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VENDOR MANAGED INVENTORY SYSTEM A CASE STUDY FOR A TRADITIONAL FMCG COMPANY

Ekin MERDAN

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VENDOR MANAGED INVENTORY SYSTEM

A CASE STUDY FOR A TRADITIONAL FMCG COMPANY

(TEDARİKÇİ YÖNETİMLİ ENVANTER SİSTEMİ

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prepared by **EKİN MERDAN** in partial fulfillment of the requirements for the degree of **Master of Science in Industrial Engineering** at the **Galatasaray University** is approved by the

Examining Committee:

Assist. Prof. Murat Levent DEMİRCAN (Supervisor)

Department of Industrial Engineering

Galatasaray University ___________________________

Assoc. Prof. Çağrı TOLGA

Department of Industrial Engineering

Galatasaray University ___________________________

Assoc. Prof. Ayberk SOYER

Department of Industrial Engineering

Istanbul Technical University ___________________________

Date: _________________

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LIST OF SYMBOLS

AHP	: Analytic Hierarchy Process
ALT	: Alternative
CRP	: Continuous Replenishment Policy
CS	: Consignment Aggrement
DEA	: Data Envelopment Analysis
DM	: Decision Maker
ECR	: Efficient Customer Response
EDI	: Electronic Data Interchange
ELECTRE	: Elimination and Choice Translating Reality
FMCG	: Fast Moving Consumer Goods
IFS	: Intuitionistic Fuzzy Sets
IIFWA	: Interval-Valued Intuitionistic Weighted Averaging Operator
IVIFS	: Interval-Valued Intuitionistic Fuzzy Sets
JIT	: Just In Time
MADM	: Multi-Attribute Decision Making
MAUT	: Multiple Attribute Utility Theory
MCDM	: Multi-Criteria Decision Making
MODM	: Multi-Objective Decision Making
PROMETHEE	: Preference Ranking Organisation Method for Enrichment Evaluations
QR	: Quick Response
R	: Retailer
TOPSIS	: Technique for Order Preference by Similarity to Ideal Solution
VMI	: Vendor Managed Inventory

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ABSTRACT

Supply chain efficiency is one of the most discussed subjects of the companies. They investigate some methods to improve this efficiency to manage their sources more efficiently and less expensive. Vendor Managed Inventory system is one of the supply chain mechanisms that allows vendors to reach and manage customer's stock level and prepare their own production, inventory and delivery plans in accordance with them. Vendors' authorization on customers' information systems give additional advantages for all the components of supply chain as flexibility, immediate response, cost reduction, stock optimization, etc.

In a VMI system, demand forecasting and quick response to the customers' demand fluctuations are extremely important for the system's performance. It is also known that demand variability is one of the main constraints of today's supply chain world. Every company has been affected by demand variability that caused by a number of internal or external quantitative and qualitative criterions. For this reason, demand forecasting procedure can be evaluated as Multi-Criteria Decision Making Problem.

In this study, we have investigated a FMCG company that uses traditional supply chain methods and proposed a new order prediction methodology as a part of vendor managed inventory system. The problem is constructed as Multi-Criteria Decision Making Problem that affected by eight criterions in which some of them are quantitative while others are quantitative.

Classical Multi-Criteria Decision Making Problems use experts' opinions with crisp values and certain assessments. But in a complexity of real world, most of the decisions are consists of linguistic evaluations. Due to the imprecision and insufficient information or ambiguity, we prefer linguistic evaluations. Additionally, in order to solve the uncertainty, subjectivity and hesitancy of human judgments interval-valued intuitionistic fuzzy sets have applied to the proposed methodology.

In the proposed methodology, real sales data of the company and real sales conditions are considered. Different combinations, sensitivity analysis and comparisons are also conducted to measure the stability of decision makers' evaluations, effectiveness of criteria weights and applicability to the different customers. It is found that the proposed methodology, which is an order prediction with using interval-valued intuitionistic fuzzy sets, gives stable and logical results for a VMI system in a FMCG company.

ÖZET

Tedarik zinciri verimliliği günümüzde şirketlerin en çok odaklandığı konuların başında gelmektedir. Şirketler kaynaklarını daha etkili kullanmak ve maliyetlerini azaltmak amacıyla bu verimliliği artırmanın yöntemlerini araştırmaktadırlar. Tedarikçi yönetimli envanter modeli tedarikçilere müşterilerinin stoklarını yönetme imkanı ile birlikte kendi üretim, stok ve dağıtım planlarını da buna göre hazırlama olanağı ile bahsedilen tedarik zinciri mekanizmalarından biridir. Tedarikçinin müşterilerinin bilgi sistemlerine giriş yetkisine sahip olması bütün tedarik zinciri bileşenlerine esneklik, hızlı reaksiyon, maliyet düşüşü ve stok iyileştirme gibi çeşitli ek avantajlar sağlamaktadır.

Tedarikçi yönetimli envanter sisteminde talep tahmini ve müşterinin talep dalgalanmaların hızlı reaksiyon gösterilmesi sistemin işleyişi açısından kritik düzeyde öneme sahiptir. Talep değişkenliği günümüz tedarik zinciri dünyasının başlıca kısıtlarından biridir. Şirketler içsel ya da dışsal sebepli birçok nicel ve nitel kriterlerden kaynaklı olarak talep değişkenliğinden etkilenmektedir. Bu sebepten dolayı, talep tahmin prosedürü çok kriterli karar verme problemi olarak değerlendirilebilir.

Bu çalışmada hızlı tüketim sektöründe geleneksel tedarik zinciri yöntemleri ile faaliyet gösteren şirket incelenmiş ve tedarikçi yönetimli envanter sisteminin bir aşaması olarak yeni bir sipariş tahmin yöntemi önerilmiştir. Problemimiz bir kısmı nicel ve nitel olmak üzere sekiz kriterlerden etkilenmek olup çok kriterli karar verme problemi olarak ele alınmıştır.

Klasik çok kriterli karar verme yöntemleri net değerler ve kesin uzman değerlendirmeleri üzerine kurulmuş iken gerçek dünyanın karmaşıklığı içerisinde kararların çoğunluğu sözel yargılardan oluşmaktadır. Belirsizlikler ve yetersiz bilgi sebebiyle çalışmamızda sözel yargılar tercih edilmiştir. Ek olarak, bu belirsizlikleri ve insan yargılarındaki öznelliği ve kararsızlıkları çözümleyebilmek amacıyla önerilen yöntemde aralık değerli sezgisel bulanık mantık kullanılmıştır.

Önerilen yöntemde, hızlı tüketim sektöründe faaliyet gösteren firmanın gerçek satış dataları ve gerçek satış koşulları probleme yansıtılmıştır. Uzman kararlarının güvenirliği, kriterlerin etkinliği ve modelin diğer müşteriler için de uygulanabilirliğini gözlemleyebilmek adına farklı kombinasyonlar, duyarlılık analizi ve karşılaştırmalar yapılmış olup aralık değerli sezgisel bulanık mantık kullanılarak sipariş tahmin yönteminin hızlı tüketim sektöründe faaliyet gösteren tedarikçi yönetimli envanter modeli için mantıklı ve istikrarlı sonuçlar verdiği gözlemlenmiştir.

1. INTRODUCTION

Supply chain can be stated as all the activities include in delivering a product from raw material through to the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all the activities (Lummus & Vokurka, 1999). Olah et al. (2017) describes supply chain as integration of four main organization: supplier, manufacturer, distributors and consumers, directly involved in the internal and external flows of products, services, finances, information from a source to a customer. In other words, supply chain starts with suppliers' suppliers and finishes at customers' customers and includes all the activities of supply of materials, production, assembly, inventory, distribution and information.

Supply chain organizations have seen themselves as independent assets for years. In a traditional supply chain, each group focus on their own inventory, production and distribution activities. With the development of information technologies, competition between organizations have changed in content and intensity and they have realized that they have only controlling a small part of value chain. Competitive environment lead to develop supply chains and makes organizations more integrated and specialized. Similar functions have affiliated first, then an internal integration within the company and external integrations with suppliers and customers have occured. Exploration of low cost and high quality materials, flexibility and quick response to customer have become more important for companies in these competitive environment. Constitution of these competitive benefits has been enabled by advanced communication for the whole supply chain (Latifoğlu, 2006; Southard & Swenseth, 2008).

Simchi et al. (2000) describes supply chain management as a combination of approaches used to effectively integrate suppliers, manufacturers, warehouses and markets, in order to produce right product at right quantities, distribute to the right locations at right time to minimize all the costs of system while satisfying service level requirements.

Water (2003) summarize some improvements that comes with supply chain integration as below:

- More collaboration along the supply chain : All organizations share the same target that satisfied final customers and cooperate to achive this aim.
- Improving communications: With the improvement of technology, new technologies such as Electronic Data Interchange (EDI) ensures integrated and increased communication with organizations
- Reduction of number of suppliers: Cooperation within a supply chain encourages to work closely and long term with best suppliers
- Globalization: Lower cost and increasing communication allow organizations to work in a wider areas.
- Outsourcing: Organizations can concentrate on their core businesses and use specialized companies for other operations.
- Cross-docking: With the coordination of supply and delivery organizations, after production goods immediately transfer to loading area and put onto vehicle. This procedure gives an advantage for minimizing holding costs.
- Direct delivery: Shipping from manufacturer to the end customer reduces lead times and additional delivery, sorting, consignment cost of distributor
- Stock reduction methods: Integration of supply chain organizations give additional opportunities to minimize total inventory costs of the system. Some methodologies like Just-in Time (JIT), consignment stocks, Vendor Managed Inventory (VMI) help organizations to challenge with excessive stocks and productions.

Information flows among the members is one of the important mechanism for coordination in supply chain. These information flows influence production, inventory and distribution directly and distortion of information can cause an enormous inefficiencies like excessive inventory, poor service level, lost sales, inaccurate capacity plans, misguided production schedules, inefficient distribution plans (Lee et al., 1997, Portes & Vieira, 2006). The Bullwhip Effect is a phenomenon that cause by distortions of information flows and where the orders to the supplier tend to have larger fluctuations than sales to retailer. Figure 1 shows the fluctuations up to supplier due to the structure of the ordering decisions. Even the sales of products do not fluctuates very much, there is a variability on retaler's order. Orders to manufacturer and manufacturer's supplier fluctuate even more.

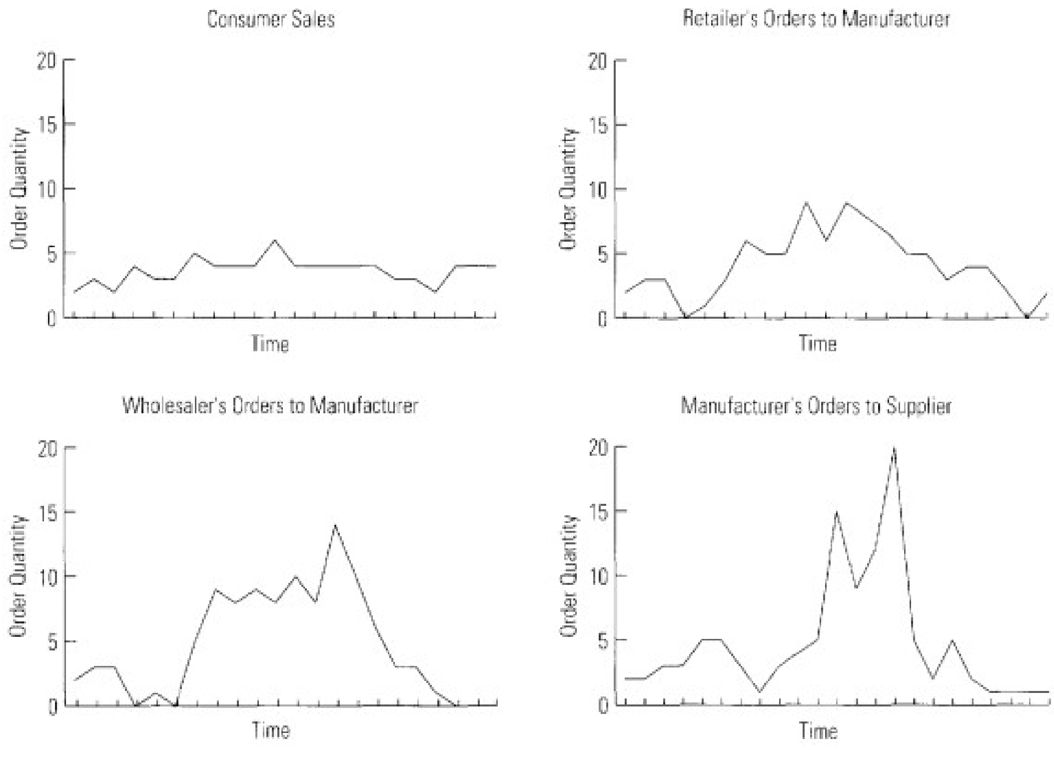


Figure 1.1: Increase of orders' variability up to supply chain (Lee et al., 1997)

In a traditional supply chains, due to the structure of the ordering decisions and lead-time for deliveries, organizations are very prone to the Bullwhip Effect. Consumer demands obviously varies and when it is increased, the retailer introduces extra variations into the demand pattern as a consequence of customer demand forecast. The distributor, whose demand forecasts are dependent with the orders of retailer, increase fluctuations further. Similarly, with the orders of distributor, manufacturer form his order with extra variations. This effect goes on up the supply chain and cause a significant distortion on the real customer demand. Stalk and Hout (1990) provide a detailed description of the Bullwhip Effect found in a clothing supply chain and Towill and McCullen (1999) summarized as shown in Figure 1.2 (Disney & Towill, 2003; Portes & Vieira, 2006). It is easily seen that fluctuations at supplier is 8 times greater than customers' demand fluctuations.

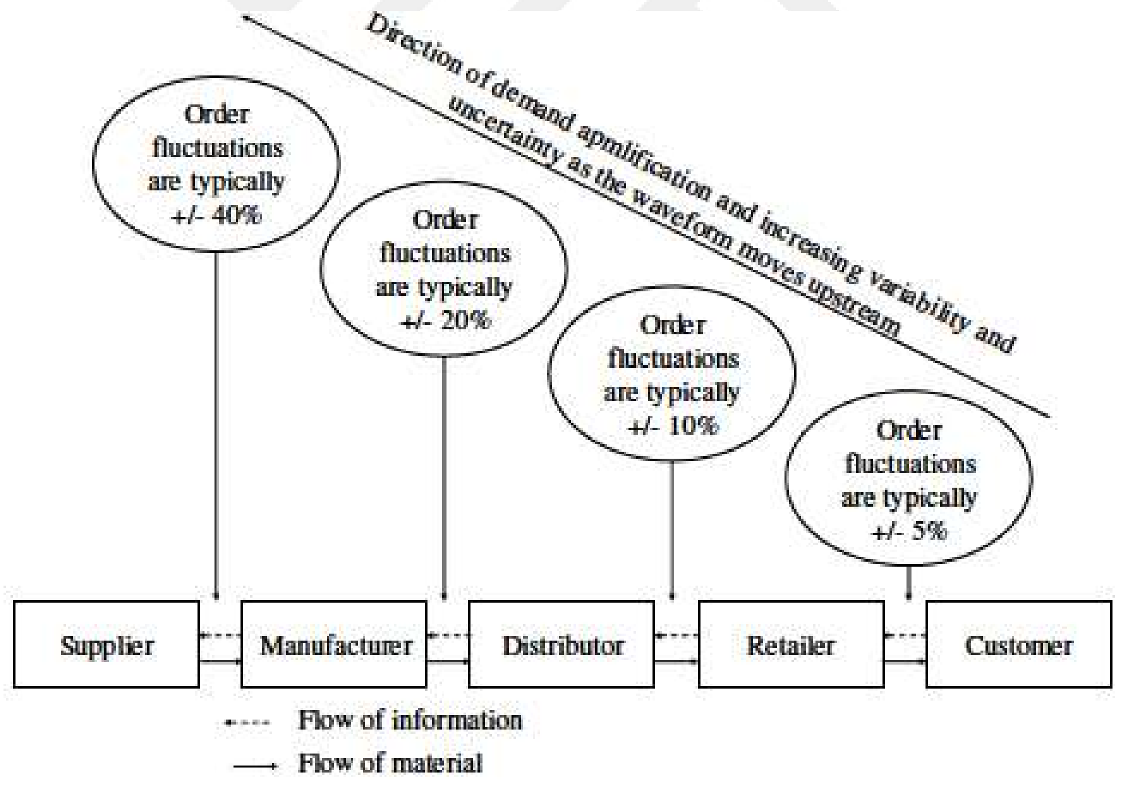


Figure 1.2: The Bullwhip Effect in a traditional retail supply chain (Disney & Towil, 2003)

Lee at al. (1997) identifies four major causes of bullwhip effect: that are demand forecast updating, order batching, price fluctuations, rationing and shortage gaming. Demand forecast updating occurs from using the past demand informations and immediate customer demands. When a downstream operation places an order, the upstream one understand it as a signal of higher demand and create extra variations to upstream organization. Order batching is a constraint of batch quantities and economics of scale. Upstream organizations will want to order for accumulated demands and supply full truck load in order to reduce order and transportation cost. But when the customers orders periodically, the bullwhip effect will occur because of batch quantitities. Price fluctuations cause by the additional discounts of manufacturers and distributors. Sometimes they offer special promotions like price discounts, quantity discounts and trade deals like payment terms,price terms in order to take bigger orders than required. As a result of these advanced opportunities, customers buy bigger quantities and stock for the future needs. Rationing and shortage gaming is the behaviour of buyers when demand exceeds supply. In a shortage times customers exaggerate their order, but when the demands cool down orders suddenly disapper and order cancelations began.

Vendor-managed inventory (VMI) is one of the most widely discussed subject for improving supply chain efficiency. Also known as a continuous replenishment or supplier-managed inventory, it was popularized in the late 1980s by Wal- Mart and Protecter & Gamble. In 1985, the partnership has dramatically improved P&G’s on-time deliveries and Wal-Mart’s sales (Buzzell and Ortmeyer, 1995). VMI became one of the key programs in the grocery industry’s pursuit of “efficient consumer response” and the garment industry’s “quick response”. K-Mart had developed over 200 VMI partners by 1992 (Schonberger, 1996). Successful VMI initiative have been trumpeted by other companies in United States, including Campbell Soup and Johnson & Johnson, and by European firms such as Barilla (Waller et al., 1999; Tyan & Wee, 2003).

