be maximized if she knows that she can find the desired cloth whenever she visits a brand's store, as a result store becomes one of the first places to visit on shopping time. Product variety does not simple mean 10 models from shirt and 10 models from skirt. When customer visits a store she expects to find the shirt that will match the desired pants, a pair of shoes and similar accessories that will look great with the clothes. These customer expectations can only be met by sustaining product variety.

Feasible Price: It is an underestimation that customers who buy luxury clothes do not care about the price. Customers primarily pay for the brand; however, on their mind they do have a certain price to pay and any price tag above or below this value might cause misperception of the brand image. According to the firm management, best supplies and premium production work are significant to designate the price of a product; furthermore, store location, the quality of the sales personnel and similar issues pay important role on deciding the optimum and feasible product price.

Marketing Activities: Although the targeted segments are A and B+ and the customers in these groups are wealthy, everyone likes promotions and campaigns. If these are especially designed and personalized for the customer they will definitely attract attention and will make the customer feel special for that brand. As a result, these promotions and campaigns will increase the sales. For the manufacturing firm, campaigns are good occasions to tighten the relationships with the customers and to increase the brand awareness. These occasions can be special sales percentages during the season, catwalks especially arranged for the customer, invitation to night shopping, notifying the coming sales 2 or 3 weeks earlier by sending card postal, attaching small gifts such as scarf, broche while sending new season catalogs, defining special campaigns to the loyalty cards to be applied above certain sales amounts or customer birthdays, inviting customers to talks with famous designers or trendsetters, etc.

Service: Customers expect have premium service once they enter the store; a good smell and an appropriate music are the first impressions they will get. A warm and smiling welcome with small treat (food or beverage) might be part of their good service

perception. In general, customer service can be categorized into two as pre-service and post-service. Replenishing the colors and sizes that are missing on the shop floor can be pre-service. After repairment, sending purchased products to customer's home, solving the customer problems related to already sold products are just some of the post-service issues. As stated before, by purchasing a luxury cloth customer purchases a qualified service. Although the customer might spend a few hours on the store, looking around and changing different clothes, at the cashier she will state that she does not have spare time and that she cannot wait. The service should be qualified and the sales personnel should be fast while serving the customers. It not something good to keep the customers waiting on the cashier, because they might find the time to evaluate their purchasing decision and leave a good without unpurchased.

Brand Awareness: Customers who purchase luxury clothing are mainly influenced by the brand and how it is perceived on the society. Customers visit the store to purchase a product that has a specific brand. For the company developing and attaining brand awareness are difficult tasks and these require intense marketing activities which will promote the brand name to the targeted segments.

The hierarchical structure for the application can be seen below (Figure 5.1):

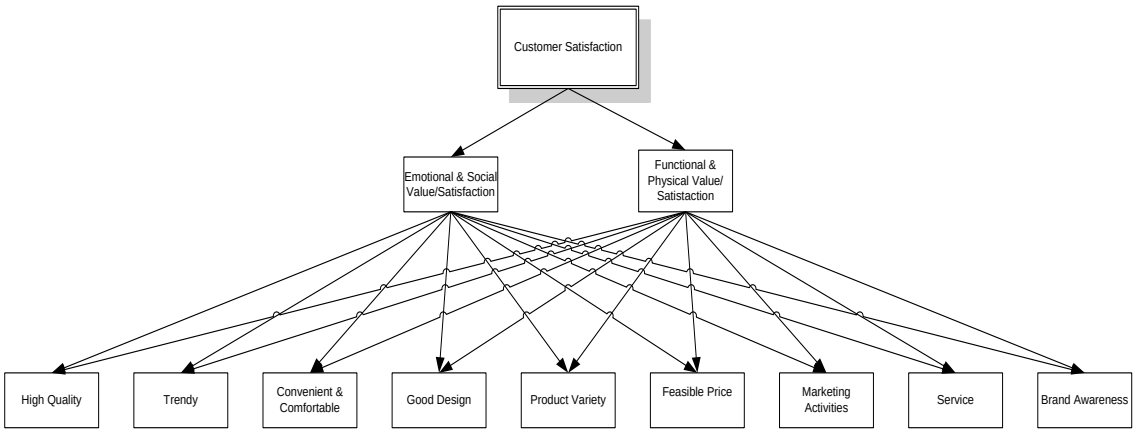

Figure 5.1 Hierarchical structure for the application

The questionnaire has been filled in by five Turkish customers who belong to the target segment, their evaluations are presented in the Appendix.

Firstly the consistency ratios are calculated for the AHP methodology with the formulas given in Chapter 4. The respective ratios are provided in the following table, as it can be seen there exist values exceeding the upper bound of 0,10 (Table 5.1).

Table 5.1 Main Criteria Consistency Ratios

Questionnaire Taker	**Emotional & Social Value/Satisfaction C.R.**	**Functional & Physical Value/Satisfaction C.R.**
1	0,100	0,118
2	0,094	0,076
3	0,109	0,103
4	0,088	0,105
5	0,099	0,101

As explained in Chapter 4, due to the fact that Chang's extended FAHP method incorporates fuzziness, inconsistent judgments are also taken into consideration. For this reason, the application is conducted according to the fuzzy extended AHP method.

According to the method used in FAHP, the scale which will be applied changes. The table for the frequently used scale, triangular fuzzy numbers, is provided below [140, 127, 103] (Table 5.2).

Table 5.2 TFN Values

Explanation	**Importance Scale**	**Importance Scale Conjugate**
Equal	(1,1,1)	(1,1,1)
Moderate	$(\frac{2}{3},1,\frac{3}{2})$	$(\frac{2}{3},1,\frac{3}{2})$
Strong	$(\frac{3}{2},2,\frac{5}{2})$	$(\frac{2}{5},\frac{1}{2},\frac{2}{3})$
Very Strong	$(\frac{5}{2},3,\frac{7}{2})$	$(\frac{2}{7},\frac{1}{3},\frac{2}{5})$
Extreme	$(\frac{7}{2},4,\frac{9}{2})$	$(\frac{2}{9},\frac{1}{4},\frac{2}{7})$

Membership functions for linguistic variables are presented below in Figure 5.2. (Eq: (1,1,1), M: (2/3,1,3/2), S: (3/2,2,5/2), VS: (5/2,3,7/2), E: (7/2,4,9/2))

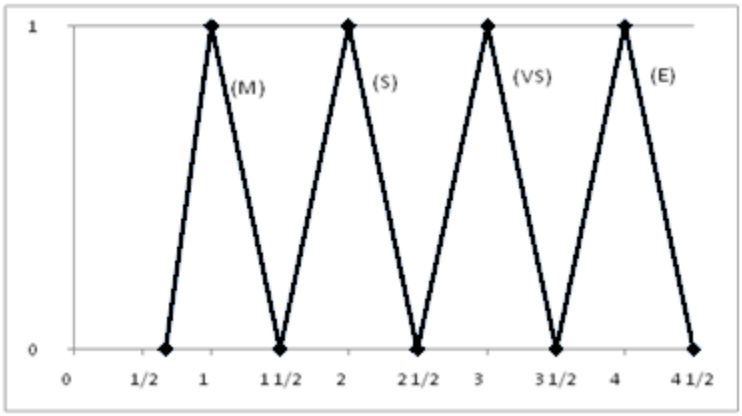

Figure 5.2 Representations of the Membership Functions

Using these fuzzy values, the opinions of the experts are combined together for an overall evaluation, where emotional&social value/satisfaction and functional & physical value/ satisfaction criteria are consolidated (Table 5.3 and Table 5.4).

The extent analysis method (EAM) is applied next to calculate crisp relative importance weights for control criteria. First multipliers are calculated to find out the fuzzy synthetic degree values. The calculations are presented below.

	HIGH QUALITY			TRENDY			CONVENIENT & COMFORTABLE			DESIGN			PRODUCT VARIATY			FEASIBLE PRICE			MARKETING ACTIVITIES			SERVICE			BRAND AWARENESS		
HIGH QUALITY	1,00	1,00	1,00	0,72	0,87	1,07	1,50	2,00	2,50	0,64	0,87	1,20	1,97	2,49	3,01	1,60	1,93	2,30	2,20	2,70	3,27	1,18	1,52	1,88	0,47	0,57	0,72
TRENDY	0,93	1,15	1,39	1,00	1,00	1,00	1,51	1,89	2,31	0,59	0,76	1,00	1,73	2,22	2,76	1,40	1,74	2,15	2,58	3,10	3,62	1,33	1,68	2,12	0,56	0,74	0,98
CONVENIENT&COMFORTABLE	0,40	0,50	0,67	0,43	0,53	0,66	1,00	1,00	1,00	0,42	0,49	0,59	0,78	1,15	1,66	0,78	1,15	1,66	1,21	1,64	2,21	0,72	1,00	1,38	0,37	0,46	0,60
DESIGN	0,83	1,15	1,56	1,00	1,32	1,70	1,70	2,05	2,38	1,00	1,00	1,00	1,97	2,49	3,01	1,42	1,89	2,45	2,58	3,10	3,62	1,56	2,05	2,58	0,77	1,00	1,30
PRODUCT VARIATY	0,33	0,40	0,51	0,36	0,45	0,58	0,60	0,87	1,28	0,33	0,40	0,51	1,00	1,00	1,00	0,60	0,87	1,28	0,78	1,00	1,28	0,65	0,87	1,18	0,29	0,34	0,41
FEASIBLE PRICE	0,43	0,52	0,63	0,47	0,57	0,71	0,60	0,87	1,28	0,41	0,53	0,70	0,78	1,15	1,66	1,00	1,00	1,00	0,85	1,15	1,53	0,59	0,76	1,00	0,31	0,37	0,46
MARKETING ACTIVITIES	0,31	0,37	0,46	0,28	0,32	0,39	0,45	0,61	0,83	0,28	0,32	0,39	0,78	1,00	1,28	0,65	0,87	1,18	1,00	1,00	1,00	0,41	0,53	0,71	0,31	0,37	0,46
SERVICE	0,53	0,66	0,85	0,47	0,59	0,75	0,72	1,00	1,38	0,39	0,49	0,64	0,85	1,15	1,53	1,00	1,32	1,70	1,41	1,89	2,41	1,00	1,00	1,00	0,40	0,52	0,68
BRAND AWARENESS	1,39	1,74	2,11	1,02	1,35	1,79	1,67	2,17	2,72	0,77	1,00	1,30	2,41	2,93	3,44	2,20	2,70	3,27	2,20	2,70	3,27	1,47	1,93	2,49	1,00	1,00	1,00