Under the VMI aggrement, the retailer provides sales plans and sales data to vendor. The vendor then produces the sales forecasts and supplies the inventory to meet agreed upon customer service levels and inventory turnover targets (Achabal et al., 2000).

VMI is actually an alternative for the traditional order based replenishment practices. It changes the problem solving characteristics of supply chain coordination. For more accurate and faster supply, the pressure on the supplier performance has been evolved into the responsibility and authorization on the management of the entire replenishment process. The customers open their own system to the supplier for the current stock level and demand information and sets the targets for availability of products. Then, the vendor decides and manages deliver time and shipped quantity. Therefore, vendor performance changes into the availability and turnover of stocks from the delivery time and accuracy (Razmi et. al., 2010).

In vendor-managed inventory (VMI) systems, the supplier is responsible not only for delivering the products and routing its vehicles to serve its customers, but also determining when and how much to deliver to them (Coelho & Laporte, 2015). That is, VMI can help the supplier for the production plan and stock control for long period with fully accession to the retailer’s current stock level and demand information, and the retailer can release his pressure on stock control and fullfillments (Hong et al., 2016). In other words, vendor decides on the appropriate inventory levels of each of the products for all retailers, and the appropriate inventory policies to maintain these levels (Clark & Hammond, 1997; Waller et al., 1999; Dong et al., 2015; Olah et al., 2017).

Disney and Towill (2003) provided that VMI comes in many different forms including quick response, synchronized consumer response, continuous replenishment, efficient customer response, rapid replenishment, collaborative planning, forecasting and replenishment, and centralized inventory management (Lin et al., 2014).

The historical perspective of VMI can be traced back to the early development of QR for general merchandized retailers and their suppliers. Due to the intense competition in the textile industry, leaders in the US apparel industry established the ‘‘Crafted With Pride in the USA Council’’ in 1984 (Lummus & Vokurka, 1999; Tyan & Wee, 2003). The Council’s analysis showed that delivery times for apparel industry is very long, 66 weeks from raw materials to customer, where 40 weeks of which spent in warehouse or transportation. Quick Response (QR), where retailers and vendors work closely to reply consumer demand quickly by information sharing, was developed to reduce inventory cost and lead time. According to Schonberger (1996), a pioneer QR implementation company, Milliken and Company, reduced lead time from 18 weeks to 3 weeks.

Similar to the textile industry, in 1992, a group of grocery industries leaders created a joint industry task force called the Efficient Consumer Response (ECR) working group. They identified set practices, which if implemented, could substantially improve overall performance of the supply chain. They also showed that by expediting the quick and accurate flow of information in the supply chain, ECR enables distributors and suppliers to forecast demand more accurately than the current system (Tyan & Wee, 2003).

A further development of ECR is the concept of Continuous Replenishment Policy (CRP). CRP is a material flow from pushing goods at warehouses to pulling products onto market shelves based on consumer demand (Lummus & Vokurka, 1999; Tyan & Wee, 2003). In a CRP strategy, retailers sales data is used by vendors for shipment and replenishment plans to ensure previously agreed specific stock levels. In an advanced form of CRP, retailers' or distribution centres' stock levels suppliers may gradually decrease on condition that supplier guarantee agreed service levels (Troyer & Denny, 1992). CRP has been introduced by so many manufacturers as P&G, Campbell Soup, Ralston, General Mills and Pillsbury and estimates showed that replenishment period reduced from 30 days to 5 days (Lummus & Vokurka, 1999).

The partnership between retailer and supplier benefits both, as well as the customer. When the partnership moves from one level to the next, a new set of skills has to be learned and employed by the vendor to implement that strategy (Tyan & Wee, 2003). Simchi-Levi et al. (2000) summarized different retailer-supplier partnership strategies as Table 1.1.

Table 1.1: Comparion of major retailer-supplier strategies (Simchi-Levi et al., 2000)

Strategy	Decision maker	Inventory ownership	New skills employed by vendor
Quick Response (QR)	Retailer	Retailer	Demand forecasting
Continuous Replenishment Policy (CRP)	Contractually agreed levels	Either party	Demand forecasting & inventory control
Advanced Continuous Replenishment	Contractually agreed to & continuously improved levels	Either party	Demand forecasting & inventory control
Vendor Managed Inventory (VMI)	Vendor	Vendor	Demand forecasting & inventory control & retail management

The idea behind the use of VMI method toward sales companies is to implement "pull" control concept instead of "push" system; manufacturing and production is to be controlled by market demand, its trends, and seasonal nature, in other words by the actual sales of sales company. The retailer share information related with their order portfolio, stock levels, sales forecasts and the vendor guarantees to cover a determinate safety stock level (De Toni & Zamolo, 2005).

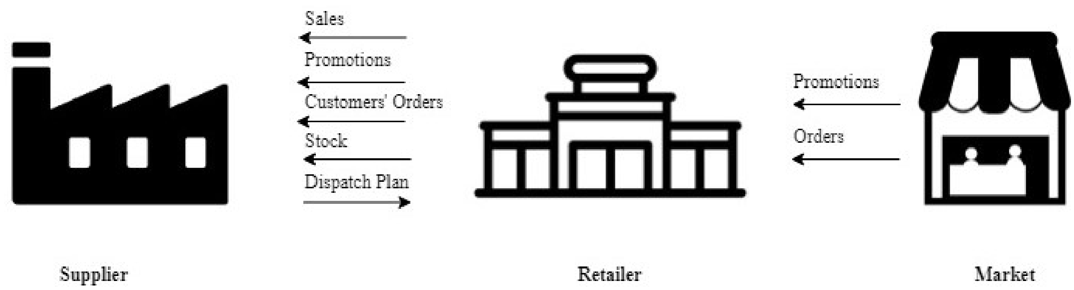


Figure 1.3: Supplier- retailer relationship

As we can see from Figure 1.3 although the customer orders take by retailers, the quantities of shipping to retailer is supplier's responsibility. The peaks of replenishments to be adjusted due to safety stock, which in turn allow a levelling of production.

Additionally, stock level of retailer, promotional activities information and sales data are shared with supplier for calculation of shipment quantities.

The evolution from traditional supply chain inventory policies to VMI has provide significant advantages for all partners of supply chain. VMI systems increase flexibility in the vendor’s operations and bring additional benefits like high customer service level as a result of immediate response for customers’ fluctuating demands, increased market visibility, smooth production and distribution plans, cost reduction for all supply chain, optimizing of inventories, better management of risks and opportunities, and increasing profit and competitiveness (Waller, 1999; Gronalt & Rauch, 2008; Borade & Sweeney, 2015). The benefits of VMI systems are shown at Table 1.2. VMI systems achieve these goals through more accurate sales forecasting methods and more effective distribution of inventory in the supply chain (Achabal et al., 2000).

Table 1.2: Benefits of VMI

-increased flexibility
-immediate response for customers’ fluctuating demand
- increased marked visibility
- smooth production
- smooth distribution
- cost reduction
- inventory optimization
- better risk and opportunity management
- increasing profit and competitiveness

In a VMI system, due to the responsibility of vendor for the replenishment decision, namely how much and how often to replenish, demand forecasting and quick response for demand fluctuations of retailer is crucial. In today’s world, all industries face challenges due to demand variability; these challenges may be produced internally or externally (Ramesh, 2009). Internally, demand variability can occur due to the introduction of a new product that includes similar characteristics of an existing product. Another internal way of creating demand instability could be due to poor communication between different stages of the supply chain: demand is increased upstream in the supply chain, a factor known as the bullwhip effect (Lee et al., 1997). Due to the bullwhip effect, the demand variation of the suppliers is much greater than the demand variation of the retailers. Externally, different promotions or sales incentives in order to increase sales and take advantage in the competition, may cause demand variability. Both internal and external challenges that summarized at Table 1.3 may impact demand fluctuations and create demand uncertainty (Govindan, 2015).

Table 1.3: Demand variability

Demand variability	internal	New product with similar characteristic
		Poor communication among different nodes of supply chain
	external	Different campaigns of competitors' product
		Sales incentives for similar products

In the literature of demand varibility on VMI system, Waller et al. (1999) evaluated demand varibilities effects to the benefits of VMI for Hewlett-Packard company and found that lower variability has the greatest reduction in stock while improving manucturer's delivery performance. Similarly, Cachon and Fisher (1997) examined forecasting and invertory management under VMI for Campbell's Soup company. They found that simple inventory management rules can significantly reduce both retailer and manufacturer's inventories while improving service level. Chen et al. (2012) showed that demand variability and correlation among retailers play important roles on the vendor's optimal distribution policy.

In other words, demand forecasting could be affected by a number of criterions some of which may be product's spesifications, stocks of customer, sales potentials, different campaigns or incentives which are quite conflicting in nature. Therefore, demand prediction can be categorised as a Multi-Criteria Decision Making problem involved in evaluating a set of criterias through which the vendor need to identify optimal demand value.

In our study, we focus on order prediction for vendor managed inventory system of FMCG companies which is a multicriteria problem that affected by a variety of quantitative and qualitative criterias. Classic multicriteria decision making problems, decisions of experts' are being represent by crisp numbers; but in reality owing to uncertain data, insufficient information and vagueness of vendor managed inventory systems we prefer linguistic evaluations. In order to solve the uncertainty, insufficiency and subjectivity in the human judgments; the fuzzy set theory was introduced by Zadeh (1965) and has been used in various areas including multicriteria decision making, aggregation operations, definition of uncertain linguistic variables, etc (Kahraman et al., 2017). The extensions of fuzzy set theory are proposed to cope with ambiguos information: Intuitionistic Fuzzy Sets (IFS) have been proposed by Atanassov (1986) and Interval-valued Intuitionistic Fuzzy Sets (IVIFS) have been introduced by Atanassov and Gargov (1989) in order to explain the information of alternatives under incomplete and uncertain information environment.

In the literature, there is not a lot of study about forecasting with fuzzy sets. Xiao et al (2009) has used forecasting accuracy as the criterion of fuzzy membership function and proposed a combined forecasting approach based on fuzzy soft sets. In a different study, a new adjustable object parameter approach to predict the unknown data in an incomplete fuzzy soft sets proposed by Liu et al. (2017). As a prediction model with intituitionistic fuzzy sets, Wei et al. (2016) proposed a prediction model for traffic emission and Wang et al. (2015) used demand prediction model for an emergency supplies.

The rest of the paper is organized as follows. Section 2 introduces literature survey and Section 3 introcudes decision making process. Section 4 includes the basics of intuitionistic fuzzy sets, interval-valued intuitionistic fuzzy sets and basic arithmetic operations. Model and methodology is presented in Section 5 and application of the proposed method,sensitivity analysis and comparison results are included in Section 6. Section 7 concludes the paper and suggestions are given for further studies.

2. LITERATURE SURVEY

There many studies about vendor managed inventory system with different models and different implemantations. They can be seperated with the number of vendors-retailers or characteristics of demand, as deterministic or stochastic, key parameters of evaluation or appliance sectors. The academic studies on this section can be categorized in three groups : (1) general papers that define VMI and describe the benefits of its application, (2) case studies from different sectors with VMI applications and discussions of results and limitations, (3) modeling papers that propose mathematical models to investigate the effect of key parameters on VMI performance.

Yao et al. (2007) developed an analytical a single vendor-single retailer model with deterministic demand to explore how order cost and inventory cost parameters affect cost saving in a VMI system. The results showed that inventory reduction both affects supplier and retailer in a positive but disproportionally with long term relationship.

Gumus et al. (2008) studied the benefits of single vendor-single retailer VMI model with deterministic demand. In contrast to general belief, the study showed that consignment inventory is beneficial for both vendor and retailer, depending of the transportation cost.

Darwish and Odah (2010) investigate a single vendor-multiple retailer VMI system with deterministic demand to find optimal solution with lower total system cost. The VMI model with contractual aggrement, retailers are protected by an upper limit on maximum stock level with penalization to the vendor for exceeding maximum stock capacity.

Rad et al. (2014) studied mathematical models with a single vendor and two retailers and find that greater optimization in total cost of supply chain can be achieved by using VMI. The key parameters are buyer's demand and transportation costs and vendor's ordering and holding costs. The study showed that VMI is more beneficial than traditional system.

Cetinkaya and Lee (2000) present an analytical model for coordinating inventory and transportation decisions in VMI systems and found that VMI greatly reduces inventory holding costs and stock-out problems with synchronization of both inventory and transportation decisions.

Chaouch (2001) developed an analytical model to calculate inventory levels and delivery rates to minimize costs for small suppliers forced to use VMI by larger customers. One important finding of the study was reducing variability in the amount and timing of demand increased the benefits of lowered inventory.

Cachon and Zipkin (1999) studied a two-echelon supply chain with a single vendor – a single retailer that both of them ready to pay customer backorder costs and choose their base stock levels seperately to minimize their own costs. With the numerical comparison to minimize total system costs, it is showed that the competition penalty will be lower if both participants share backorder costs, but if not, it can be much more.

Cachon (2001) studied VMI model with one vendor and multiple retailers and presented that when both the participants are willing to pay fixed transfer payments in order to take part of VMI contracts and share the benefits, VMI can achieve to minimize total supply chain costs.

Mateen and Chatterjee (2015) have explored different replenishment policies for a single vendor-multiple retailer model and proposed some general guidelines specifying different conditions under which different policies may become more beneficial. The policies differ primarily in terms of the number of retailers replenished in each delivery cycle, timing of replenishment and the size of the delivery sub-batch.

Hong et al. (2016) studied a two echelon distribution system with multiple vendors and retailer in a traditional inventory systems and VMI systems to identify the benefits of vendor managed inventory system. The demand is stochastic with a uniform distribution and the key parameters are setup cost and holding cost for vendors and transportation and order costs for retailers. The results illustrate that VMI system total inventory cost is lower than a traditional system where the shortage is allowed.

Razmi et al. (2010) developed a single vendor- single retailer model to compare performance of traditional and vendor managed inventory system when customer demand is normally distributed. The key performance parameter is total inventory cost in the suppy chain and they investigate how increasing or reducing the related parameters affect the total cost of two systems. Analyzes result that VMI works better and delivers lower cost in all conditions than traditional system.

Yu et al. (2015) compares retailer managed and vendor managed systems where the retailer faces demand uncertainty and the supplier faces exchange rate uncertainy. They suggest that VMI does not perform better than RMI all time then VMI cannot reduce ordering, delivery and holding costs. Additionally, VMI performs worse first and better later as the degree of exchange rate fluctuation increases.

Kim (2004) investigate optimal replenishment policy for a single vendor and single outsourcing partner where production of certain products are made and raw materials for production are supplied by the vendor. The model is formulated as a Markov decision problem and using dynamic programming, he presented a simple procedure that finds optimal shipment rule and replenishment quantity.

Borade and Sweeney (2015) used Genetic Algorithms based decision support system to provide singnificant economic benefits measured in terms of cost, profit, stockouts and service levels in an uncertain demand environment.

Ben-Daya et al. (2013) studied a single vendor- multiple retailers model with combination of consignment and vendor-managed inventory policy. Three vendor- retailers partnerships are studied to examine the benefits of vendor managed inventory and consignment aggrement. It is found that VMI & CS aggrement is more beneficial when there is no capacity constraint. It is also presented that if setup costs of vendors are not significant according to the order costs of retailers, VMI & CS aggrement is more attractive for retailers.

Tyan and Wee (2003) studied the vendor- retailer relationship through a vendor managed inventory system in the Taiwanese grocery industry with service level and inventory level as key parameters. It is stated that besides the cost reduction and service level improvement, VMI is considered as one of the main systems in strategic partnership.

Achabal et al. (2000) described a decision support system in the apparel industry with vendor managed inventory system. Market forecasting and inventory managements are main components of VMI decision support system. A case study with a vendor managed sales forecasing and inventory replenishmen system resulted in effective supply chain coordination, improved service levels and faster inventory turns.

De Toni and Zamolo (2005) implemented vendor managed inventory system in household electrical appliances sector, Electrolux Italia. The study demonstrated the benefits and detailed comparison with traditional system of VMI system.

Lin et al. (2014) proposed a forecast forward replenishment model for a single seller and single buyer vendor managed inventory system. A real case for electronic components company examined and a simulation study is conducted to compared the model with other strategies. The key parameters are inventory cost and service level.

Govindan (2015) studied one vendor and multiple reailers supply chain with stochastic demand in pharmaceutical industry. The study aims to investigate the supply chain that minimizes system cost performance between traditional and VMI system. Adjusted Silver-Meal and Least Unit Cost heuristics are used.

Lin et al. (2010) developed a dynamic fuzzy system in a VMI supply chain with fuzzy demand. Genetic Algorithm method is used to search optimal parameters of the model. The results show that the fuzzy VMI model is better than crisp VMI model and, can simultaneously reduce the Bullwhip effect and inventory response in supply chain.

Kristiano et al. (2012) proposed an adaptive fuzzy control application to generate a smooth forecasting, production and delivery plan and to eliminate Houlihan effect, Burbidge effect and the Bullwhip effect. Adaptive fuzzy VMI control exceed fuzzy VMI control and traditional VMI in terms of mitigating the Bullwhip effect and backorders.

Table 2.1 summarizes some articles chronological which are search on VMI with different methods and aspect.