Table 5.3 Aggregated expert opinions for emotional&social value/satisfaction

	HIGH QUALITY			TRENDY			CONVENIENT & COMFORTABLE			DESIGN			PRODUCT VARIATY			FEASIBLE PRICE			MARKETING ACTIVITIES			SERVICE			BRAND AWARENESS		
HIGH QUALITY	1,00	1,00	1,00	1,44	1,78	2,15	0,56	0,80	1,15	1,02	1,43	1,97	2,05	2,55	3,11	1,71	2,05	2,42	2,58	3,10	3,62	1,56	2,05	2,58	1,02	1,35	1,79
TRENDY	0,47	0,56	0,69	1,00	1,00	1,00	0,37	0,46	0,60	0,65	0,87	1,18	0,85	1,15	1,53	0,67	1,00	1,50	0,94	1,25	1,64	0,92	1,15	1,41	0,61	0,80	1,06
CONVENIENT&COMFORTABLE	0,87	1,25	1,78	1,67	2,17	2,72	1,00	1,00	1,00	1,66	2,17	2,67	1,85	2,35	2,90	1,85	2,35	2,90	2,58	3,10	3,62	1,67	2,17	2,72	1,02	1,43	1,97
DESIGN	0,51	0,70	0,98	0,85	1,15	1,53	1,66	2,17	2,67	1,00	1,00	1,00	1,84	2,35	2,86	1,33	1,78	2,33	1,85	2,35	2,90	1,20	1,64	2,18	1,00	1,32	1,70
PRODUCT VARIATY	0,32	0,39	0,49	0,65	0,87	1,18	1,85	2,35	2,90	0,35	0,43	0,54	1,00	1,00	1,00	0,83	1,00	1,20	0,85	1,15	1,53	0,83	1,00	1,20	0,65	0,80	1,00
FEASIBLE PRICE	0,41	0,49	0,59	0,67	1,00	1,50	0,34	0,43	0,54	0,43	0,56	0,75	0,83	1,00	1,20	1,00	1,00	1,00	1,18	1,32	1,44	0,60	0,87	1,28	0,67	1,00	1,50
MARKETING ACTIVITIES	0,28	0,32	0,39	0,61	0,80	1,06	0,28	0,32	0,39	0,34	0,43	0,54	0,65	0,87	1,18	0,69	0,76	0,85	1,00	1,00	1,00	0,54	0,76	1,08	0,48	0,66	0,92
SERVICE	0,39	0,49	0,64	0,71	0,87	1,08	0,37	0,46	0,60	0,46	0,61	0,83	0,83	1,00	1,20	0,78	1,15	1,66	0,92	1,32	1,84	1,00	1,00	1,00	0,61	0,80	1,06
BRAND AWARENESS	0,56	0,74	0,98	0,94	1,25	1,64	0,51	0,70	0,98	0,59	0,76	1,00	1,00	1,25	1,54	0,67	1,00	1,50	1,09	1,52	2,07	0,94	1,25	1,64	1,00	1,00	1,00

Table 5.4 Aggregated expert opinions for functional&physical value/satisfaction

When the table for emotional&social value/satisfaction is examined, the following results for the first multiplier are obtained applying the formula in 5.1, (Table 5.5)

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{5.1}$$

l_j	m_j	u_j
11,27	13,96	16,94
11,64	14,28	17,33
6,12	7,92	10,43
12,84	16,05	19,61
4,96	6,21	8,01
5,44	6,92	8,97
4,47	5,39	6,67
6,78	8,62	10,95
14,14	17,53	21,39

Table 5.5 Coefficients for the first step of FAHP for emotional&social value/satisfaction

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) = (77.65, 96.87, 120.29)$$

The reciprocal of the last multiplier is,

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) = (0.008, 0.010, 0.013)$$

Fuzzy synthetic degree values are calculated using the following formula:

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \odot \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \tag{5.2}$$

As an example, the fuzzy synthetic degree values of control criterion, high quality, can be calculated as follows:

$$\begin{aligned} S_1 &= \sum_{j=1}^{m} M_{g_i}^{j} \odot \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \\ &= (11.27 \times 0.008, 13.96 \times 0.010, 16.94 \times 0.013) \\ &= (0.09, 0.14, 0.22) \end{aligned}$$

Following a similar calculation, the fuzzy synthetic degree values of other nine control criteria are obtained as shown below:

$S_1 = (0.09, 0.14, 0.22)$
$S_2 = (0.10, 0.15, 0.22)$
$S_3 = (0.05, 0.08, 0.13)$
$S_4 = (0.11, 0.17, 0.25)$
$S_5 = (0.04, 0.06, 0.10)$
$S_6 = (0.05, 0.07, 0.12)$
$S_7 = (0.04, 0.06, 0.09)$
$S_8 = (0.06, 0.09, 0.14)$
$S_9 = (0.12, 0.18, 0.28)$

Subsequent to the calculation of the degrees of possibility the weight vectors are computed as follows:

$W' = (d'(A_1), d'(A_2), d'(A_3), d'(A_4), d'(A_5), \ldots\ldots, d'(A_n))^T$
→ W' = (0.72, 0.75, 0.14, 0.89, 0.00, 0.00, 0.00, 0.20, 1.00)

After normalization, the normalized weight vector is:

$W = (d(A_1), d(A_2), d(A_3), d(A_4), d(A_5), d(A_6), \ldots\ldots, d(A_n))^T$
→ W_1 = (0.19, 0.20, 0.04, 0.24, 0.00, 0.00, 0.00, 0.05, 0.27)

The normalized weight vector for the functional & physical value/ satisfaction is calculated with the same procedure:

→ W_2 = (0.23, 0.05, 0.26, 0.20, 0.06, 0.09, 0.00, 0.03, 0.09)

Same processes are repeated to find out the main criteria weights which are presented below (Table 5.6). The weight of the emotional&social value/satisfaction is calculated as 0,87 and the weight of the functional&physical value/satisfaction is calculated as 0,13.

Table 5.6 Criteria Weights of Customer Needs with respect to Emotional & Social and Functional & Physical Value/Satisfaction

CRITERIA	EMOTIONAL & SOCIAL VALUE / SATISFACTION	FUNCTIONAL & PHYSICAL VALUE / SATISFACTION
HIGH QUALITY	0,19	0,23
TRENDY	0,20	0,05
CONVENIENT&COMFORTABLE	0,04	0,26
DESIGN	0,24	0,20
PRODUCT VARIATY	0,00	0,06
FEASIBLE PRICE	0,00	0,09
MARKETING ACTIVITIES	0,00	0,00
SERVICE	0,05	0,03
BRAND AWARENESS	0,27	0,09

As it can easily be seen from the results, customers give more importance to emotional&social value/satisfaction compared to functional&physical value/satisfaction for the main criteria. For the customers in this segment, the joy of purchasing and owning luxury clothing is far more significant. The following table represents the results of FAHP methodology (Table 5.7). Brand awareness is at the top with a significant weight of 24,66 % and it is not surprising because brand is an important indicator to show off the class and the status of the customer. The first four criteria on the list, namely brand awareness, design, high quality and trendy make up 86% of the weights. There exists a common trait for these customer needs; it is the fact that all of them distinguish the owner of the luxury good from the people that do not own it.

Table 5.7 FAHP Ranking of the Customer Needs

CRITERIA	RELATIVE WEIGHTS (%)
BRAND AWARENESS	24,66%
DESIGN	23,55%
HIGH QUALITY	19,91%
TRENDY	18,27%
CONVENIENT&COMFORTABLE	6,65%
SERVICE	5,08%
FEASIBLE PRICE	1,11%
PRODUCT VARIATY	0,77%
MARKETING ACTIVITIES	0,00%

Marketing activities have zero weight; this can be due to the immense amount of significance given to the other luxury good properties. Furthermore, marketing activities can be conducted while the customers are not clearly aware of it. For example, the marketing department of a brand can organize a seminar with a famous trendsetter as the guest speaker followed by a small fashion show. Customers will think that attending the seminar is significant to show off in a prestigious crowd, they will have their pictures taken and published in magazines. Furthermore, they will get information on the new collection and follow the trends. Brands try to attract customers with these events; although they may not seem a lot of important for the customers, they are significant for the brands.

In order to test the validity of these results sensitivity analysis is conducted. FAHP method uses the criteria hierarchy modeled at the problem definition phase and then these criteria are evaluated during problem solution. Sensitivity analysis is applied to evaluate the effect of adding a new alternative to the existing problem set. In the proposed model, with respect to the weights assigned to the new alternative the boundaries for the existing alternatives are set. Table 5.8 shows the change in importance levels if a new alternative (customer request) is added to the system. When all of the customer needs are evaluated, except the "convenient&confortable" need, all of them have the lowest value of 0. This evaluation shows the fact that when a new alternative is included to the system it is probable that the new customer request might suppress all of the other customer requests according to the criteria. When the highest boundary value is investigated, it is seen that the values of the customer requests vary.

For example, customers' importance weight for the service requirement with respect to emotional & social value/satisfaction criterion can be 7,55 % when a new customer need is added to the system. With this information, decision maker will know that the service requirement will not exceed the calculated value when a new request is included to the list of needs and he/she will give more a realistic decision.

Table 5.8 Sensitivity Analysis in case of Adding a New Criteria

	Emotional & Social Value/ Satisfaction		**Functional & Physical Value / Satisfaction**	
CRITERIA	LOWEST	HIGHEST	LOWEST	HIGHEST
HIGH QUALITY	0,00%	19,46%	0,00%	22,98%
TRENDY	0,00%	20,27%	0,00%	6,95%
CONVENIENT&COMFORTABLE	0,00%	6,37%	4,76%	26,11%
DESIGN	0,00%	24,05%	0,00%	20,10%
PRODUCT VARIATY	0,00%	1,18%	0,00%	7,91%
FEASIBLE PRICE	0,00%	3,30%	0,00%	8,62%
MARKETING ACTIVITIES	0,00%	0,00%	0,00%	0,00%
SERVICE	0,00%	7,55%	0,00%	5,52%
BRAND AWARENESS	0,00%	27,03%	0,00%	10,07%
X	0,00%	100,00%	0,00%	95,24%

5.3. HOF APPLICATION DERIVED FROM QFD

In order to be a leading figure in the textile sector, manufacturing firms should cope with all of the issues and problems stated previously. The flexibility types which can satisfy the solutions for these issues and problems are presented to the experts and with the results from the literature survey and the expert opinions the following flexibility types are filtered. Using HoF, which flexibility type can accomplish customer satisfaction and at what extent is evaluated.

First House

For this application flexibility types are categorized into two as manufacturing and management flexibilities. The brief descriptions and textile sector implications of the

flexibility types used in this application are provided below. Experts have made their evaluations based on these flexibility type definitions.

Manufacturing Flexibility

Product-mix flexibility is the ability of the company to produce different combinations of products in a cost-effective and efficient way with the existing manufacturing capacity. As one might imagine, in the same season many models are designed and manufactured in the textile sector. Firms manufacturing capacity should be able to meet this production variety.

New product flexibility is defined as the ability of a system to add or remove new products to its product-mix. It is a necessity in technology intensive markets to swiftly design and market several new products at the same time. In each season, new models should be designed and the timing is very significant in this sector. Manufacturing firms that want to be successful in the market should have a wide product portfolio.

Volume flexibility is expressed as the ability to change the level of production of a manufacturing process. It is an important flexibility to be able to increase production volume to meet rising demand and to keep inventory as low as possible when the demand falls. Textile firms do not prefer to produce goods for the inventory because if they do so, then their products might become out of fashion or defective due to excess transportation. The production of already sold goods might be obstructed because these non-favored goods have already been produced with the same raw materials and there may not be enough raw materials left. For these reasons, manufacturing firms should have volume flexibility to deal with the demand fluctuations.