Table 2.1: Literature survey on VMI

Topic	Date	Authors	Article Name	Demand type	Methodology	Key findings	Further study
Benefits of VMI	1999	Cachon and Zipkin	Competitive and cooperative inventory policies in a two-stage supply chain	Stochastic	game theory	if the supplier and retailer equally share backorder costs, the competition penalty is lower, but if not, it will be much more.	
Benefits of VMI	2000	Çetinkaya and Lee	Stock replenishment and shipment scheduling for vendor-managed inventory systems	Stochastic	renewal theoretical model	VMI reduces inventory holding costs and stock-out problems with synchronization of both inventory and transportation decisions	
Implementation	2000	Achabal et al.	A Decision Support System for a Vendor Managed Inventory	Deterministic	decision support system	A case study with a vendor managed sales forecasing and inventory replenishmen system resulted in effective supply chain coordination, improved service levels and faster inventory turns.	Micromarketing data can provide the basis for more accurate store level sales forecastion and consequently more effective inventory management.
Benefits of VMI	2001	Chaouch	Stock levels and delivery rates in vendor-managed inventory programs	Deterministic	theoretical model	a model that seeks the best trade-off among inventory investment, delivery rates, and permitting shortages to occur, given some random demand pattern for the product	
Benefits of VMI	2001	Cachon	Stock wars: Inventory competition in a two-echelon supply chain with multiple retailers	Stochastic	game theory	If both participants are willing to pay fixed transfer payments to take a part of VMI contracts and share the benefits, the total supply chain costs will be smaller	
Implementation	2003	Tyan and Wee	Vendor managed inventory : a survey of the Taiwanese grocery industry.	Deterministic	analytical model	It is stated that besides the cost reduction and service level improvement, VMI is considered as one of the main systems in strategic partnership.	Further VMI applications may be integration of online e-grocery with existing grocery chains
Mathematical model	2004	Kim	Stochastic vendor managed replenishment with demand dependent shipment	Stochastic	Markov desicion problem, dynamic programming	The model is formulated as a Markov decision problem and using dynamic programming and presented that finds optimal shipment rule and replenishment quantity.	

Table 2.1: Literature survey on VMI (continued)

Topic	Date	Authors	Article Name	Demand type	Methodology	Key findings	Further study
Implementation	2005	De Toni and Zamolo	From a traditional replenishment system to vendor-managed inventory. A case study from the household electrical appliances sector	Stochastic	algorithms	The study demonstrated the benefits and detailed comparison with traditional system of VMI system	
Benefits of VMI	2007	Yao et al.	Supply chain integration in vendor-managed inventory	Deterministic	analytical model	using an analytical model that helps to provide a better understanding of how key supply chain parameters, namely ordering costs and carrying charges, affect the benefits to be realized from VMI and the disproportionally distribution of these savings between retailers and suppliers.	Future modeling could examine how these payments can be used to encourage supply chain partners to adopt these programs.
Benefits of VMI	2008	Gumus et al.	Impact of consignment inventory and vendor-managed inventory for a two-party supply chain	Deterministic	theoretical model	In contrast to general belief, the study showed that consignment inventory is beneficial for both vendor and retailer, depending of the transportation cost.	
Benefits of VMI	2010	Darwish and Odah	Vendor managed inventory model for single-vendor multi-retailer supply chains	Deterministic	non-linear programming	The VMI model with contractual aggrement, the vendor is penalized for exceeding maximum stock capacity and retailers are protected by an upper limit on maximum inventory level.	Impacts of randomness in the demand pattern and transportation cost on inventory decisions.
Benefits of VMI	2010	Razmi et al.	Developing a two-echelon mathematical model for a vendor-managed inventory (VMI) system	Stochastic	analytical model	VMI works better and delivers lower cost in all conditions than traditional system	Lost sales of buyer that caused by shortages should be also consideren in the model.
Mathematical model	2010	Lin et al.	A simulation of vendor managed inventory dynamics using fuzzy arithmetic operations with genetic algorithms	Deterministic	fuzzy & genetic algrorithm	From observing results the stock performance of fuzzy VMI model is better than previous crisp VMI model, and Bullwhip measure also can get reasonable and good performance in the fuzzy VMI model.	the other types of VMI model also may be extended to consider fuzzy input parameters/variables with the fuzzy system dynamic.
Mathematical model	2012	Kristianto et al.	Adaptive fuzzy vendor managed inventory control for mitigating the Bullwhip effect in supply chains	Deterministic	adaptive fuzzy system	The results show that the adaptive fuzzy VMI control surpasses fuzzy VMI control and traditional VMI in terms of mitigating the Bullwhip effect and lower delivery overshoots and backorders	The adaptive fuzzy VMI control should optimize production lead time to mitigate the Bullwhip effect in the inventory

Table 2.1: Literature survey on VMI (continued)

Topic	Date	Authors	Article Name	Demand type	Methodology	Key findings	Further study
Benefits of VMI	2013	Ben-Daya et al.	Consingment and vendor managed inventory in single-vendor multiple buyer supply chains	Deterministic		VMI&CS aggrement is more beneficial when there is no capacity constraint. And if order costs are very high and setup cost are not significant, aggrement is more attractive for retailers.	Capacity constraints with allocation problems and demand shortages may be considered for further studies.
Benefits of VMI	2014	Rad et al.	Optimizing an integrated vendor-managed inventory system for a single-vendor two-buyer supply chain with determining weighting factor for vendor's ordering cost.	Deterministic	analytical model	VMI is more beneficial than traditional retailer managed inventory system for total inventory cost.	the model in which shortage is allowed in the form of lost sales can be the subject of future research
Implementation	2014	Lin et al.	A comparison study of replenishment strategies in vendor-managed inventory	Stochastic	analytical model	A forecast forward replenishment model proposed for electronic components company and compared with other replenishment strategies.	Multiple warehouses and buyer and the allocation policy from the plants to multiple warehouses will be future study.
Benefits of VMI	2015	Mateen and Chatterjee	Vendor managed inventory for single-vendor multi-retailer supply chains	Deterministic	analytical model	different replenishment policies for a single vendor-multiple retailer model proposed guidelines specifying different conditions under which different policies may become more beneficial.	how changing demand and vendor's capacity flexibility can impact the system ?
Benefits of VMI	2015	Yu et al.	How much does VMI better than RMI in a global environment?	Deterministic	analytical model	VMI does not perform better than RMI all time then VMI cannot reduce ordering , delivery and holding costs	reduction of the ordering/delivery/ holding costs of both the supplier and the retailer caused by VMI is not considered
Implementation	2015	Borade and Sweeney	Decision support system for vendor managed inventory supply chain: a case study	Deterministic	Genetic algorithms	provides empirical evidence that significant economic benefits can be achieved with the use of a genetic algorithm (GA)-based decision support system (DSS) in a VMI supply chain	Further work would aim to develop an algorithm which can consider multiple products/retailers with variable locations and also focus on establishing routes based on replenishment time.
Mathematical model	2015	Govindan	The optimal replenishment policy for time- varying stochastic demand under vendor managed inventory	Stochastic	Adjusted Silver-Meal heuristic & Least Unit cost heuristic	The buyer who acquire the same product from the vendor, the better opportunities for the vendor to consolidate the demand and to decide upon common replenishment dates.	Integration of backordering costs and shortage problems may be the main focus of further studies with extension of the Silver-Meal Heuristic with augmentation quantity model
Benefits of VMI	2016	Hong et al.	Multiple-vendor, multiple-retailer based vendor-managed inventory	Stochastic	analytical model	VMI system total inventory cost is lower than a traditional system where the shortage is allowed.	different cycle times and several products could take account in the system

3. DECISION MAKING PROCESS

Decision making is one of the most important and most frequent activities of human beings. It is a procedure of identifying and choosing alternatives. Selected alternatives will not only have the highest success probability, but also best match with decision maker's goals, objectives or desires. Each decision is a selection among alternatives made by groups or individuals but it has changes over the last decades. Decision making environments developed increasingly to become multi-criteria and multi-decision maker environments (Triantaphyllou, 2000).

A decision making framework proposed by Simon (1977) and consist of three phase: intelligence, design and choice. Implementation phase has added later. Figure 3.1 shows the framework and its steps.

Decision making process starts with intelligence phase, where the definitions of the problem and problem statement is defined. Required data and other requirements are also found and gathered in this phase. In the design phase, the model is constructed by making assumptions. Formulation of the model, generation of the alternatives and determination of the criterias are made in this phase. The choice part is the phase that where analysis of results and the selection of the proposed solution for the model is stated. When the proposed solution is reasonable, implementation phase begins. Successful implementations concludes in reality problems while failured ones return to the previous phases.

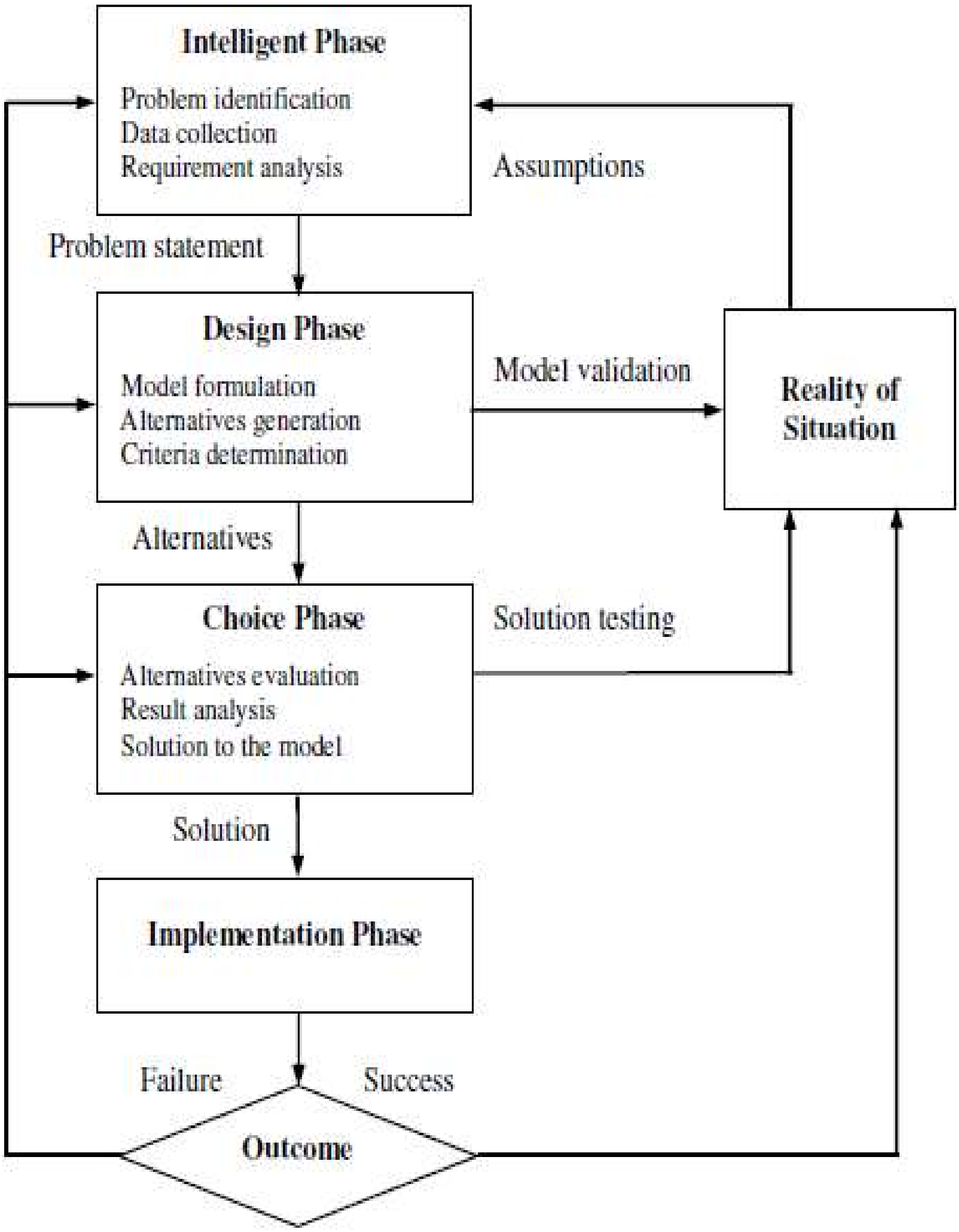


Figure 3.1: Decision making process framework (Lu et al., 2007)

3.1. Multi-Criteria Decision Making (MCDM)

Multi-criteria decision making defines making decisions in the presence of multiple and conflicting criterias. In everyday life, multiple criteria decision making problems occur commonly. However, even with the diversity, all the MCDM problems share the following common characteristics (Hwang & Yoon, 1981; Triantaphyllou, 2000):

- Alternatives: In general, the alternatives represent the different choices of action available to the decision maker.
- Multiple criteria: Each problem has multiple criteria which can be objectives or attributes.
- Conflict among attributes: Since different attributes represent different dimensions of the alternatives, they usually conflict with each other.
- Incommensurable units: Different criterias may be associated with different units of measure.
- Decision weights: Most of the MCDM methods require that the attribute be assigned weights of importance.
- Decision Matrix: A MCDM problem can be expressed in a matrix format. A decision matrix A is a $(m\,x\,n)$ matrix whose element a_{ij} indicates the performance alternative A_i, with respect to decision criterion C_j (for $i = 1,2,\dots,m$ and $j = 1,2,\dots,n$). In other words, the matrix is called as the matrix of decision or performance table. Each line of the matrix expresses the performances of the action or alternative i relative to n criteria considered. Each column j expresses the evaluations of all the actions made by the decision maker, relative with the criteria (Üçüncüoğlu, 2010).

There two types of criteria which are objectives and attributes. For this reason, in the literature there are two basic approach for multicriteria decision process, which are Multi-Objective Decision Making (MODM) and Multi-Attribute Decision Making (MADM). The main difference between MODM and MADM is decision spaces. MODM has a continuous decision space while MADM has a discrete one. In MADM problems, set of decision alternatives are determined and the focus of the problem is selecting the best alternative among the predetermined finite set of alternatives. On the other hand, MODM designs alternatives when possible number of alternatives is high or infinite. Table 3.1 shows the differences of MODM and MADM approaches (Hwang & Yoon, 1981).

Table 3.1: The differences of MODM and MADM approaches (Hwang & Yoon, 1981).

	MODM	MADM
Criteria defined by	Objectives	Attributes
Objectives defined	Explicitly	Implicitly
Attributes defined	Implicitly	Explicitly
Constraints defined	Explicitly	Implicitly
Alternatives defined	Implicitly	Explicitly
Number of Alternatives	Continuous- Infinite	Discrete- Finite
Decision Maker's Control	Significant	Limited
Usage	Design	Selection & Evaluation

3.1.1. Multi-Objective Decision Making (MODM)

Multi-Objective Decision Making (MODM) is known as continuos type of the MCDM. It is used for designing of the problems and the decision makers need to achieve incommensurable and conflicting infinite number of objectives. Most of MODM methods are based on mathematical programming in which there are more than one objective to be optimized and try to obtain an appropriate compromise solution form a set of efficient solution (Üçüncüoğlu, 2010). Generally a multiple objective decision making problem can be formulated as follows:

$$\max F(x) = \{f_1(x), f_2(x), \dots, f_k(x)\}$$
$$subject\ to\ g_j(x) \leq 0\ for\ i = 1, \dots, m \tag{1}$$

where x is an n-vector of decision variables and $f_1(x), f_2(x), \dots, f_k(x)$ are the objective functions to be maximized.

A feasible solution that maximizes all the objectives simultaneously is called a superior solution of MCDM problem. In most MODM problems, a superior solution does not exist as the objectives conflict with one another (Ravindran, 2008).

3.1.2. Multi-Attribute Decision Making (MADM)

Multi-Attribute Decision Making (MADM) is making preference decision, like evaluation, selection, prioritization, among the available multiple conflicting attributes. As a main characteristic of MADM, there a finite number of predetermined attributes and the final decision is made among these attributes (Lu et al., 2007). Mathematical formulation of MADM is stated as:

$$\begin{gathered} Select\ A_i\ from\ A_1, \dots, A_m \\ subject\ to\ C_1, C_2, \dots, C_n \end{gathered} \tag{2}$$

where $A = (A_1, \dots, A_m)$ denotes m alternatives, $C = (C_1, C_2, \dots, C_n)$ is n attributes for characterising a decision situtaion. The select function is usually maximizing a multiple attribute utility function. The decision matrix for MADM problem is shown as below:

$$\begin{gathered} D = \begin{matrix} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & \dots & C_n \end{matrix} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{matrix} \\ W = [w_1, w_2, \dots, w_n] \end{gathered} \tag{3}$$

where $A_1, A_2, \dots, A_m$ are alternatives from which decision makers select, $C_1, C_2, \dots, C_n$ are attributes with which alternative performances are measured, $x_{ij}, i = 1,2, \dots, m$ and

$j = 1,2, \dots, n$ is the rating of alternative A_i with respect to attribute C_j and w_j is the weight of attribute C_j (Lu et al., 2007).

3.1.2.1. Multi-Attribute Decision Making Methods

Multi-attribute decision making methods have been developed for evaluation of alternatives defined by multiple attributes. Hwang and Yoon (1981) classified 17 typical MADM methods accordingly to the type and outstanding features of information received from decision makers. Later, in 1995, Yoon and Hwang modified a taxonomy of 13 MADM methods (Lu et al., 2007). In this study, we will define the most frequently methods of MADM. The following sectios gives a brief information about them and the main concepts and features as stated.

3.1.2.1.1. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The principle of TOPSIS is that the chosen alternative should be the closest one o the ideal solution and the furthest one from the negative-ideal solution. The ideal solution is constituted as a composition of the best performance values displayed in the decision matrix by any alternative for each attribute. The negative-ideal solution is the composite of the worst performance values (Kahraman, 2008). TOPSIS assumes that each attribute takes either increasing or decreasing monotonically (Hwang & Yoon, 1981). For the decisions of beneficial criteria, the decision makers will be willing to have maximum value among the alternatives where as the minimum values. However, he/she will wants to have minimum values for the decision of criterias with disadvantages.

3.1.2.1.2. Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) was first proposed by Charnes et al. (1978) and it is a nonparametric method of measuring the efficiency of a decision making unit. DEA is a relative, technical efficiency measurement tool that uses operations research techniques to automatically calculate the assigned weightes of the production units' inputs and outputs being assessed. The actual input and output data values are then multiplied with the calculated weights to determine the efficiency scores. DEA is a nonparametric multiple criteria method; no production, cost, or profit function is estimated from the data (Kahraman, 2008).

3.1.2.1.3. Multiple Attribute Utility Theory (MAUT)

Utility theory describes the selection of a solution that the maximization of satisfaction derived from its selection. The one that maximizes utility is best alternative for the decision maker's stated preference structure. There are two utility models which are additive and multiplicative utility model (Kahraman, 2008). The main steps in using a multiple attribute utility model are :

1) utility functions determination for individual attributes,

2) determination of weighting or scaling factors,

3) determination of the utility model type,

4) the measurement of the utility values for each alternative with respect to the considered attributes,

5) the selection of the best alternative (Üçüncüoğlu, 2010).

3.1.2.1.4. Elimination and Choice Translating Reality (ELECTRE)

The basic concept of the ELECTRE (Elimination Et Choix Traduisant la Réalité or Elimination and Choice Translating Reality) method uses outranking relationship. By using pairwise comparisons among alternatives, it deals with outranking relation under each criteria separately. The outranking relationship of two alternatives, denoted as $A_i \rightarrow A_j$ describes that even though two alternatives i and j do not dominate each other mathematically, the decision maker accepts the risk of regarding A_i as almost surely better than A_j. An alternative is dominated if another alternative outranks it at least in one criterion and equals it in the remaining criteria (Kahraman, 2008).

3.1.2.1.5. Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE)

The preference ranking organization method of enrichment evaluations (PROMETHEE) methods have been developed by Brans and Vincke (1985). Different from the concept of ELECTRE, concordance and discordance, positive and negative outranking flow concepts are used for gathering evidence about preference of alternatives and constructing the outranking relation. After aggregation of outranking relations, criterion wise ranking is done by using the information on the level of evidence that shows how much the alternative outranks other alternatives (positive outranking net flow) and how much the alternative is outranked by others (negative outranking net flow). PROMETHEE I relies on an ordinal aggregation of these evidence and produces a partial rank where a better ranked alternative has both a higher positive outranking net flow and a lower negative outranking net flow. PROMETHEE II aggregates these evidences cardinally and produces a complete rank (Üçüncüoğlu, 2010).

3.1.2.1.6. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process was developed by Saaty (1980) and it is a measurement theory through pairwise comparisons and relies on experts' evaluations to derive priority scales that measure intangibles in relative terms (Saaty, 2008). The speciality of AHP is comes from its flexibility for integration with different techniques like Linear Programming, Quality Deployment, Fuzzy Logic, etc. This speciality enables to extracts benefits from all combined methods. Thus, it has been very popular in the literature (Vaidya & Kumar, 2006).

In the application of AHP, the decision problem is first structured in levels of a hierarchy. The goal or purpose of the problem is at the top level. The subsequent levels represent criteria, subcriteria, and so on. The decision alternatives are represented at the last level.

After the structure of the problem in the form of a hierarchy, the next step is to find value judgments concerning the alternatives with respect to the next higher level subcriteria. These value judgments may be obtained from available measurements or, if measurements are not available, from pairwise comparison or preference judgments (Ravindran, 2009). To make comparisons, a scale of numbers needed to indicate that one element how many times more important or dominant over another with respect to the criteria. Table 3.2 exhibits the scale for providing prefence judgment (Saaty, 2008). After the judgments of alternatives have been received composite values that indicates overall relative priorities of alternatives are determined by finding weighted average values across all levels of the hierarchy (Ravindran, 2009).

Table 3.2: The scale of numbers for AHP comparison (Saaty, 2008)

Scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong importance	An activity is favoured very strongly over another
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

3.2. Decision Making Environment

The context or the environment of the decision making process can be categorized based on the nature of the problem, the nature of the data or both. There are two broad categories of decision problems which are decision making under certainty and uncertainty. Some break decision making under uncertainty goes further in terms of whether the problem can be modeled by probability distributions (risk) or not (uncertainty) (Ravindran, 2009).

Three decision making environments are stated below:

- Decision making under conditions of certainty (deterministic environment)
- Decision making under situations of risk (stochastic environment)
- Decision making under conditions of uncertainty (fuzzy environment)

Decision making under the certainty conditions, the data are known deterministically or at least at an estimated level and the decision maker is comfortable with in terms of variation. Likewise, the decision alternatives can be well defined and modeled. Decision making under risky conditions, there is uncertainty in the data, but this uncertainty can be modeled probabilistically. Decision making under uncertainty conditions, the probability model for the data is unknown or cannot be modeled probabilistically and the data are imprecise or vague (Ravindran, 2009).

The classic MCDM methods, all the criterias and their respective weights are known deterministically and expressed in crisp values. But, one of the problematic points of the crisp evaluation that some criterias which are difficult to measure by crisp values may be neglected during the evaluation. Another problem with crisp values is about mathematical models. These methods with crisp values cannot deal with decision makers' ambiguities, uncertainties and vagueness. Additionally, the performance of the criteria can only expressed by qualitatively or linguistic terms that cannot state with crisp values (Kahraman, 2008).

In a real life decision situations the classical MCDM applications may experience serious practical constraints from the criteria which are containing imprecision or uncertainty inherent in the information. It is common that rating values of alternatives for criteria cannot be assessed precisely. The imprecision may come from different sources as: (Chen & Hwang, 1992)

- Unquantifiable information
- Incomplete information
- Nonobtainable information
- Partial ignorance.

In the literature, studies that try to model uncertainty in decision making process is done through probability theory or fuzzy set theory. The stochastic nature of decision analysis is presented by probability theory while the subjectivity of human behaviours presents with fuzzy set theory. It is also presented that a stochastic decision method does not measure the imprecision of human behaviour, nevertheless fuzzy set theory is a convenient method for modelling uncertainty or imprecision of mental phenomena which are neither random nor stochactic (Chen & Hwang, 1992).

Fuzzy set theory was introduced by Zadeh (1965) as a modeling tool and very suitable for solving problems in which there is imprecise, uncertain or vaguness conditions. The term “fuzzy” refers that there are no well-defined boundaries of the set of activities or observations (Chen & Hwang, 1992). Fuzzy logic allows computers to model the real life as the same with people can. Reasoning vague, ambiguous and imprecise knowledge is more simple. In a Boolean logic, every statement is true or false, which are characterized as 1 or 0. So, the membership values are crisp in this logic. Contrarily, fuzzy sets have more flexible membership values that allow for partial membership in a set.

In the concept of fuzzy sets, we have a membership function with the non-membership function which is found by one minus of the membership function. It means that the membership degree represents the evidence for the element while the non-membership degree represents the evidence againts for element without how much there is for each. But in reality, decision maker may not be sure when he/she decide his/her preference, so there is usually a hesitation or uncertainty about the degree. Fuzzy sets do not have any hesitation or uncertainty part (Tan & Chen, 2013; Deb & Kaur, 2017).

Intuitionistic Fuzzy Sets (IFS) have been proposed by Atanassov (1986) extends the ordinary fuzzy sets with an additional degree, called the degree of hesitancy, in order to explain the information of alternatives under incomplete and uncertain information environment. Comparing with traditional fuzzy sets, IFS show more flexibility and practically than traditional fuzzy sets, in dealing with uncertainty or hesitancy degree. IFS considers the both membership value and non-membership value to define any x in X such that the sum of membership and non-membership values is not necessarily equal to 1, because of hesitancy degree. Moreover, IFS gives an additionaly possility to represent imperfect knowledge.

However, it is difficult to determine the membership degree and the non-membership degree as exact number because of the impossibility of estimate their ranges. Atanassov and Gargov (1989) introduced interval-valued intuitionistic fuzzy sets(IVIFS) on the basis of intuitionistic fuzzy sets (IFS). Compared to fuzzy sets, interval-valued fuzzy sets and intuitionistic fuzzy sets, an interval-valued intuitionistic fuzzy sets has a membership and non-membership function that both of them are denoted by interval numbers of the unit interval [0,1]. Many IVIF based methods have developed to solve MCDM problems with the flexibility and effectiveness of IVIFS at imperfect an imprecise information situations (Wang et al., 2014; Zhang et al., 2014; Gao & Liu, 2016). Section 4 gives detailed information and mathematical formulations of IVIFS.

4- INTERVAL-VALUED INTUITIONISTIC FUZZY SETS (IVIFS)

Interval-valued intuitionistic fuzzy sets are the generalization of intuitionistic fuzzy sets. Different from IFS, the membership function and non-membership function values are intervals rather than exact numbers. The introduction of intervals for describing the value of membership and non-membership helps to reduce the cognitive demand on the decision makers in representing their subjective assessments in the decision making process (Wibowo, 2013).

4.1. Preliminaries

Definition 1. An intuitionistic fuzzy sets (IFS) $\tilde{A}$ in X is defined as object of the

$$\tilde{A} = \{\langle x, \mu_{\tilde{A}}(x), \vartheta_{\tilde{A}}(x)\rangle; x \in X\} \quad (4)$$

where the functions: $\mu_{\tilde{A}} : X \rightarrow [0,1]$ and $\vartheta_{\tilde{A}} : X \rightarrow [0,1]$ defines the membership and the non-membership degree of the element $x \in X$, respectively, and for every $x \in X$:

$$0 \leq \mu_{\tilde{A}}(x) + \vartheta_{\tilde{A}}(x) \leq 1. \quad (5)$$

Definition 2. Intuitionistic fuzzy numbers (IFNs) is defines as follows:

I. An intutionistic fuzzy subset of the real line.

II. Normal, there is any $x_0 \in \mathbb{R}$, $\mu_{\tilde{A}}(x_0) = 1$ $(\vartheta_{\tilde{A}}(x_0) = 0$.

III. A convex set for the membership function $\mu_{\tilde{A}}(x)$:

$$\mu_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \geq min\big(\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)\big)$$
$$\forall\, x_1, x_2 \in \mathbb{R}, \qquad \lambda \in [0,1] \tag{6}$$

IV. A concave set for the non-membership function $\vartheta_{\tilde{A}}(x)$:

$$\vartheta_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \leq max\big(\vartheta_{\tilde{A}}(x_1), \vartheta_{\tilde{A}}(x_2)\big)$$
$$\forall\, x_1, x_2 \in \mathbb{R}, \qquad \lambda \in [0,1]. \tag{7}$$

Definition 3. α- cut of an intuitionistic fuzzy set is described as:

$$\check{A}_\alpha = \{\, x \in X \,|\, \mu_{\tilde{A}}(x) \geq \alpha, \qquad \vartheta_{\tilde{A}}(x) \leq 1-\alpha \,\} \tag{8}$$

4.2. Inverval-Valued Intuitionistic Fuzzy Sets

$E \subseteq [0,1]$ is a set of all closed subintervals of the interval and X is a universe, an Interval-Valued Intuitionistic Fuzzy Set (IVIFS) $\tilde{A}$ over X is:

$$\tilde{A} = \{\langle x, \mu_{\tilde{A}}(x), \vartheta_{\tilde{A}}(x) \rangle | \; x \in X\} \qquad (9)$$

where $\mu_{\tilde{A}} \rightarrow E \subseteq [0,1]$, $\vartheta_{\tilde{A}} \rightarrow E \subseteq [0,1]$ are intervals for all $x \in X$:

$$0 \leq \sup \mu_{\tilde{A}}(x) + \sup \vartheta_{\tilde{A}}(x) \leq 1 \, . \qquad (10)$$

The IVIFS have geometrical interpretations similar but more complex than IFS. Figure 4.1 shows the geometrical interpretations of the IVIFS.

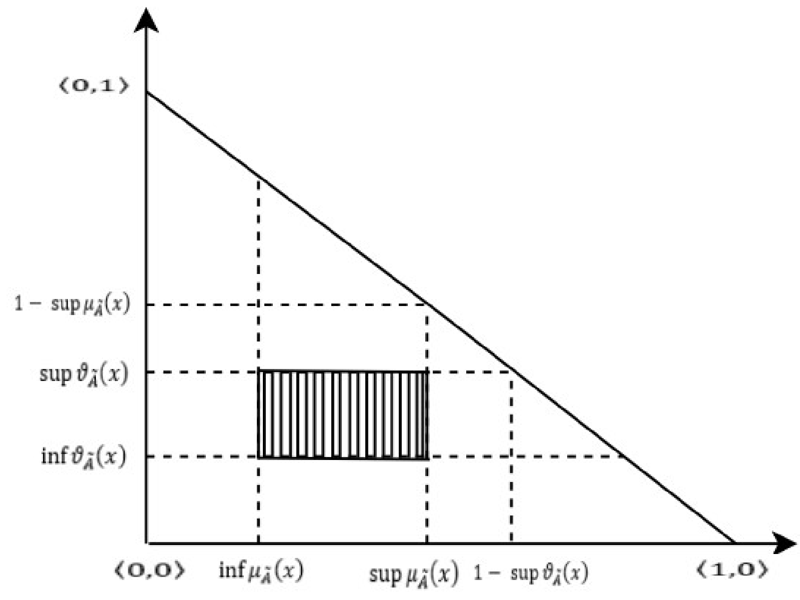


Figure 4.1: Geometric interpretation of an IVIFS (Atanassov, 1999)

If $\inf \mu_{\tilde{A}}(x) = \sup \mu_{\tilde{A}}(x)$ and $\inf \vartheta_{\tilde{A}}(x) = \sup \vartheta_{\tilde{A}}(x)$ then the IVIFS $\tilde{A}$ is reduced to an IFS.

For each $x \in X$, $\mu_{\tilde{A}}(x)$ and $\vartheta_{\tilde{A}}(x)$ are closed intervals, so their upper and lower points are denoted by $\mu_{\tilde{A}}^{+}(x)$, $\mu_{\tilde{A}}^{-}(x)$, $\vartheta_{\tilde{A}}^{+}(x)$, $\vartheta_{\tilde{A}}^{-}(x)$ respectively. An inverval-valued intuitionistic fuzzy set is denoted by:

$$\tilde{A} = \{\langle x, [\mu_{\tilde{A}}^{-}(x), \mu_{\tilde{A}}^{+}(x)], [\vartheta_{\tilde{A}}^{-}(x), \vartheta_{\tilde{A}}^{+}(x)]\rangle | x \in X\} \quad (11)$$

where $0 \leq \mu_{\tilde{A}}^{+}(x) + \vartheta_{\tilde{A}}^{+}(x) \leq 1 \quad ; \quad \mu_{\tilde{A}}^{-}(x) \geq 0,\ \vartheta_{\tilde{A}}^{-}(x) \geq 0.$

The value of $\pi_{\tilde{A}}(X)$ is called the degree of hesitancy (uncertainy) of an interval-valued intuitionistic fuzzy sets of $x \in X$ in $\tilde{A}$ is:

$$\pi_{\tilde{A}}(X) = 1 - \mu_{\tilde{A}}(x) - \vartheta_{\tilde{A}}(x) = \left([1 - \mu_{\tilde{A}}^{+}(x) - \vartheta_{\tilde{A}}^{+}(x)], 1 - \mu_{\tilde{A}}^{-}(x) - \vartheta_{\tilde{A}}^{-}(x)\right) \quad (12)$$

So we can describe that,

$$\mu_{\tilde{A}}(x) = [\mu_{\tilde{A}}^{-}(x), \mu_{\tilde{A}}^{+}(x)] = [\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}],$$

$$\vartheta_{\tilde{A}}(x) = [\vartheta_{\tilde{A}}^{-}(x), \vartheta_{\tilde{A}}^{+}(x)] = [\vartheta_{\tilde{A}}^{-}, \vartheta_{\tilde{A}}^{+}(x)]$$

$$\tilde{A} = ([\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}], [\vartheta_{\tilde{A}}^{-}, \vartheta_{\tilde{A}}^{+}])$$

4.3. Arithmetic Operations with IVIFS

Let $\lambda \geq 0$, $\tilde{A} = ([\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}], [\vartheta_{\tilde{A}}^{-}, \vartheta_{\tilde{A}}^{+}])$, $\tilde{B} = ([\mu_{\tilde{B}}^{-}, \mu_{\tilde{B}}^{+}], [\vartheta_{\tilde{B}}^{-}, \vartheta_{\tilde{B}}^{+}])$

$$\bar{\tilde{A}} = ([\vartheta_{\tilde{A}}^{-}, \vartheta_{\tilde{A}}^{+}], [\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}]) \quad (13)$$

$$\lambda \tilde{A} = \left(\left[1 - (1 - \mu_{\tilde{A}}^{-})^{\lambda}, 1 - (1 - \mu_{\tilde{A}}^{+})^{\lambda}\right], \left[\vartheta_{\tilde{A}}^{-\lambda}, \vartheta_{\tilde{A}}^{+\lambda}\right]\right) \quad (14)$$

$$\tilde{A} \oplus \tilde{B} = \left(\left[\mu_{\tilde{A}}^{-} + \mu_{\tilde{B}}^{-} - \mu_{\tilde{A}}^{-}\mu_{\tilde{B}}^{-},\ \mu_{\tilde{A}}^{+} + \mu_{\tilde{B}}^{+} - \mu_{\tilde{A}}^{+}\mu_{\tilde{B}}^{+}\ \right], \left[\vartheta_{\tilde{A}}^{-}\vartheta_{\tilde{B}}^{-}, \vartheta_{\tilde{A}}^{+}\vartheta_{\tilde{B}}^{+}\right]\right) \tag{15}$$

$$\tilde{A} \otimes \tilde{B} = \left(\left[\mu_{\tilde{A}}^{-}\mu_{\tilde{B}}^{-},\ \mu_{\tilde{A}}^{+}\mu_{\tilde{B}}^{+}\right], \left[\vartheta_{\tilde{A}}^{-} + \vartheta_{\tilde{B}}^{-} - \vartheta_{\tilde{A}}^{-}\vartheta_{\tilde{B}}^{-},\ \vartheta_{\tilde{A}}^{+} + \vartheta_{\tilde{B}}^{+} - \vartheta_{\tilde{A}}^{+}\vartheta_{\tilde{B}}^{+}\right]\right) \tag{16}$$

$$\tilde{A} \oplus \tilde{B} = \tilde{B} \oplus \tilde{A} \tag{17}$$

$$\tilde{A} \otimes \tilde{B} = \tilde{B} \otimes \tilde{A} \tag{18}$$

$$\lambda\left(\tilde{A} + \tilde{B}\right) = \lambda\,\tilde{A} + \lambda\,\tilde{B} \tag{19}$$

$$\tilde{A} \cup \tilde{B} = \left(\left[max\left(\mu_{\tilde{A}}^{-}, \mu_{\tilde{B}}^{-}\right), max\left(\mu_{\tilde{A}}^{+}, \mu_{\tilde{B}}^{+}\right)\right], \left[min\left(\vartheta_{\tilde{A}}^{-}, \vartheta_{\tilde{B}}^{-}\right), min\left(\vartheta_{\tilde{A}}^{+}, \vartheta_{\tilde{B}}^{+}\right)\right]\right) \tag{20}$$

$$\tilde{A} \cap \tilde{B} = \left(\left[min\left(\mu_{\tilde{A}}^{-}, \mu_{\tilde{B}}^{-}\right), min\left(\mu_{\tilde{A}}^{+}, \mu_{\tilde{B}}^{+}\right)\right], \left[max\left(\vartheta_{\tilde{A}}^{-}, \vartheta_{\tilde{B}}^{-}\right), max\left(\vartheta_{\tilde{A}}^{+}, \vartheta_{\tilde{B}}^{+}\right)\right]\right) \tag{21}$$