Machine flexibility refers to the manufacturing firm's capacity to switch between operations with minimum setup cost, effort and delays. As stated before, products with different models and production processes are manufactured within the same season, in order to prevent production disruptions machine flexibility is a necessity.

Labor flexibility is the ability of the workforce to conduct a wide range of manufacturing tasks. In production, the manufacturing tasks differ due to cloth type, imprinting, embroidery, accessories, model designs, etc. For every manufacturing process, workforce differentiation cannot be performed, as a result labor flexibility is required and the workforce should be multi-skilled.

Delivery time flexibility is defined as the ability of a system to decrease the order-to-delivery time. If the manufacturing firm can reduce or expand the delivery time according to the fluctuations, rush orders or delayed shipment requests, in the customer requirements then the firm is stated to have delivery time flexibility. There are certain deadlines for the products to be put on the shop floor, such as season openings, Christmas Eve, special days, etc and even if there exist production delays the lost period should be compensated with fast delivery. Otherwise issues might arise like the season opening being late or the new products might arrive to the shop floor during the sales season.

Management Flexibility

Design flexibility is expressed as the ability to change the design of a product very quickly in a cost effective way [33]. It might be necessary to design similar models from the rival brands that are favored by the customers and do not exist in the collection. Likewise, there might be models preferred quite a lot in the collection and similar models should be designed to attract more customers or the non-favored models should be collected and modified. All of these cases require design flexibility which should be managed fast and economically. Many of the firms adjust their collections according to seasonal trends and make purchases; again design flexibility is a necessity for trend adjustments.

Market flexibility involves the ability to adapt to different markets and to have a high market share and international presence so that the products are sold in a large number of international and geographic markets. In every market, the customer needs and expectations differ. Market flexibility is significant to respond to these needs.

Information system flexibility requires an agile IS where a major change will not be required in the information systems to support business processes that are changing and expanding. Different markets and business processes should not need heavy investment on the IS or the new installations in the IS should not disrupt the manufacturing processes.

Logistics flexibility eases the transfer of materials smoothly from one site to another site in the manufacturing firms. An example from the textile sector can be given as such: the raw materials can be imported from the Far East, goods can be manufactured in Turkey and they can be exported to Poland. In this case the logistics operations are very significant and they should be managed effectively and efficiently.

Spanning flexibility enables the integration of different process departments or groups in the manufacturing firm to organize product design, production, and delivery to add value. When all of the organizational units in the firm and related companies are in cooperation there will be an overall satisfaction and success.

Strategic flexibility is described as the organization's capability to identify major changes in the external environment quickly and dedicate resources to cope with these changes. In textile sector, assets and capabilities are deployed to develop appropriate strategies to adapt to the changing environment conditions.

R&D flexibility is required for both the design of the product functionalities, as well as the raw material innovation and research for knowhow. It can be defined as the capacity for the manufacturing firm to produce and apply the new knowledge. Both for manufacturing new raw materials and products and for testing their conformity to the customer needs, R&D activities are significant.

The evaluation of the experts is provided in Table 5.9. Here, the non-evaluated boxes indicate that there exists no relationship in between the need and the flexibility lever. The value of "1" indicates little correlation, "3" indicates more correlation and "9" indicates great correlation.

Table 5.9 House of Flexibility

		MANUFACTURING FLEXIBILITY						MANAGEMENT FLEXIBILITY						
CUSTOMER IMPORTANCE (%)	FLEXIBILITY LEVERS / CUSTOMER NEEDS	PRODUCT MIX FLEXIBILITY	NEW PRODUCT FLEXIBILITY	VOLUME FLEXIBILITY	MACHINE FLEXIBILITY	LABOR FLEXIBILITY	DELIVERY TIME FLEXIBILITY	DESIGN FLEXIBILITY	MARKET FLEXIBILITY	I.S. FLEXIBILITY	LOGISTICS FLEXIBILITY	SPANNING FLEXIBILITY	STRATEGIC FLEXIBILITY	R&D FLEXIBILITY
19,91	HIGH QUALITY	1	1	1	3	3						3		3
18,27	TRENDY	1	9	1	1	1	3	3	3		3	3	3	3
6,65	CONVENIENT&COMFORTABLE							1				1		1
23,55	DESIGN	1	3			1		9	3			3	3	3
0,77	PRODUCT VARIETY	9	9	1	1	1		3			1	3		1
1,11	FEASIBLE PRICE	1	1	3	3	3	1		1		3	1	3	1
0,00	MARKETING ACTIVITIES								1	3		1	3	
5,08	SERVICE	1					1		1	1	1			
24,66	BRAND AWARENESS	1	1					1	3					
	WEIGHT	99,5	287,7	42,3	82,1	105,6	61,0	300,4	205,6	5,1	64,0	195,3	128,8	193,7
	RELATIVE IMPORTANCE (%)	5,6	16,2	2,4	4,6	6,0	3,4	17,0	11,6	0,3	3,6	11,0	7,3	10,9

According to the results of the first house, the importance weights of the flexibility types satisfying the customer needs are presented above (Table 5.10). The first five flexibility types are design flexibility, new product flexibility, market flexibility, spanning flexibility and R&D flexibility and these five consist the majority of the weights. A brand that comes up with a new collection each season and follows the trends in fashion should have a flexible design and it should be able to model new products flexibly. Market flexibility is a significant issue because in order to operate in many countries and multiple cities it is required to adapt to the market conditions and increase market share. For the brand to be successful in the processes such as R&D, design, production and marketing, the departments should cooperate and support each others' operations with feedbacks.

Table 5.10 Importance Ranking of Flexibility Types by HoF

DESIGN FLEXIBILITY	16,96%
NEW PRODUCT FLEXIBILITY	16,24%
MARKET FLEXIBILITY	11,61%
SPANNING FLEXIBILITY	11,03%
R&D FLEXIBILITY	10,94%
STRATEGIC FLEXIBILITY	7,27%
LABOR FLEXIBILITY	5,97%
PRODUCT MIX FLEXIBILITY	5,62%
MACHINE FLEXIBILITY	4,64%
LOGISTICS FLEXIBILITY	3,61%
DELIVERY TIME FLEXIBILITY	3,44%
VOLUME FLEXIBILITY	2,39%
I.S. FLEXIBILITY	0,29%

R&D flexibility is a flexibility type that adds value to the brand and it aids the brand differentiation. Least significant flexibility types are volume and IS flexibilities. When the demand exceeds the maximum production volume, manufacturing firm might choose to have contract production and by this way will be able to satisfy the excess demand. As a result, volume flexibility is important; however, it is not as significant as the flexibility types stated previously. On the other hand, IS flexibility is getting more and more important every day; however, for this specific application the other flexibility types are relatively more important than the IS flexibility.

The purpose of the second house is to designate the system factors ensuring the flexibility types and to find out the importance weights of these system factors. At this stage, the second house is modeled as an extension of HoF. The system factors are selected from the literature with the help of the experts, their meanings for this application are provided below.

Second House

Raw materials: In textile sector, the products are made of fabric and accessories. In order for the products to be admired and purchased by the target customer segment, the raw materials should be processed and tested.

Business development: Attending fairs and exhibitions, locating the best store locations, new market development, developing new marketing and sales channels are part of the business development activities.

Creative team: Creative team designates the next season's trends via marketing activities and gathering feedback from the customers. They also work on the R&D activities, aid in raw material selection and build up the collection with respect to production costs and manufacturing processes. This team makes sure that the shop window designs are aligned with the season trends and the theme of the collection.

Supply chain: Supply chain consists of all of the directly or indirectly involved parties in customer request fulfillment. Transporters, warehouses, retailers and tailoring service belong to the supply chain as much as the manufacturer and suppliers do. In textile sector, supply chain management is very important. There exists a certain period of time in between the raw material purchase and the purchase of the end product by the customers and the coordination between the parties should be tight so that the trends are not missed.

Product development: Product development processes should be managed swiftly and effectively. It is significant for a textile brand to prepare a new collection every season while following the trends and producing new models with original materials. On the other hand, being the first in the market with the right products brings great amount of competitive advantage. This leap makes sure that the firm becomes the leading figure and the rivals are prone to follow the leader. If the trends of a firm are followed by the rivals in the sector, then this brand can be declared as the most successful brand. Concurrent engineering, integrated product-process design, multi-functional teams, and

incorporation of customer voice are some of the enabling solutions for effective product development.

Organization structure: Organization structure is a significant element which enables the smooth information flow within the organizational units and effective communication in between the departments and external stakeholders. If the organizational structure supports information sharing then it is more probable that better decisions are taken in a timely manner.

Technology: Technology has positive effect on all of the system factors stated above. Successful manufacturing companies deploy most advanced technologies to produce in a more efficient and effective way. Although hand crafting can be time consuming and may require a lot of workforce, it can be preferred in some product lines to add value to the goods.

System capacity: System capacity can be defined as the total output rate of the business process. This capacity should be balanced with the work required to fulfill the customer demands. System capacity depends on the aggregate of all of the organization unit (export, warehouse, etc.) capacities that make up the whole system.

Information systems: Information systems consist of the store management systems, store IS operations, ERP, CRM, delivery tracking, B2B, B2C, etc. They are implemented on the manufacturing firm to keep track of the operations, processes and to improve the efficiency and the effectiveness of the organization. Information should be retrieved very fast on demand so that better decisions can be made, such as sorting out the customer data from the CRM system and defining a special campaign for these customers for a certain period of time or sending promotion information to increase customer loyalty.

Human resources (workforce): Manufacturing firm's human resource consists of its white collar and blue collar workers. Skilled and qualified workforce makes sure that the operations are carried out with little waste and upmost efficiency.

R&D: Research and development activities can be listed as raw material research for product differentiation, testing the convenience of the goods for light, washing, dry cleaning aspects, matching the product attributes with the raw material properties, etc.

Retail and marketing systems: Marketing department is the customer facing organization unit in a manufacturing firm. It acts as a bridge between the other departments and the customers and activities like campaign, CRM, sales, advertising and stock management are managed by these two systems.

The house constructed for the second stage is provided below (Table 5.11).

Table 5.11 Second House

Importance Weigth From First House %	System Factors / Flexibility Levers	RAW MATERIALS	BUSINESS DEVELOPMENT	CREATIVE TEAM	SUPPLY CHAIN	PRODUCT DEVELOPMENT	ORGANIZATION STRUCTURE	TECHNOLOGY	SYSTEM CAPACITY	INFORMATION SYSTEM	WORKFORCE	R&D	RETAIL&MARKETING SYST.
5,62	PRODUCT MIX FLEXIBILITY	1		3	1	3		3	1	1	1	1	
16,24	NEW PRODUCT FLEXIBILITY	3		3	1	9	1	3	1		1	3	1
2,39	VOLUME FLEXIBILITY	1			1			3	3		3		
4,64	MACHINE FLEXIBILITY							3	3		1		
5,97	LABOR FLEXIBILITY						1		1		9		
3,44	DELIVERY TIME FLEXIBILITY		1		9			1	1	1	1		
16,96	DESIGN FLEXIBILITY	3		3	1	9	1	1			1	3	
11,61	MARKET FLEXIBILITY		9	3	3	3	1		1	3			9
0,29	I.S. FLEXIBILITY		1					1		9	1		
3,61	LOGISTICS FLEXIBILITY		1		9		1			1		1	
11,03	SPANNING FLEXIBILITY		1	1	3		3			3	1		3
7,27	STRATEGIC FLEXIBILITY		3	3	1	1	3	1	1	1	1	3	3
10,94	R&D FLEXIBILITY			1	1							9	
	Weight	1,076	1,447	1,951	1,908	3,578	1,093	1,146	0,712	0,904	1,263	2,291	1,756
	Relative Weight (%)	5,6	7,6	10,2	10,0	18,7	5,7	6,0	3,7	4,7	6,6	12,0	9,2