The arithmetic operations can be acquired by the following general equation, using the extension principle, where * symbol defines one of the algebraic operations:

$$\tilde{A} \circledast \tilde{B} = \left\{ \begin{matrix} \left\langle \begin{matrix} z, \left[max_{z=x*y} min\{\mu_{\tilde{A}}^{-}(x), \mu_{\tilde{B}}^{-}(y)\}, max_{z=x*y} min\{\mu_{\tilde{A}}^{+}(x), \mu_{\tilde{B}}^{+}(y)\}\right], \\ \left[min_{z=x*y} max\{\vartheta_{\tilde{A}}^{-}(x), \vartheta_{\tilde{B}}^{-}(y)\}, min_{z=x*y} max\{\vartheta_{\tilde{A}}^{+}(x), \vartheta_{\tilde{B}}^{+}(y)\}\right] \end{matrix} \right\rangle \Bigg| \\ (x, y) \in XxY \end{matrix} \right\} \tag{22}$$

For example, the subtraction operation can be shown as:

$$\tilde{A} \ominus \tilde{B} = \left\{ \begin{matrix} \left\langle \begin{matrix} z, \left[max_{z=x-y} min\{\mu_{\tilde{A}}^{-}(x), \mu_{\tilde{B}}^{-}(y)\}, max_{z=x-y} min\{\mu_{\tilde{A}}^{+}(x), \mu_{\tilde{B}}^{+}(y)\}\right], \\ \left[min_{z=x-y} max\{\vartheta_{\tilde{A}}^{-}(x), \vartheta_{\tilde{B}}^{-}(y)\}, min_{z=x-y} max\{\vartheta_{\tilde{A}}^{+}(x), \vartheta_{\tilde{B}}^{+}(y)\}\right] \end{matrix} \right\rangle \Bigg| \\ (x, y) \in XxY \end{matrix} \right\} \tag{23}$$

5. MODEL AND METHODOLOGY

At the beginning of model, we make a comparison matrices created with experts' assessments and gathered into using aggregation operators for IVIFS. The proposed method is evolved from the study of Onar et al. (2015) and Wu et al.(2013) and applied for the vendor managed inventory problem. Aggregation operators are illustrated in Definition 4.

Definition 4. $\tilde{\alpha}_j = ([a_j, b_j], [c_j, d_j])$ j=1,2,..., n) is an interval-valued intuitionistic fuzzy set and interval-valued intuitionistic weighted averaging operator (IIFWA) $Q^n \to Q$ if:

$$IIFWA_w(\tilde{\alpha}_1, \tilde{\alpha}_2, \dots, \tilde{\alpha}_n) = w_1\tilde{\alpha}_1 \oplus w_2\tilde{\alpha}_2 \oplus \dots \oplus w_n\tilde{\alpha}_n \quad (24)$$

where Q is the set of all IVIFS, the weight factor of the IVIFS w is:

$$w = (w_1, w_2, \dots, w_n), w_j > 0, \sum_{j=1}^{n} w_j = 1 \quad (25)$$

IIFWA operator can convert into the following type:

$$IIFWA_W(\tilde{\alpha}_1, \tilde{\alpha}_2, \dots, \tilde{\alpha}_n) = \left(\left[1 - \left(\prod_{i=1}^{n} (1 - a_i) \right)^{w_i}, \left(\prod_{i=1}^{n} (1 - b_i) \right)^{w_i} \right], \left[\left(\prod_{i=1}^{n} c_i \right)^{w_i}, \left(\prod_{i=1}^{n} d_i \right)^{w_i} \right] \right) \quad (26)$$

If $w = (1/n, 1/n, \dots, 1/n)$, IIFWA converts to interval-valued fuzzy averaging operator (IIFA), where

$$IIFA(\tilde{\alpha}_1, \tilde{\alpha}_2, \dots, \tilde{\alpha}_n) = \frac{1}{n}(\tilde{\alpha}_1 \oplus \tilde{\alpha}_2 \oplus \dots \oplus \tilde{\alpha}_n) IIFA(\tilde{\alpha}_1, \tilde{\alpha}_2, \dots, \tilde{\alpha}_n)$$

$$= \left(\left[1 - \left(\prod_{i=1}^{n}(1-a_i)\right)^{1/n}, \left(\prod_{i=1}^{n}(1-b_i)\right)^{1/n}\right], \left[\left(\prod_{i=1}^{n} c_i\right)^{1/n}, \left(\prod_{i=1}^{n} d_i\right)^{1/n}\right]\right) \quad (27)$$

The steps of the proposed methodology is stated below :

Step 1. For each attribute, create the linguistic pairwise comparison matrix from the Table 5.1.

Table 5.1: Linguistic pairwise comparison matrix

Decision Maker	A1	A2	A3	A4	A5	A6	A7	A8
A1	EE							
A2	-	EE						
A3	-	-	EE					
A4	-	-	-	EE				
A5	-	-	-	-	EE			
A6	-	-	-	-	-	EE		
A7	-	-	-	-	-	-	EE	
A8	-	-	-	-	-	-	-	EE

Step 2. Turn linguistic data into the internal-valued intuitionistic fuzzy sets using linguistic scale from Table 5.2 to create individual interval-valued intuitionistic judgment matrix :

$$\tilde{R} = (\tilde{r}_{ij})_{nxn} = ([\mu_{ij}^-, \mu_{ij}^+], [\vartheta_{ij}^-, \vartheta_{ij}^+])_{nxn}$$

$$= \begin{bmatrix} ([\mu_{11}^-, \mu_{11}^+], [\vartheta_{11}^-, \vartheta_{11}^+]) & \cdots & ([\mu_{1n}^-, \mu_{1n}^+], [\vartheta_{1n}^-, \vartheta_{1n}^+]) \\ \vdots & \ddots & \vdots \\ ([\mu_{n1}^-, \mu_{n1}^+], [\vartheta_{n1}^-, \vartheta_{n1}^+]) & \cdots & [\mu_{nn}^-, \mu_{nn}^+], [\vartheta_{nn}^-, \vartheta_{nn}^+] \end{bmatrix} \quad (28)$$

where i and j describe the criterion number.

The reciprocal value of $([\mu_{ij}^-,\mu_{ij}^+],[\vartheta_{ij}^-,\vartheta_{ij}^+])$ in $\tilde{R}$ is $([\vartheta_{ji}^-,\vartheta_{ji}^+],[\mu_{ji}^-,\mu_{ji}^+])$. For exactly equal, $EE = ([0.5,0.5],[0.5,0.5])$ with the reciprocal value $([0.5,0.5],[0.5,0.5]$.

Table 5.2: Linguistic scale and corresponding IVIFS (Onar et al, 2015)

Linguistic Terms	Membership and Non-Membership
Absolutely Low (AL)	([0,0.2],[0.5,0.8])
Very Low (VL)	([0.1,0.3],[0.4,0.7])
Low (L)	([0.2,0.4],[0.3,0.6])
Medium Low (ML)	([0.3,0.5],[0.2,0.5])
Approximately Equal (E)	([0.4,0.6],[0.2,0.4])
Medium High (MH)	([0.5,0.7],[0.1,0.3])
High (H)	([0.6,0.8],[0,0.2])
Very High (VH)	([0.7,0.9],[0,0.1])
Absolutely High(AH)	([0.8,1.0],[0,0])

Step 3. Collect the interval- valued intuitionistic fuzzy pairwise comparison matrices. With this step experts' aggregated interval-valued intuitionistic judgment matrix $\tilde{R}_g$ is created.

$$\tilde{R}_g = \begin{bmatrix} ([\mu_{g_{11}}^-,\mu_{g_{11}}^+],[\vartheta_{g_{11}}^-,\vartheta_{g_{11}}^+]) & \cdots & ([\mu_{1n}^-,\mu_{1n}^+],[\vartheta_{1n}^-,\vartheta_{1n}^+]) \\ \vdots & \ddots & \vdots \\ ([\mu_{g_{n1}}^-,\mu_{g_{n1}}^+],[\vartheta_{g_{n1}}^-,\vartheta_{g_{n1}}^+]) & \cdots & [\mu_{g_{nn}}^-,\mu_{g_{nn}}^+],[\vartheta_{g_{nn}}^-,\vartheta_{g_{nn}}^+]] \end{bmatrix} \quad (29)$$

Step 4. The score judgment matrix $\tilde{S} = (\tilde{s}_{ij})_{nxn}$ and interval multiplicative matrix

$\tilde{A} = (\tilde{a}_{ij})_{nxn}$.

The score judgment matrix of $\tilde{R}_g$ is described by the matrix

$$\tilde{S} = (\tilde{s}_{ij})_{nxn} = \left[\mu^-_{g_{ij}} - \vartheta^+_{g_{ij}}, \mu^+_{g_{ij}} - \vartheta^-_{g_{ij}}\right]$$

$$\tilde{S} = \begin{bmatrix} [\mu^-_{g_{11}} - \vartheta^+_{g_{11}}, \mu^+_{g_{11}} - \vartheta^-_{g_{11}}] & \cdots & [\mu^-_{g_{1n}} - \vartheta^+_{g_{1n}}, \mu^+_{g_{1n}} - \vartheta^-_{g_{1n}}] \\ \vdots & \ddots & \vdots \\ [\mu^-_{g_{n1}} - \vartheta^+_{g_{n1}}, \mu^+_{g_{n1}} - \vartheta^-_{g_{n1}}] & \cdots & [\mu^-_{g_{nn}} - \vartheta^+_{g_{nn}}, \mu^+_{g_{nn}} - \vartheta^-_{g_{nn}}] \end{bmatrix} \tag{30}$$

The interval multiplicative matrix is shown as:

$$\tilde{A} = (\tilde{a}_{ij})_{nxn} = \left[10^{\left(\mu^-_{g_{ij}} - \vartheta^+_{g_{ij}}\right)}, 10^{\left(\mu^+_{g_{ij}} - \vartheta^-_{g_{ij}}\right)}\right]$$

$$= \begin{bmatrix} \left[10^{(\mu^-_{g_{11}} - \vartheta^+_{g_{11}})}, 10^{(\mu^+_{g_{1n}} - \vartheta^-_{g_{1n}})}\right] & \cdots & \left[10^{\left(\mu^-_{g_{1j}} - \vartheta^+_{g_{1j}}\right)}, 10^{\left(\mu^+_{g_{1j}} - \vartheta^-_{g_{1j}}\right)}\right] \\ \vdots & \ddots & \vdots \\ \left[10^{(\mu^-_{g_{n1}} - \vartheta^+_{g_{n1}})}, 10^{(\mu^+_{g_{n1}} - \vartheta^-_{g_{n1}})}\right] & \cdots & \left[10^{(\mu^-_{g_{nn}} - \vartheta^+_{g_{nn}})}, 10^{(\mu^+_{g_{nn}} - \vartheta^-_{g_{nn}})}\right] \end{bmatrix} \tag{31}$$

$$= \begin{bmatrix} [\tilde{a}^-_{11}, \tilde{a}^+_{11}] & \cdots & [\tilde{a}^-_{1n}, \tilde{a}^+_{1n}] \\ \vdots & \ddots & \vdots \\ [\tilde{a}^-_{n1}, \tilde{a}^+_{n1}] & \cdots & [\tilde{a}^-_{nn}, \tilde{a}^+_{nn}] \end{bmatrix}$$

with this step, the score judgment matrix $\tilde{S} = (\tilde{s}_{ij})_{nxn}$ is converted to matrix with values are between 0 and 10.

Step 5. The priority vector of the interval multiple matrix $\tilde{A} = (\tilde{a}_{ij})_{nxn}$ is found by calculation of the $\widetilde{w}_i$ interval for each attribute:

$$\widetilde{w}_i = \left[\frac{\sum_{j=1}^{n} \tilde{a}^-_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^+_{ij}}, \frac{\sum_{j=1}^{n} \tilde{a}^+_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^-_{ij}}\right] = [w^-_i, w^+_i], \qquad i = 1, \dots, n \tag{32}$$

Step 6. Build the possibility degree matrix $P = (p_{ij})_{nxn}$ by comparing the obtained weights in previous step.

$$P(w_i \geq w_j) = p_{ij} = \frac{min\left\{L_{w_i} + L_{w_j}, max(w_i^+ - w_j^-, 0)\right\}}{L_{w_i} + L_{w_j}} \tag{33}$$

where $L_{w_i} = w_i^+ - w_i^-$ and $L_{w_j} = w_j^+ - w_j^-$; $p_{ij} \geq 0, p_{ij} + p_{ji} = 1, p_{ii} = \frac{1}{2}$

Step 7. Prioritize the $P = (p_{ij})_{nxn}$

$$w_i = \frac{1}{n}\left[\sum_{j=1}^{n} p_{ij} + \frac{n}{2} - 1\right] \tag{34}$$

Step 8. Normalize the weights vector calculated in previous step and get the normalized weights w_i^T of the alternatives:

$$w_i^T = \frac{w_i}{\sum_{i=1}^{n} w_i} \tag{35}$$

Step 9. Consider the hierarchy and repeat the previous steps (1-8) for the pairwise comparison of the alternatives with respect to each attribute and build the scores of the alternatives, φ_{ij} for alternative j $(j = 1,2, \dots, m)$ and attribute i $(i = 1,2, \dots, n)$

Step 10. Combined attribute weights and alternatives' scores by weighted average method. The possibility value of each alternative is:

$$P_j = \sum_{i=1}^{n} w_i \, \varphi_{ij} \, , \qquad j = 1,2,..m \tag{36}$$

Step 11. Calculate predicted order of retailer x with production of possibilities and crisp values of each alternative:

$$\Delta R_x = \sum_{j=1}^{n} P_j * ALT_j \tag{37}$$

6. A NUMERICAL EXAMPLE : ORDER PREDICTION MODEL FOR VMI IN FMCG SECTOR

In our case, the company operates in a very competitive market where the products are fully substitutable by competitors' products. The company aims to prevent loss of sales due to late deliveries and to take right positions against changing market conditions and as a consequence increase the profit. Prices of products are set by the market, so the company can not increase the profit with increasing prices. Therefore, the company can only increase its profit by decreasing the cost. Main cost components are raw material acquisitions, transportation costs, energy consumption cost, labor costs, inventory holding costs and setup costs. Since the company has no control on the purchasing costs and reluctant to decrease labor cost, the mainly focus is on transportation, setup and inventory costs.

The company operate its sales for three sales channel which are retailers, supermarkets and export channel. Export channel orders are make to order and supermarkets have an individual stock level because stock out means loss of shelf and market share. The biggest sales channel, retailers are keeping inventory at a certain level. There has no calculations on the replenishment, experience and unreliable forecasts characterize the amount. So, sometimes ordered amounts can be too much for all of the chain. The most VMI studies focus on invertory policies to reduce cost with a certain service level, but in our study we aim to concentrated on forecasts which are generated by vendors. The purpose of the company is evolution from a push flow, characterized by the experience of one group and fluctuating demands, to pull from that based on the different criterias directly effect the retailer's orders. Figure 6.1 shows the proposed model for the traditional FMCG company

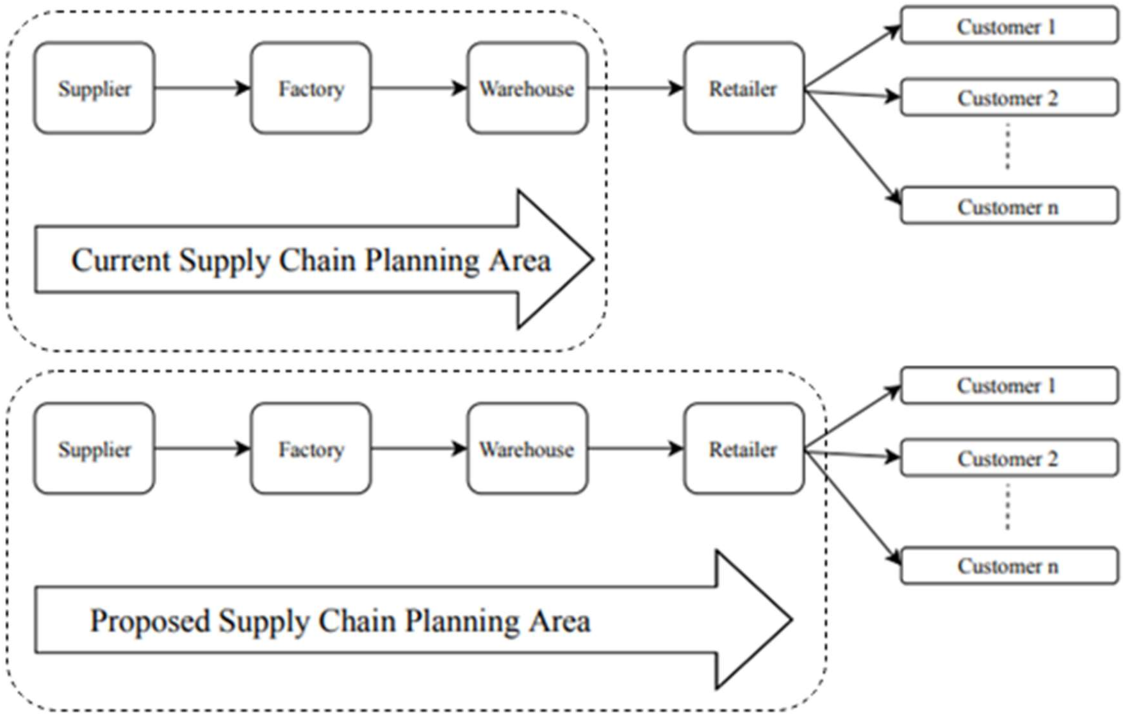


Figure 6.1: Proposed model for the company

Eight criteria considered for demand forecasting procedure at vendor. First one is the location of retailer which effects the sales potential of products. Some factors like presence of discount markets nearby, purchasing power of customer etc. can change variety and quantity of sales. Experience level of retailer is also important factor for demand, the quantities will remain constant at the old retailer while fluctuates at the new retailer. Sales conditions like competitors' promotions, retailer's promotional activities or new born products are the main factors that effects the demand. Financial stability is the most important factor in business life, steady payments are crucial for both producers and vendors. Therefore, noone will want to send goods more than contracted, financial stability of retailer is one of the criteria for demand forecasting. Capacity of retailer's warehouse is one of the factors that affect the quantities of goods shipped to retailer. When determining the quantities physical capacity of warehouse, current stock and customer orders and backorders will be issues to take into account. Table 6.1 summarize the criterias.