Weights from the house of flexibility and the values acquired from the system factor evaluations are given in the following table (Table 5.12). Product development has a high importance weight (18,71%), this is the most important system factor satisfying the flexibility types in the first house. This result is normal for a textile firm that should design brand new models each season. Product development is one of the most important factors attracting customers' attention in the high competitive market. First step is the product development and the rest of the steps follow this phase. For this reason, if the manufacturing firm fails at this stage, it is very difficult for the collection to become successful. The first three system factors are product development, R&D and creative team which are the most significant components for manufacturing. In order to be a successful brand, the firm should follow the trends closely and if possible should be the company whose trends are followed by the others. Another important system factor is supply chain, when the design of the model is completed the raw materials should be procured and when the production is done the end products should be delivered to the customers. Lastly the fifth system factor is retail&marketing system which meets the product with the customer. The right product presentation should be conducted by this department with appropriate campaigns and CRM activities.

Table 5.12 Importance Ranking of System Factors by HoF

PRODUCT DEVELOPMENT	18,71%
R&D	11,98%
CREATIVE TEAM	10,20%
SUPPLY CHAIN	9,98%
RETAIL&MARKETING SYSTEMS	9,18%
BUSINESS DEVELOPMENT	7,56%
WORKFORCE	6,61%
TECHNOLOGY	5,99%
ORGANIZATION STRUCTURE	5,71%
RAW MATERIALS	5,63%
INFORMATION SYSTEM	4,73%
SYSTEM CAPACITY	3,72%

5.4. RESULTS OF THE COMBINED METHODOLOGY

As the methodology, a decision making model is developed by combining FAHP and HoF derived from QFD. The application of this combined approach is interrogated in an international women's ready-to-wear firm based in Turkey which targets high consumer segment. The results of the first stage of the model, FAHP, point out the fact that the customers in this segment value brand awareness, design, high quality and trendy the most. These are in fact important indicators to show off the class and the status of the customer distinguishing the owner of the luxury goods from the people that do not own it. According to the outcomes of the HoF method, the first five flexibility types that can satisfy the customer needs ranked via FAHP are design flexibility, new product flexibility, market flexibility, spanning flexibility and R&D flexibility and these five consist the majority of the weights. The second house is constructed to evaluate the flexibility levers with respect to the system factors. According to the evaluation of the experts, product development is found to be the most important factor. The results of the application are shared and discussed with the experts in the conclusion chapter.

6. CONCLUSION

In conclusion, it can be stated that today manufacturing enterprises are in severe competition and cannot survive on the market unless they respond to internal and external changes quickly. As the business conditions fluctuate and technological developments occur, the customers are less predictable in their behavior of purchasing. They expect the utmost from the manufacturers and use their buying power to impose their demands. In order to survive in the competition and to increase the market share, flexibility is proposed as a solution in many academic researches. The textile sector is a good example for an environment which possesses all of the challenges stated above. It is one of the fastest growing sectors in Turkey and this industry is very important for the country's economy due to its large share in exports. For the reasons stated above, a Turkish textile firm is selected for the application and the best flexibility portfolio is investigated.

As the methodology, a decision making model is developed by combining FAHP and HoF derived from QFD. The application is conducted for a Turkish women's ready-to-wear firm in the high consumer segment and its purpose is to find out the best flexibility lever portfolio satisfying customer needs and providing a quick solution to deal with the uncertainties and the risks this company faces. First of all, the customer needs are ranked using FAHP, then the flexibility levers matching the customer needs are weighted via HoF based on the study of Olhager and West [6] and lastly, management and manufacturing system factors are evaluated by the second house, the extension of the HoF. The results are discussed with the experts.

According to the customer needs ranking via FAHP, the consumers in this segment value the socail&emotional value/satisfaction more than the physical&functional value/satisfaction. The factor that affects their shopping the most is the brand

awareness. This factor is followed by design, high quality and trendy. Through the interviews with the experts, it has been seen that these factors reflect the truth. Customers give value to attracting other people's attention, showing off status (brand label being visible at the front, clothes being worn by the celebrities, having advertisements of the brand on foreign newspapers and the magazines) more than the price and the cloth being comfortable and convenient. Although these preferences have been pointed out in this analysis, other factors such as service and marketing activities are significant customer needs too. Customers may not not give value or may not think that they give value to other less significant issues. However, the quality of the service provided before and after the purchase of the good such as the interest of the store personnel, the service level provided to satisfy the needs of the customer, repairment, delivery to the customer's house, etc. are important for the customers as well. Similarly, marketing activities like special sales on the customer's birthday, notifying sales to VIP customers before the public advertisements, invitation to the stores on sales periods and special fashion shows, activities such as coctails and late shopping nights will make the customer feel special and prefer a particular brand. In the following sections of the analysis, these needs are assumed to be less significant due to the results of the FAHP method.