Table 6.1: Selection Attributes and Definitions

Attributes	Definitions
Location	Presence of discount markets nearby, purchasing power of customers can affect sales potential
Experience Level	New retailers' sales quantities can fluctuate while the experinced one's steady
Competitors' Activities	Different campaings of competitors' can change demand directly
Promotional Activities	Retailers' promotions will be increase the demand of current products
Financial Stability	Steady payments of sales are crucial for business parts.
Current Stock & Customer Order	Current situations of stock and orders will be another issues to define demand quantities.
Physical Capacity	Retailers' warehouse capacity will affect not only shipment quantities but also forecasted demand.

In this model, we have 3 equally weighted decision makers from different teams of the FMCG company. One of whom is Sales and Marketing team, who is responsible for sales of both current products or new-born ones. Their sales targets are always aggressive and growing continuously, so demand forecasts are excessive high most of the time. Supply Chain team is another decision maker, which is consist of production planning and logistics departments. Due to production, stock or shipment constraints they are usually cautious about forecast quantities. The last decision team is Trade Marketing department, who concentrate on financial aspects of sales. They decide promotional activities, which and how much product will be selected for promotional events. Generally, their forecasts are stable and on average quantities. Different teams and different aspects ensure balance for forecasts and make them more reliable.

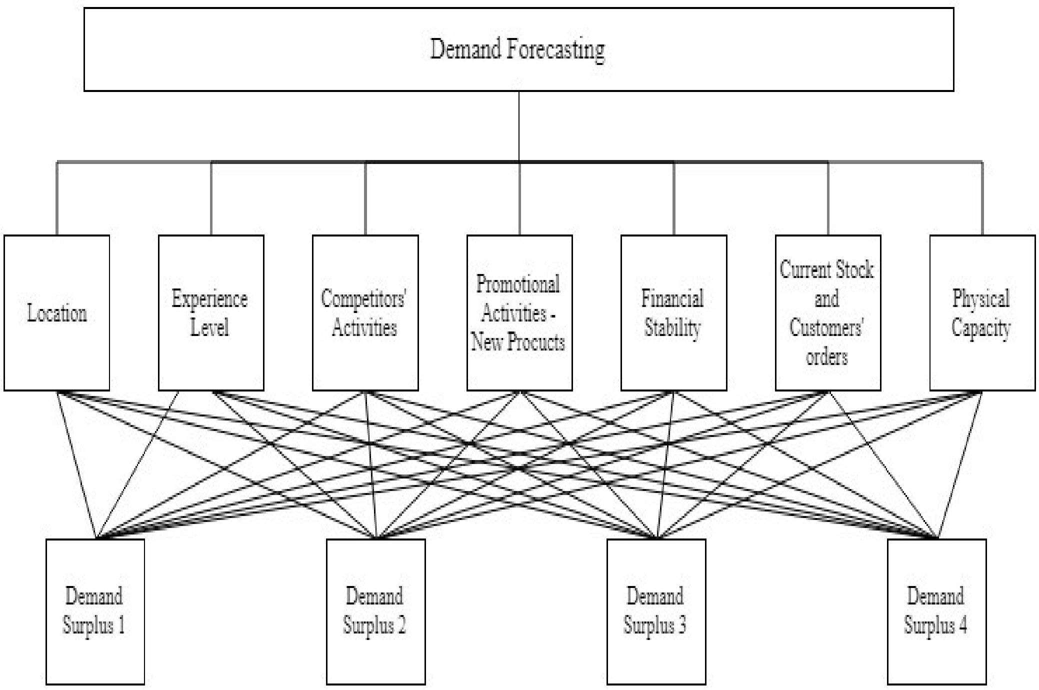
We have 4 alternatives which are demand surplus levels basically. They all calculated from real life sales data for traditional FMCG sales company and describes additional demands according to past sales. Table 6.2 shows alternatives and its numerical equivalences.

Table 6.2: Alternatives and its numerical equivalence

ALT 1	Demand Surplus 1	Low Surplus	600 pieces
ALT 2	Demand Surplus 2	Medium Surplus	1000 pieces
ALT 3	Demand Surplus 3	High Surplus	1200 pieces
ALT 4	Demand Surplus 4	Very High Surplus	2000 pieces

Hierarchy of the model with eight attribute and four alternative is presented in Figure 6.2.

Figure 6.2: Hierarchical structure of model



6.1. Application of the proposed methodology

At the beginning of the model, decision makes create the linguistic pairwise comparison matrix by using the scale in Table 5.2. The assigned linguistic evaluations are given in Table 6.3.

Table 6.3: Pairwise comparisons of attributes by Decision Makers.

		A1	A2	A3	A4	A5	A6	A7	A8
Decision Maker 1	A1	EE	VH	L	VL	H	MH	ML	VH
	A2		EE	VL	L	E	E	ML	MH
	A3			EE	E	VH	AH	ML	VH
	A4				EE	AH	AH	VH	AH
	A5					EE	ML	L	E
	A6						EE	ML	E
	A7							EE	VH
	A8								EE
Decision Maker 2	A1	EE	L	L	VL	ML	AL	AL	E
	A2		EE	MH	VL	E	VL	VL	ML
	A3			EE	L	ML	L	VL	AL
	A4				EE	AH	VH	H	MH
	A5					EE	L	AL	AL
	A6						EE	ML	E
	A7							EE	H
	A8								EE
Decision Maker 3	A1	EE	VL	H	ML	L	MH	AL	H
	A2		EE	ML	MH	ML	ML	ML	H
	A3			EE	ML	VL	VL	VL	ML
	A4				EE	ML	VH	E	VH
	A5					EE	VH	VH	AH
	A6						EE	L	VL
	A7							EE	VH
	A8								EE

Aggregated comparison matrix for attributes are obtained from Table 6.3 by Eq. (27) is shown as Table 6.4. To show the calculation of the values in Table 6.4, an example of the calculation is given in the following. For instance, the value indicated in bold numbers in Table 6.4 that shows the importance of A2-Experience Level with respect to A3-Competitors' Activities. There experts assign Very Low, Medium High, Medium Low for this comparison. The corresponding numerical intervals are ([0.1,0.3],[0.4,0.7]), ([0.5,0.7],[0.1,0.3]) and ([0.3,0.5],[0.2,0.5]). Using Eq.(27) we take $IIFA(\tilde{\alpha}_1, \tilde{\alpha}_2, \tilde{\alpha}_3)$

$$= \left(\begin{array}{c} \left[1-\left((1-0{,}1)^{\frac{1}{3}}x(1-0{,}5)^{\frac{1}{3}}x(1-0{,}3)^{\frac{1}{3}}\right), 1-\left((1-0{,}3)^{\frac{1}{3}}x(1-0{,}7)^{\frac{1}{3}}x(1-0{,}5)^{\frac{1}{3}}\right)\right], \\ \left[\left((0{,}4)^{\frac{1}{3}}x(0{,}1)^{\frac{1}{3}}x(0{,}2)^{\frac{1}{3}}\right), \left((0{,}7)^{\frac{1}{3}}x(0{,}3)^{\frac{1}{3}}x(0{,}5)^{\frac{1}{3}}\right)\right] \end{array} \right)$$

$$= ([0.32,0.53],[0.20,0.47])$$

Table 6.4: Aggregated Comparison Matrix

	A1				**A2**				**A3**				**A4**			
	μ_{ij}^-	μ_{ij}^+	ϑ_{ij}^-	ϑ_{ij}^+	μ_{ij}^-	μ_{ij}^+	ϑ_{ij}^-	ϑ_{ij}^+	μ_{ij}^-	μ_{ij}^+	ϑ_{ij}^-	ϑ_{ij}^+	μ_{ij}^-	μ_{ij}^+	ϑ_{ij}^-	ϑ_{ij}^+
A1	0,50	0,50	0,50	0,50	0,40	0,65	0,00	0,35	0,37	0,58	0,00	0,42	0,17	0,37	0,32	0,63
A2	0,00	0,35	0,40	0,65	0,50	0,50	0,50	0,50	**0,32**	**0,53**	**0,20**	**0,47**	0,29	0,50	0,23	0,50
A3	0,00	0,42	0,37	0,58	0,20	0,47	0,32	0,53	0,50	0,50	0,50	0,50	0,30	0,51	0,23	0,49
A4	0,32	0,63	0,17	0,37	0,23	0,50	0,29	0,50	0,23	0,49	0,30	0,51	0,50	0,50	0,50	0,50
A5	0,00	0,39	0,39	0,61	0,20	0,43	0,37	0,57	0,00	0,33	0,43	0,67	0,00	0,00	0,70	1,00
A6	0,17	0,42	0,37	0,58	0,00	0,00	0,28	0,48	0,00	0,00	0,48	1,00	0,00	0,00	0,74	1,00
A7	0,37	0,68	0,11	0,32	0,25	0,56	0,24	0,44	0,32	0,63	0,17	0,37	0,00	0,20	0,58	0,80
A8	0,00	0,20	0,58	0,80	0,00	0,31	0,48	0,69	0,00	0,34	0,41	0,66	0,00	0,00	0,69	1,00
	A5				**A6**				**A7**				**A8**			
A1	0,39	0,61	0,00	0,39	0,37	0,58	0,17	0,42	0,11	0,32	0,37	0,68	0,58	0,80	0,00	0,20
A2	0,37	0,57	0,20	0,43	0,28	0,48	0,25	0,52	0,24	0,44	0,25	0,56	0,48	0,69	0,00	0,31
A3	0,43	0,67	0,00	0,33	0,48	1,00	0,00	0,00	0,17	0,37	0,32	0,63	0,41	0,66	0,00	0,34
A4	0,70	1,00	0,00	0,00	0,74	1,00	0,00	0,00	0,58	0,80	0,00	0,20	0,69	1,00	0,00	0,00
A5	0,50	0,50	0,50	0,50	0,45	0,69	0,00	0,31	0,38	0,64	0,00	0,36	0,51	1,00	0,00	0,00
A6	0,00	0,31	0,45	0,69	0,50	0,50	0,50	0,50	0,27	0,47	0,23	0,53	0,31	0,52	0,25	0,48
A7	0,00	0,36	0,38	0,64	0,23	0,53	0,27	0,47	0,50	0,50	0,50	0,50	0,67	0,87	0,00	0,13
A8	0,00	0,00	0,51	1,00	0,25	0,48	0,31	0,52	0,00	0,13	0,67	0,87	0,50	0,50	0,50	0,50

Score judgment matrix calculated by using Eq.(30) is shown as Table 6.5. As an example of the calculations, the value indicated in bold numbers in Table 6.5 is calculated as: $\tilde{s}_{A2,A3} = [0{,}32 - 0{,}47{,}0{,}53 - 0{,}20] = [0{,}15{,}0{,}33]$

Table 6.5: Score judgment matrix of attributes

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	0,00	0,00	0,05	0,65	-0,05	0,58	-0,45	0,06	0,00	0,61	-0,05	0,41	-0,57	-0,05	0,38	0,80
A2	-0,65	-0,05	0,00	0,00	**-0,15**	**0,33**	-0,21	0,27	-0,06	0,37	-0,24	0,23	-0,32	0,19	0,17	0,69
A3	-0,58	0,05	-0,33	0,15	0,00	0,00	-0,19	0,28	0,10	0,67	0,48	1,00	-0,45	0,06	0,06	0,66
A4	-0,06	0,45	-0,27	0,21	-0,28	0,19	0,00	0,00	0,70	1,00	0,74	1,00	0,38	0,80	0,69	1,00
A5	-0,61	0,00	-0,37	0,06	-0,67	-0,10	-1,00	-0,70	0,00	0,00	0,14	0,69	0,02	0,64	0,51	1,00
A6	-0,41	0,05	-0,48	-0,28	-1,00	-0,48	-1,00	-0,74	-0,69	-0,14	0,00	0,00	-0,26	0,24	-0,17	0,27
A7	0,05	0,57	-0,19	0,32	-0,06	0,45	-0,80	-0,38	-0,64	-0,02	-0,24	0,26	0,00	0,00	0,54	0,87
A8	-0,80	-0,38	-0,69	-0,17	-0,66	-0,06	-1,00	-0,69	-1,00	-0,51	-0,27	0,17	-0,87	-0,54	0,00	0,00

Table 6.6 presents the interval multiplicative matrix obtained by using Eq. (31). The value that indicated in bold numbers are calculated as follows:

$$\tilde{a}_{A2,A3} = [10^{-0{,}15}, 10^{0{,}33}] = [0.70, 2.13]$$

Table 6.6: Interval multiplicative matrix of attributes

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	1,00	1,00	1,13	4,49	0,89	3,84	0,35	1,14	1,00	4,06	0,90	2,59	0,27	0,89	2,42	6,31
A2	0,22	0,89	1,00	1,00	**0,70**	**2,13**	0,61	1,86	0,87	2,34	0,57	1,69	0,48	1,54	1,48	4,89
A3	0,26	1,12	0,47	1,42	1,00	1,00	0,65	1,90	1,26	4,71	2,99	10,00	0,35	1,14	1,16	4,55
A4	0,88	2,84	0,54	1,63	0,53	1,54	1,00	1,00	4,97	10,00	5,47	10,00	2,42	6,31	4,89	10,00
A5	0,25	1,00	0,43	1,15	0,21	0,80	0,10	0,20	1,00	1,00	1,37	4,89	1,04	4,33	3,21	10,00
A6	0,39	1,11	0,33	0,53	0,10	0,33	0,10	0,18	0,20	0,73	1,00	1,00	0,55	1,74	0,68	1,84
A7	1,13	3,73	0,65	2,09	0,88	2,84	0,16	0,41	0,23	0,97	0,58	1,83	1,00	1,00	3,50	7,48
A8	0,16	0,41	0,20	0,68	0,22	0,86	0,10	0,20	0,10	0,31	0,54	1,48	0,13	0,29	1,00	1,00

Priority vector matrix calculated by Eq. (32) is shown as Table 6.7.

Table 6.7: Priority Vector

Attribute	Priority	
A1	0,048	0,378
A2	0,036	0,254
A3	0,049	0,402
A4	0,124	0,674
A5	0,046	0,364
A6	0,020	0,116
A7	0,049	0,317
A8	0,015	0,081

Possibility degree matrix and attributes' weights are calculated by using the steps 6-8 shown as Table 6.8. An example of calculations, the value 0,359 that is indicated in bold numbers is calculated as follows:

$$P(w_{A2} \geq w_{A3} = \frac{min\{\big((0{,}254 - 0{,}036) + (0{,}402 - 0{,}049)\big), \max(0{,}254 - 0{,}049{,}0)\}}{(0{,}254 - 0{,}036) + (0{,}402 - 0{,}049)}$$
$$= 0{,}359$$

The prioritized values for the criteria w_i are calculated by using Eq. (34). As an example, w_{A2} is calculated as follows:

$$w_{A2} = \frac{1}{8}\left[(0{,}376 + 0{,}500 + 0{,}359 + 0{,}169 + 0{,}389 + 0{,}744 + 0{,}422 + 0{,}840) + \frac{8}{2} - 1\right]$$
$$= 0{,}850$$

Table 6.8: Possibility degree matrix and weights of the attributes

	A1	A2	A3	A4	A5	A6	A7	A8		*w*	w^T
A1	0,500	0,624	0,482	0,288	0,513	0,840	0,551	0,916		0,964	0,138
A2	0,376	0,500	**0,359**	0,169	0,389	0,744	0,422	0,840		**0,850**	0,121
A3	0,518	0,641	0,500	0,307	0,531	0,850	0,569	0,923		0,980	0,140
A4	0,712	0,831	0,693	0,500	0,724	1,000	0,765	1,000		1,153	0,165
A5	0,487	0,611	0,469	0,276	0,500	0,830	0,537	0,907		0,952	0,136
A6	0,160	0,256	0,150	0,000	0,170	0,500	0,185	0,623		0,631	0,090
A7	0,449	0,578	0,431	0,235	0,463	0,815	0,500	0,903		0,922	0,132
A8	0,084	0,160	0,077	0,000	0,093	0,377	0,097	0,500		0,549	0,078

According to calculated weights given in Table 6.8, the most important attribute is Promotional Activities- New Products (**A4**). Other attributes are following as Competitors Activities (**A3**) > Location (**A1**) > Financial Stability (**A5**) > Customer Order (**A7**) > Experience Level (**A2**) > Current Stock (**A6**) > Physical Capacity (**A8**).

After the calculation of weights of the attributes, each decision maker compares the alternatives with respect to each attribute. Table 6.9 shows the comparison results with linguistic evaluations for one retailer. Following step 9-11, the scores of alternatives with respect to attributes are provided and used for calculating the possibility values of the alternatives. Related results are presented in the following Table 6.10 to Table 6.14. At the last step of the proposed model, the predicted order is found by the production of possibilities and demand surpluses and shown at Table 6.15. It means that next forecast period, retailer's demand will be the sum of the average sales quantity of past and demand surplus that calculated with model.