In the first stage, HoF, customer needs are reduced to firm needs, in other terms to flexibility types. Design, new product, market and spanning flexibilities consist substantial part of the overall flexibility types. It is expected that design and new product flexibilities are defined as significant, because a firm that should deliver a trendy new collection each season on time should act flexible in product development to conserve the brand image. Spanning flexbility notes the fact that the firm should be operating in coordination and with agility in such a dynamic environment. I.S. flexibility will become important more and more as the firm seeks to enlarge and become a brand in different markets. Although flexibility types such as volume, machine and labor are consequential, it will not result in serious issues if the firm does not invest on flexibility for these flexibility types. This is due to the fact that they do not support differentiation, it will not be problem as long as the quality standarts are

preserved and manufacturing by the third parties will only add extra cost but it will not affect the overall operations of the firm.

In the second house, the problem is detailed down by reducing the flexibility types determined in the first stage into system factors. Considering the results of the second house, product development, creative team and R&D system factors stand in the forefront and consist most of the weight. A brand with a syle should be supported by the R&D activities, and the R&D processes should be effectively managed with the strong and creative team. These are the factors that will maintain differentiation and will make the customers prefer this particular brand. System capacity is found to be less significant due to the fact that this brand operates in boutique style, aiming to sell its goods to special consumers other than targeting the mass market and selling numerous products. The deficiency of system capacity can be made up via acquiring support out of the firm and the prices of the luxury goods will not be affected from the extra costs attained by the outer support. Experts are surprised again on the fact that the I.S. flexibility and the value of the I.S. in the system factors are low. It is believed that while working on the product differentiation, applications that will enchance customer satisfaction (faster cashier, CRM applications, etc.) should be developed as well, furthermore, I.S. is significant for the management of the firms that operate in several markets.

In this work, there are certain aspects which should be developed further more. This firm has many sales points (own stores, retailers and frenchises) and so the brand exists in several countries, however, the evaluations are based on the preferences of the Turkish customers on the target segment and the application is developed on top of this analysis. If the same product portfolio will be sold on different markets, it will be more accurate to combine the evaluations of the customers from different nations which have variant needs and preferences and this will yield more valid results.

In future work, the results of the combined methodology in this study will be used to construct portfolios. These portfolios will be evaluated via real option, a quantitative valuation method, which incorporates the uncertainties such as market demand, labor

supply and cost, material supply and cost, inflation, etc. and does not ignore the effect of flexibility in decision making processes. This approach will enable the firm to choose the best portfolio and to satisfy the customer needs. Similarly, this case can be solved via Fuzzy QFD and the acquired portfolio can be evaluated. The results of the combined FAHP and HoF can be compared with the results of the Fuzzy QFD approach and the validity of the results in real life can be discussed with the experts.

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APPENDICES

THE QUESTIONNAIRE

In the following questionnaire there exist 5 options (extreme, very strong, strong, moderate and equal) to choose from. According to the importance level of each item, please will in the questions.

Q1: How significant is the main criteria to fulfill customer satisfaction?

	Importance/Preference of One Over Another									
	Extreme	Very strong	Strong	Moderate	Equal	Moderate	Strong	Very strong	Extreme	
Emotional&Social Value/Satisfaction										Functional&Physical Value/Satisfaction

Q2: How significant is each criteria with respect to emotional&social value/satisfaction to fulfill customer satisfaction?

	Importance/Preference of One Over Another									
Criteria	Extreme	Very strong	Strong	Moderate	Equal	Moderate	Strong	Very strong	Extreme	Criteria
High quality										Trendy
High quality										Convenient and comfortable
High quality										Design
High quality										Product variety
High quality										Feasible price
High quality										Marketing activities
High quality										Service
High quality										Brand awareness
Trendy										Convenient and comfortable
Trendy										Design
Trendy										Product variety
Trendy										Feasible price
Trendy										Marketing activities
Trendy										Service
Trendy										Brand awareness
Convenient and comfortable										Design
Convenient and comfortable										Product variety
Convenient and comfortable										Feasible price
Convenient and comfortable										Marketing activities
Convenient and comfortable										Service
Convenient and comfortable										Brand awareness
Design										Product variety
Design										Feasible price
Design										Marketing activities
Design										Service
Design										Brand awareness
Product variety										Feasible price
Product variety										Marketing activities
Product variety										Service
Product variety										Brand awareness
Feasible price										Marketing activities
Feasible price										Service
Feasible price										Brand awareness
Marketing activities										Service
Marketing activities										Brand awareness
Service										Brand awareness

Q3: How significant is each criteria with respect to functional&physical value/satisfaction to fulfill customer satisfaction?

	Importance/Preference of One Over Another									
Criteria	Extreme	Very strong	Strong	Moderate	Equal	Moderate	Strong	Very strong	Extreme	Criteria
High quality										Trendy
High quality										Convenient and comfortable
High quality										Design
High quality										Product variety
High quality										Feasible price
High quality										Marketing activities
High quality										Service
High quality										Brand awareness
Trendy										Convenient and comfortable
Trendy										Design
Trendy										Product variety
Trendy										Feasible price
Trendy										Marketing activities
Trendy										Service
Trendy										Brand awareness
Convenient and comfortable										Design
Convenient and comfortable										Product variety
Convenient and comfortable										Feasible price
Convenient and comfortable										Marketing activities
Convenient and comfortable										Service
Convenient and comfortable										Brand awareness
Design										Product variety
Design										Feasible price
Design										Marketing activities
Design										Service
Design										Brand awareness
Product variety										Feasible price
Product variety										Marketing activities
Product variety										Service
Product variety										Brand awareness
Feasible price										Marketing activities
Feasible price										Service
Feasible price										Brand awareness
Marketing activities										Service
Marketing activities										Brand awareness
Service										Brand awareness

BIOGRAPHICAL SKETCH

The author of this thesis was born in 1985 in Istanbul, Turkey.

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