According to the these results, even if ALT1- Low Surplus has the highest possibility, other alternatives ALT2- Medium Surplus, ALT3- High Surplus and ALT4- Very High Surplus possibilities effect the total predicted order and balance it. Hence, the score will be more than ALT2- Medium Surplus. This approach not only prevents shortages of products for sales but also help supply chain for material supply plans and to all company with improving service level.

If the company aims to increase their sales; it is cleverly proposed that the main focus should be on A4- Promotional Activities. Any additional sales opportunities like promotions, campaigns or other marketing activities will increase predicted demands of next periods. Moreover, if there is a A3- Competitors' Activities at forecast horizon, new promotional activities can be planned to prevent the decrease of company's own sales. Additionally, for new retailer aggreements, decision makers should take A1-Location and A5- Financial stability of candidate into account to make logical selection.

Table 6.9: Pairwise comparison of alternatives with respect to attribute for R_1

		DM1				DM2				DM3			
		ALT 1	**ALT 2**	**ALT 3**	**ALT 4**	**ALT 1**	**ALT 2**	**ALT 3**	**ALT 4**	**ALT 1**	**ALT 2**	**ALT 3**	**ALT 4**
A1	**ALT 1**	EE	ML	VL	L	EE	MH	E	MH	EE	E	L	ML
	ALT 2		EE	ML	VL		EE	MH	E		EE	E	L
	ALT 3			EE	L			EE	E			EE	ML
	ALT 4				EE				EE				EE
A2	**ALT 1**	EE	MH	ML	H	EE	H	ML	AH	EE	E	ML	VL
	ALT 2		EE	ML	ML		EE	ML	VH		EE	MH	H
	ALT 3			EE	ML			EE	MH			EE	H
	ALT 4				EE				EE				EE
A3	**ALT 1**	EE	H	H	VH	EE	VH	VH	AH	EE	H	VH	AH
	ALT 2		EE	VL	VL		EE	VH	AH		EE	MH	AH
	ALT 3			EE	VL			EE	MH			EE	AH
	ALT 4				EE				EE				EE
A4	**ALT 1**	EE	ML	L	AL	EE	MH	H	AL	EE	AL	AL	AL
	ALT 2		EE	VL	AL		EE	L	VL		EE	VL	AL
	ALT 3			EE	AL			EE	VL			EE	AL
	ALT 4				EE				EE				EE
A5	**ALT 1**	EE	L	VL	AL	EE	H	VH	AH	EE	L	L	VL
	ALT 2		EE	ML	VL		EE	H	VH		EE	L	L
	ALT 3			EE	VL			EE	VH			EE	L
	ALT 4				EE				EE				EE
A6	**ALT 1**	EE	L	VL	AL	EE	H	E	AH	EE	ML	L	VL
	ALT 2		EE	L	VL		EE	H	VH		EE	ML	L
	ALT 3			EE	L			EE	VH			EE	L
	ALT 4				EE				EE				EE
A7	**ALT 1**	EE	ML	VL	AL	EE	H	H	VH	EE	ML	L	AL
	ALT 2		EE	L	VL		EE	MH	VH		EE	L	L
	ALT 3			EE	VL			EE	H			EE	L
	ALT 4				EE				EE				EE
A8	**ALT 1**	EE	L	VL	AL	EE	H	VH	AH	EE	L	L	VL
	ALT 2		EE	VL	AL		EE	H	AH		EE	L	VL
	ALT 3			EE	VL			EE	VH			EE	ML
	ALT 4				EE				EE				EE

Table 6.10: Aggregated comparison matrix of alternatives

	ALT 1				ALT 2				ALT 3				ALT 4			
ALT 1	0,50	0,50	0,50	0,50	0,43	0,65	0,00	0,35	0,38	0,62	0,00	0,38	0,46	1,00	0,00	0,00
ALT 2	0,00	0,35	0,43	0,65	0,50	0,50	0,50	0,50	0,36	0,58	0,00	0,42	0,42	1,00	0,00	0,00
ALT 3	0,00	0,38	0,38	0,62	0,00	0,42	0,36	0,58	0,50	0,50	0,50	0,50	0,38	1,00	0,00	0,00
ALT 4	0,00	0,00	0,46	1,00	0,00	0,00	0,42	1,00	0,00	0,00	0,38	1,00	0,50	0,50	0,50	0,50

Table 6.11: Score judgment matrix of alternatives based on criteria

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	0,01	0,45	-0,31	0,16	-0,10	0,37
	ALT 2	-0,45	-0,01	0,00	0,00	0,01	0,45	-0,31	0,16
	ALT 3	-0,16	0,31	-0,45	-0,01	0,00	0,00	-0,19	0,28
	ALT 4	-0,37	0,10	0,04	0,16	-0,28	0,19	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,22	0,71	-0,20	0,30	0,58	1,00
	ALT 2	-0,16	0,31	0,00	0,00	-0,05	0,42	0,35	0,78
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	0,17	0,69
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,48	0,84	0,54	0,87	0,77	1,00
	ALT 2	-0,33	0,15	0,00	0,00	0,21	0,72	0,67	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	0,55	1,00
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	-0,20	0,29	-0,14	0,54	-0,80	-0,30
	ALT 2	0,05	0,57	0,00	0,00	-0,53	-0,03	-0,73	-0,23
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,73	-0,23
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	-0,05	0,58	0,05	0,65	0,44	1,00
	ALT 2	-0,28	0,19	0,00	0,00	0,00	0,61	0,05	0,65
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	0,05	0,65
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	0,00	0,61	-0,31	0,16	0,44	1,00
	ALT 2	-0,61	0,00	0,00	0,00	0,00	0,61	0,05	0,65
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	0,09	0,67
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	0,05	0,63	-0,10	0,56	-0,07	0,60
	ALT 2	-0,37	0,10	0,00	0,00	-0,16	0,32	0,05	0,65
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	-0,10	0,56
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	-0,05	0,58	0,05	0,65	0,44	1,00
	ALT 2	-0,58	0,05	0,00	0,00	-0,10	0,56	0,44	1,00
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	0,10	0,67
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table 6.12: Interval multiplicative matrix of attributes for each criteria

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	1,03	2,82	0,49	1,44	0,79	2,35
	ALT 2	0,35	0,97	1,00	1,00	1,03	2,82	0,49	1,44
	ALT 3	0,69	2,03	0,35	0,97	1,00	1,00	0,65	1,90
	ALT 4	0,43	1,27	1,11	1,45	0,53	1,54	1,00	1,00
A2	**ALT 1**	1,00	1,00	1,65	5,15	0,63	2,00	3,84	10,00
	ALT 2	0,69	2,03	1,00	1,00	0,90	2,63	2,22	6,09
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	1,48	4,89
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	3,00	6,94	3,50	7,48	5,90	10,00
	ALT 2	0,47	1,42	1,00	1,00	1,63	5,30	4,68	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	3,56	10,00
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	0,63	1,96	0,72	3,48	0,16	0,50
	ALT 2	1,13	3,73	1,00	1,00	0,29	0,94	0,19	0,59
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,19	0,59
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	0,89	3,84	1,13	4,49	2,73	10,00
	ALT 2	0,53	1,54	1,00	1,00	1,00	4,06	1,13	4,49
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	1,13	4,49
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	1,00	4,06	0,49	1,44	2,73	10,00
	ALT 2	0,25	1,00	1,00	1,00	1,00	4,06	1,13	4,49
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	1,24	4,68
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	1,12	4,28	0,80	3,65	0,85	3,98
	ALT 2	0,43	1,27	1,00	1,00	0,69	2,07	1,13	4,49
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	0,80	3,65
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	0,89	3,84	1,13	4,49	2,73	10,00
	ALT 2	0,26	1,12	1,00	1,00	0,80	3,65	2,73	10,00
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	1,26	4,71
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table 6.13: Priority vector of alternatives based on each attribute

		Priority	
A1	**ALT 1**	0,010	0,061
	ALT 2	0,009	0,050
	ALT 3	0,008	0,048
	ALT 4	0,009	0,042
A2	**ALT 1**	0,022	0,146
	ALT 2	0,015	0,095
	ALT 3	0,013	0,093
	ALT 4	0,013	0,090
A3	**ALT 1**	0,041	0,090
	ALT 2	0,024	0,205
	ALT 3	0,016	0,143
	ALT 4	0,004	0,105
A4	**ALT 1**	0,008	0,056
	ALT 2	0,008	0,050
	ALT 3	0,009	0,061
	ALT 4	0,009	0,066
A5	**ALT 1**	0,018	0,156
	ALT 2	0,011	0,089
	ALT 3	0,009	0,062
	ALT 4	0,005	0,025
A6	**ALT 1**	0,016	0,133
	ALT 2	0,010	0,085
	ALT 3	0,010	0,070
	ALT 4	0,005	0,025
A7	**ALT 1**	0,012	0,104
	ALT 2	0,010	0,071
	ALT 3	0,008	0,059
	ALT 4	0,005	0,030
A8	**ALT 1**	0,018	0,156
	ALT 2	0,015	0,127
	ALT 3	0,009	0,063
	ALT 4	0,004	0,020

Table 6.14: Possibility degree matrix and weights of the alternatives with respect to attributes

		ALT 1	ALT 2	ALT 3	ALT 4	w	w^T
A1	**ALT 1**	0,500	0,567	0,587	0,618	0,818	0,273
	ALT 2	0,433	0,500	0,520	0,549	0,751	0,250
	ALT 3	0,413	0,480	0,500	0,528	0,730	0,243
	ALT 4	0,382	0,451	0,472	0,500	0,701	0,234
A2	**ALT 1**	0,776	0,830	0,844	0,870	1,080	0,276
	ALT 2	0,645	0,708	0,726	0,756	0,959	0,245
	ALT 3	0,633	0,695	0,712	0,741	0,945	0,241
	ALT 4	0,620	0,683	0,700	0,730	0,934	0,238
A3	**ALT 1**	0,799	0,902	0,930	0,988	1,155	0,271
	ALT 2	0,839	0,882	0,893	0,914	1,132	0,266
	ALT 3	0,743	0,794	0,808	0,833	1,045	0,245
	ALT 4	0,624	0,676	0,690	0,715	0,926	0,218
A4	**ALT 1**	0,461	0,526	0,545	0,573	0,776	0,245
	ALT 2	0,430	0,496	0,516	0,544	0,747	0,236
	ALT 3	0,493	0,560	0,579	0,609	0,810	0,256
	ALT 4	0,519	0,584	0,603	0,632	0,835	0,263
A5	**ALT 1**	0,770	0,819	0,832	0,856	1,069	0,322
	ALT 2	0,613	0,674	0,691	0,720	0,925	0,279
	ALT 3	0,493	0,559	0,578	0,607	0,809	0,244
	ALT 4	0,210	0,265	0,284	0,297	0,514	0,155
A6	**ALT 1**	0,731	0,785	0,799	0,825	1,035	0,313
	ALT 2	0,595	0,657	0,674	0,703	0,907	0,275
	ALT 3	0,538	0,603	0,621	0,651	0,853	0,258
	ALT 4	0,203	0,258	0,276	0,288	0,506	0,153
A7	**ALT 1**	0,654	0,712	0,728	0,755	0,962	0,302
	ALT 2	0,543	0,608	0,626	0,656	0,858	0,269
	ALT 3	0,478	0,543	0,562	0,591	0,794	0,249
	ALT 4	0,263	0,322	0,341	0,358	0,571	0,179
A8	**ALT 1**	0,770	0,819	0,832	0,856	1,069	0,319
	ALT 2	0,715	0,769	0,784	0,810	1,020	0,304
	ALT 3	0,501	0,566	0,585	0,614	0,816	0,243
	ALT 4	0,151	0,200	0,219	0,223	0,448	0,134

Table 6.15: Possibilities of alternatives and predicted order for R_1

	A1	A2	A3	A4	A5	A6	A7	A8	P_j	ALT_j	
	0,138	**0,121**	**0,140**	**0,165**	**0,136**	**0,090**	**0,132**	**0,078**			
ALT 1	0,273	0,276	0,271	0,245	0,322	0,313	0,302	0,319	0,286	600	172
ALT 2	0,250	0,245	0,266	0,236	0,279	0,275	0,269	0,304	0,262	1000	262
ALT 3	0,243	0,241	0,245	0,256	0,244	0,258	0,249	0,243	0,248	1200	297
ALT 4	0,234	0,238	0,218	0,263	0,155	0,153	0,179	0,134	0,204	2000	408
									ΔR_1		**1139**

6.2. Sensitivity Analysis of Attributes

A sensitivity analysis is applied to examine the effects of the possible changes in the weights of the attributes on order prediction methodology for vendor managed inventory system. Figure 6.3 displays the results of analysis. In this figure, X axis represents the weights of attributes and Y axis represents the possibilities of alternatives. In this analysis, the value of attributes' weights are changed while other attributes weights are comparatively distributed. As an example, when the A1-Location's weights has changed from 0,138 to 0,1 , the weight of A2- Experience Level is updated as $w_2^T = \frac{0,121}{(1-0,138)} x\,(1-0,1) = 0,127$. This proses is conducted for all attributes and new attribute weights and alternative scores are calculated.

Sensitivity analysis represents that all the attributes except A4- Promotional Activities has no sensitity on the ranking of alternative possibilities. But when the weight of A4 has passed 0,9 the ranking of alternative possibilities are changing. This results approves our results of weights that found previous section which is the most important attribute is A4- Promotional Activities. It is also means that decisions for the retailer are robust against the possible changes in attribute weights. In Figure 6.4, we can see the changing of final scores according to the changings of attributes' weights. It is easily seen that A1- Location, A2-Experience Level, A3- Competitors' Activities, A4- Promotional Activities has a positive impact while A5-Financial Stability, A6- Current Stock, A7- Customer Order and A8- Physical Capacity has negative. It is also seen that while the weight of the most important attribute A4- Promotional Activities are increasing, it effects the results more than others that total score has passed ALT3- High Surplus level.

Figure 6.3: Sensitivity Analysis results of attributes

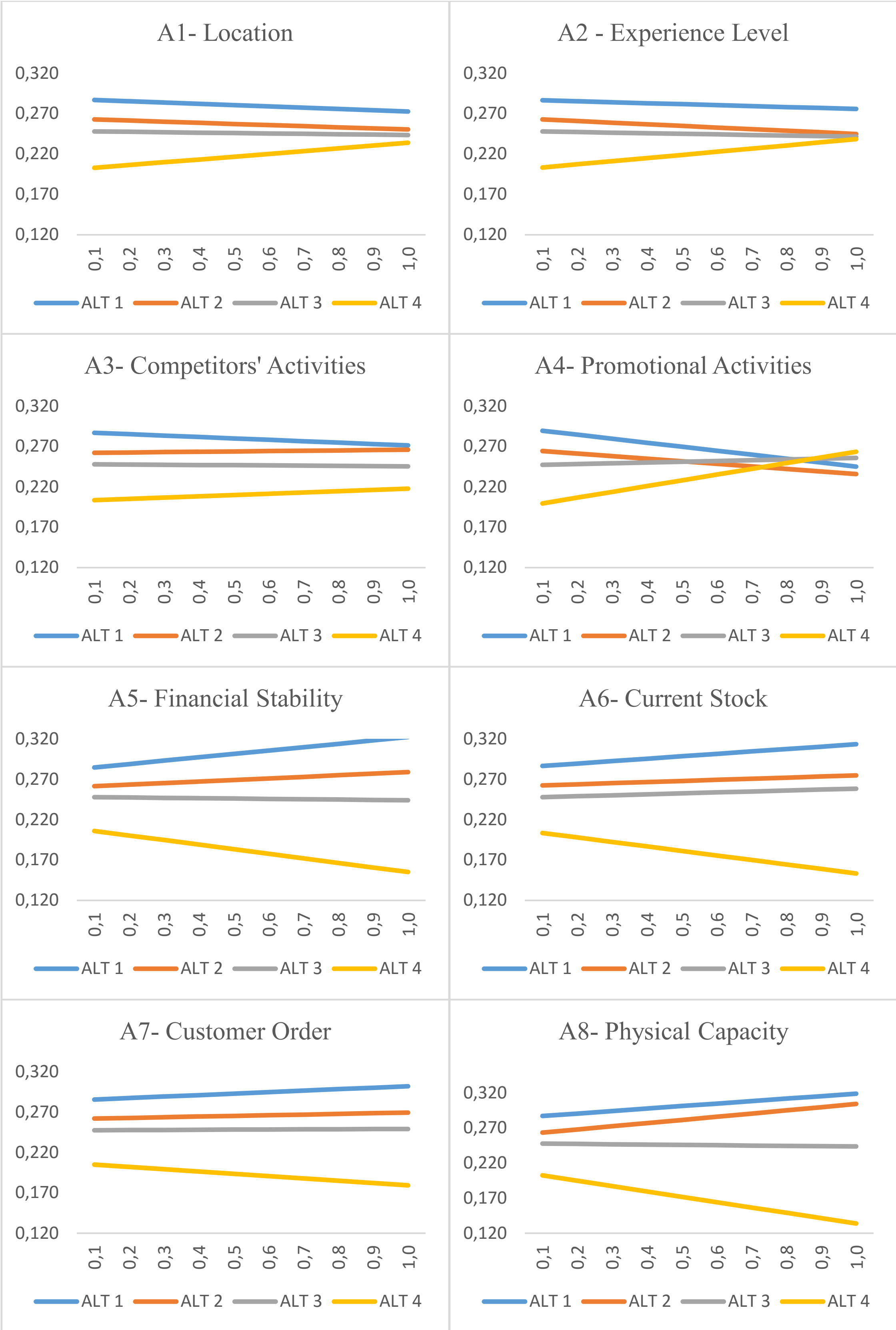
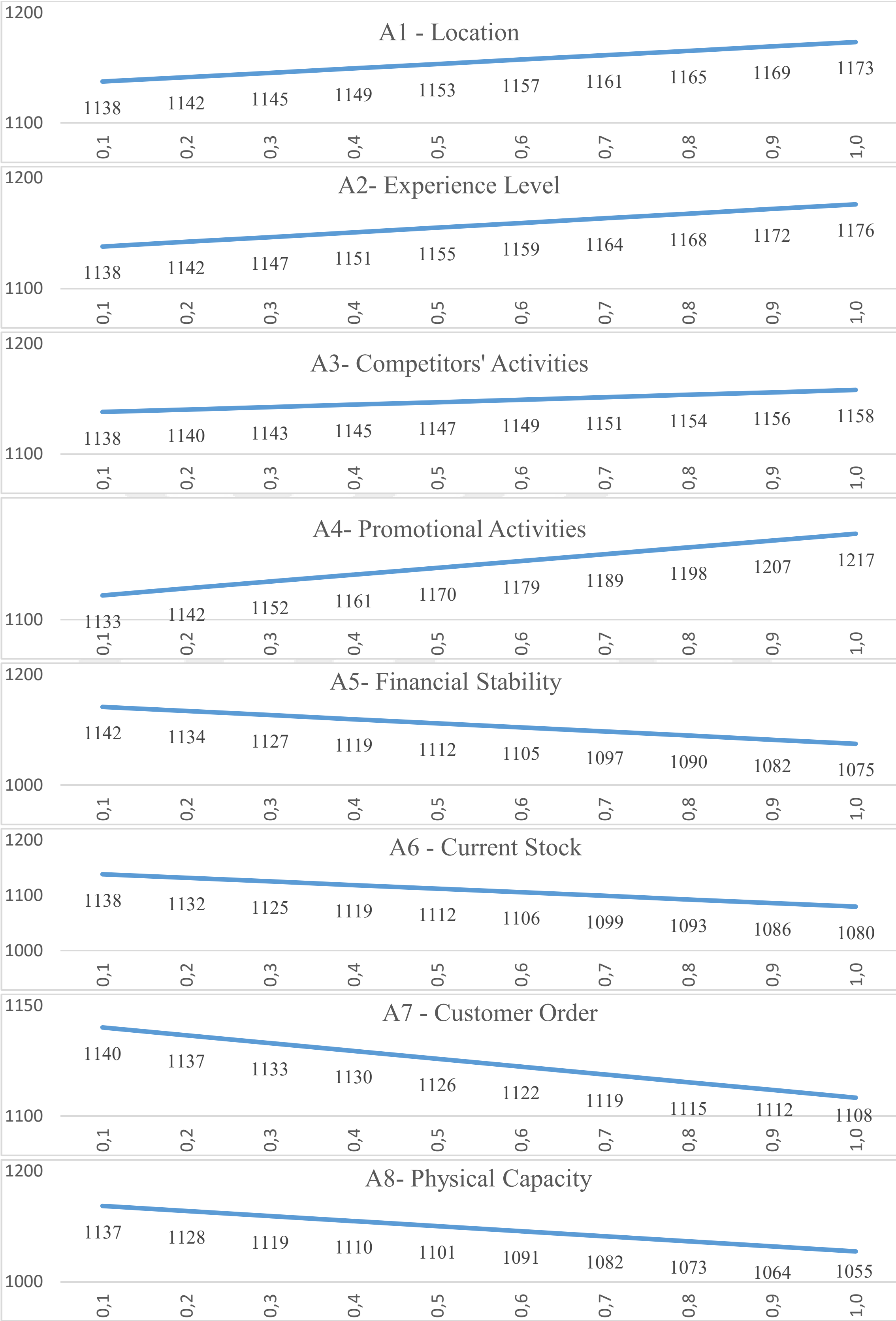


Figure 6.4: Sensitivity Analysis results of retailer



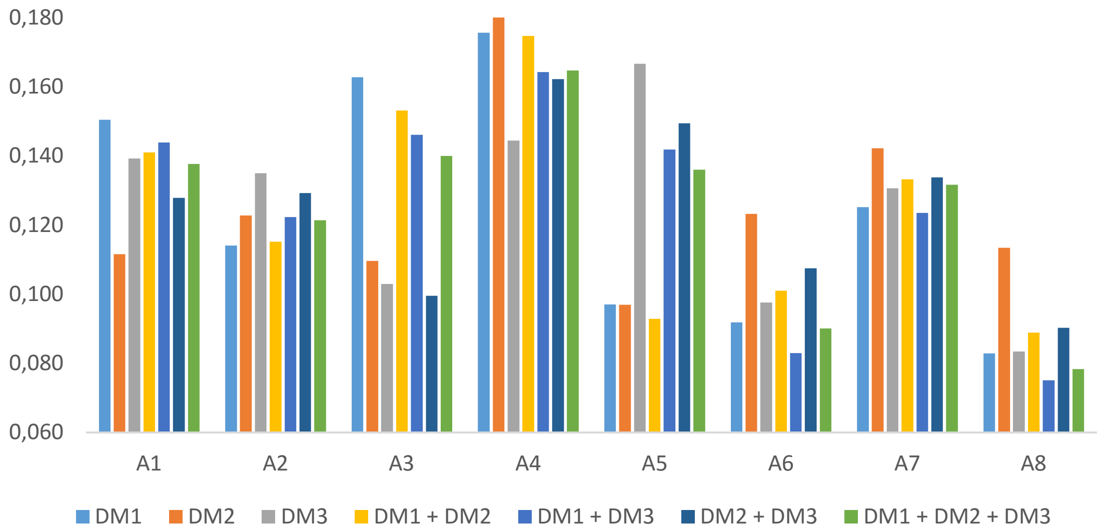
6.3. Comparison results

6.3.1.Comparisons of decision makers' preferences

In the proposed methodology, three equal decision maker from different teams of FMCG company has evaluated the retailer based on given attributes. To distinguish the decisions of expert, we have operated the model with different combinations of decision makers. Related tables that presents decision maker's and combination of decision makers are stated at Appendix A. Pairwise comparisons of attributes and alternatives with respect to attributes are not repeated again.

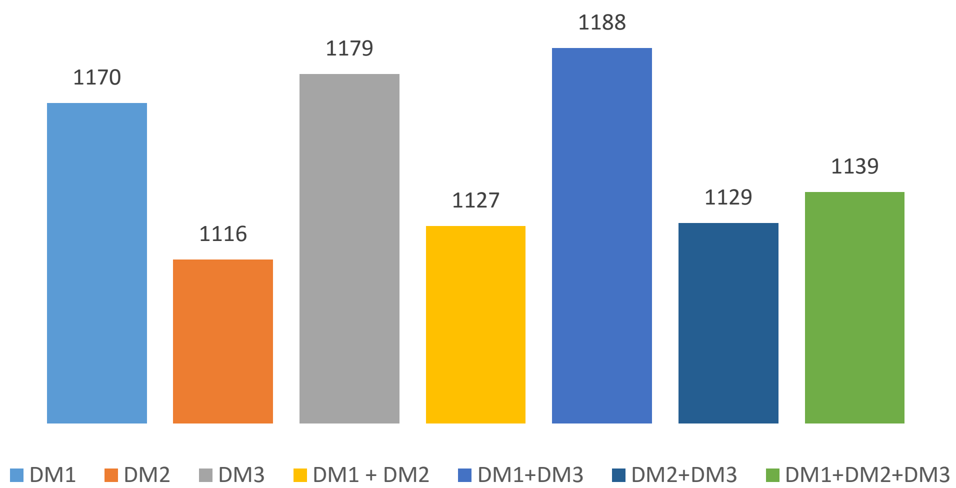
According to these results, the most important criterias are promotional activities, competitors' activities and location for DM1; promotional activities, experience level and customer order for DM2 and financial stability, promotional activities and location for DM3. Although promotional activities is common for both, other criterias and their weights are changing according to the decision makers' preference. When different decision makers come together, weights of the criterias are slightly changing. For instance, with a combination of DM1 and DM2, location's weight is decreasing while customer order's weight increasing in comparison with if only DM1 decide. Similarly, when DM2 and DM3 evaluate together, financial stability's weight is increasing while promotional activities's weight decreasing. Figure 6.5 presents the changings of attributes in accordance with decision makers' preferences.

Figure 6.5: Attribute weights with respect to decision makers' preference



Additionally, although DM1 and DM3 gives higher points to the retailer, DM2's decisions are lower than others. It is also found that collaboration of DM1 and DM3 has the highest value. These result shows that different decision makers are important for stable results, otherwise the results may be tricky for demand forecasting and it may also cause overstock or lack of inventory scenarios. Figure 6.6 shows the results of different combinations of decision makers.

Figure 6.6: Comparison of evaluations of different decision makers



6.3.2. Comparisons of different retailers

Additionally, to observe the effects of different retailers' conditions, the study ran for 3 different real life retailer with different conditions and forecasted demand surpluses calculated from past sales data. Past sales data is synchronized for each retailer to simplify and interpret the comparison. Retailers' informations are hidden due to privacy conditions of sales company and their names are shown as R_1, R_2 and R_3. Tables that the comparison results with linguistic evaluations for each retailer are presented at Appendix B.

Figure 6.7 summarizes the comparison results of retailers for each alternative. Comparison results show that although all the possibilities effect the total score, due to the crisp values of alternatives, possibilities of ALT3- High Surplus and ALT4- Very High Surplus effect the total score highly. Since R_2 has the highest possibilities for these alternatives, it has the highest prediction.

Although R_1 has the highest and R_2 has the lowest possibility for ALT2- Medium Surplus, it doesn't effect the total score as much as the possibilities of ALT3- High Surplus and ALT4- Very High Surplus. Thus, R_2 has higher prediction than R_1.

ALT1- Low Surplus has lowest effect to the total score with crisp value 600, it has limited impact to total score. Even R_3 has the highest score for ALT1, it has lowest prediction due to the possibilities of other alternatives are lower than R_1 and R_2.

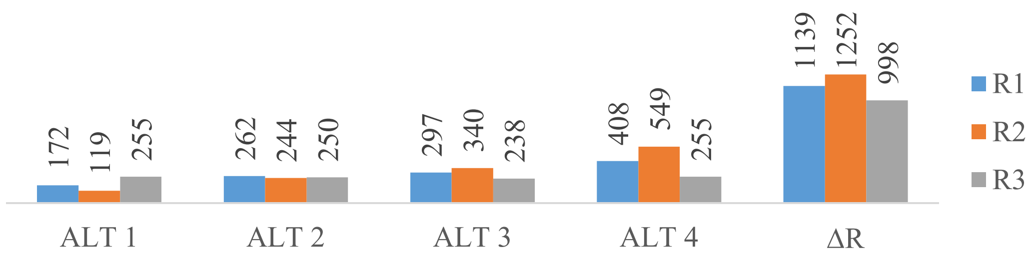


Figure 6.7: Comparison results of retailers

7.CONCLUSION

This study concentrates on order predicting procedure of Vendor Managed Inventory System (VMI) which has critical importance for the success of VMI system. The study includes a multicriteria problem affected by quantitative and qualitative criterias for a real FMCG company. An intuitionistic fuzzy sets and aggregation operators are implemented to solve the uncertainty, imprecise and subjectivity in the human judgments.

Eight attribute that directly effect demand forecasting are considered in this study: location, which are experience level, competitors' activities, promotional activities, financial stability, current stock, customer order and physical capacity. They all evaluated linguistically by three equal weighted decision makers from different teams of FMCG company and converted to interval valued intuitionistic fuzzy numbers. All the weights of attributes has been calculated and promotional activities has found as the most important attribute for demand forecasting of this FMCG company. Competitors' activities, location and financial stability attributes are following it. The sensitivity analysis showed that small changes in the weight of the attributes did not cause any major changes at the end. If the company aims to increase their sales; it is cleverly proposed that the main focus should be on Promotional Activities. Any additional sales opportunities like promotions, campaigns or other marketing activities will increase predicted demands of next periods. Moreover, if there is a competitor activities at forecast horizon, new promotional activities can be planned to prevent the decrease of company's own sales. Additionally, for new retailer aggreements, decision makers should take location and financial stability of candidate into account to make logical selection.

Four alternative have been chosen to evaluated based on eight attributes by three equally weighted decision makers. In the proposed method, even if one of the alternative has the highest value, final demand surplus may be different due to the possibilities of other alternatives. The proposed methodology avoids giving same valuable order forecast for all retailers with different conditions and characteristics with summing the production of possibilities and demand surplusses instead of ranking the possibilities. It is shown that experienced retailer with good location and promotions opportunities takes highest prediction while new bad located retailer takes lower prediction. Comparisons of different retailers showed that the proposed method yields logical and reliable results. It is also seen that the proposed order prediction methodology improves supply chain performance of the company while preventing excessive stocks and customer backorders with equalization of the alternatives.

We have three equal weighted decision maker from different teams of the FMCG company. The comparison of the decision makers' results has showed that different decision makers with different targets and characteristics are critical for stable results, otherwise the results may be tricky for demand forecasting.

Further studies are suggested to consider more attributes to increase complexity of the problem and alternatives can be increased to find more precise solutions. Additionally, another fuzzy Multi-Criteria Decision Making methods such as heuristic, Electre, Topsis and other extensions of fuzzy sets such as hesitant fuzzy sets, type-2 fuzzy sets can also be used for the same problem.

Furthermore, forecasted demand that calculated by proposed methodology may combine with inventory replenishment methods that studied in the literature in order to find optimum inventory levels and replenishment quantities more accurate and more sensible for considered companies.

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APPENDICES

Appendix A. Comparisons of decision makers' preferences

Table A.1: Aggregated Comparison Matrix for the preferences of DM 1

	A1				A2				A3				A4			
A1	0,50	0,50	0,50	0,50	0,58	0,71	0,00	0,29	0,42	0,47	0,42	0,53	0,39	0,44	0,46	0,56
A2	0,00	0,29	0,58	0,71	0,50	0,50	0,50	0,50	0,39	0,44	0,46	0,56	0,42	0,47	0,42	0,53
A3	0,42	0,53	0,42	0,47	0,46	0,56	0,39	0,44	0,50	0,50	0,50	0,50	0,47	0,54	0,37	0,46
A4	0,46	0,56	0,39	0,44	0,42	0,53	0,42	0,47	0,37	0,46	0,47	0,54	0,50	0,50	0,50	0,50
A5	0,00	0,37	0,54	0,63	0,37	0,46	0,47	0,54	0,00	0,29	0,58	0,71	0,00	0,00	0,63	1,00
A6	0,29	0,42	0,50	0,58	0,00	0,00	0,47	0,54	0,00	0,00	0,63	1,00	0,00	0,00	0,63	1,00
A7	0,37	0,50	0,44	0,50	0,37	0,50	0,44	0,50	0,37	0,50	0,44	0,50	0,00	0,29	0,58	0,71
A8	0,00	0,29	0,58	0,71	0,29	0,42	0,50	0,58	0,00	0,29	0,58	0,71	0,00	0,00	0,63	1,00
	A5				**A6**				**A7**				**A8**			
A1	0,54	0,63	0,00	0,37	0,50	0,58	0,29	0,42	0,44	0,50	0,37	0,50	0,58	0,71	0,00	0,29
A2	0,47	0,54	0,37	0,46	0,47	0,54	0,37	0,46	0,44	0,50	0,37	0,50	0,50	0,58	0,29	0,42
A3	0,58	0,71	0,00	0,29	0,63	1,00	0,00	0,00	0,44	0,50	0,37	0,50	0,58	0,71	0,00	0,29
A4	0,63	1,00	0,00	0,00	0,63	1,00	0,00	0,00	0,58	0,71	0,00	0,29	0,63	1,00	0,00	0,00
A5	0,50	0,50	0,50	0,50	0,44	0,50	0,37	0,50	0,42	0,47	0,42	0,53	0,47	0,54	0,37	0,46
A6	0,37	0,50	0,44	0,50	0,50	0,50	0,50	0,50	0,44	0,50	0,37	0,50	0,47	0,54	0,37	0,46
A7	0,42	0,53	0,42	0,47	0,37	0,50	0,44	0,50	0,50	0,50	0,50	0,50	0,58	0,71	0,00	0,29
A8	0,37	0,46	0,47	0,54	0,37	0,46	0,47	0,54	0,00	0,29	0,58	0,71	0,50	0,50	0,50	0,50

Table A.2: Score judgment matrix of attributes with the prefence of DM 1

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	0,00	0,00	0,29	0,71	-0,12	0,05	-0,17	-0,02	0,17	0,63	0,08	0,29	-0,06	0,13	0,29	0,71
A2	-0,71	-0,29	0,00	0,00	-0,17	-0,02	-0,12	0,05	0,00	0,17	0,00	0,17	-0,06	0,13	0,08	0,29
A3	-0,05	0,12	0,02	0,17	0,00	0,00	0,00	0,17	0,29	0,71	0,63	1,00	-0,06	0,13	0,29	0,71
A4	0,02	0,17	-0,05	0,12	-0,17	0,00	0,00	0,00	0,63	1,00	0,63	1,00	0,29	0,71	0,63	1,00
A5	-0,63	-0,17	-0,17	0,00	-0,71	-0,29	-1,00	-0,63	0,00	0,00	-0,06	0,13	-0,12	0,05	0,00	0,17
A6	-0,29	-0,08	-0,54	-0,47	-1,00	-0,63	-1,00	-0,63	-0,13	0,06	0,00	0,00	-0,06	0,13	0,00	0,17
A7	-0,13	0,06	-0,13	0,06	-0,13	0,06	-0,71	-0,29	-0,05	0,12	-0,13	0,06	0,00	0,00	0,29	0,71
A8	-0,71	-0,29	-0,29	-0,08	-0,71	-0,29	-1,00	-0,63	-0,17	0,00	-0,17	0,00	-0,71	-0,29	0,00	0,00

Table A.3: Interval multiplicative matrix of attributes for the preferences of DM 1

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	1,00	1,00	1,93	5,10	0,77	1,11	0,68	0,95	1,47	4,28	1,20	1,93	0,87	1,35	1,93	5,10
A2	0,20	0,52	1,00	1,00	0,68	0,95	0,77	1,11	1,01	1,47	1,01	1,47	0,87	1,35	1,20	1,93
A3	0,90	1,31	1,06	1,47	1,00	1,00	1,01	1,47	1,93	5,10	4,28	10,00	0,87	1,35	1,93	5,10
A4	1,06	1,47	0,90	1,31	0,68	0,99	1,00	1,00	4,28	10,00	4,28	10,00	1,93	5,10	4,28	10,00
A5	0,23	0,68	0,68	0,99	0,20	0,52	0,10	0,23	1,00	1,00	0,87	1,35	0,77	1,11	1,01	1,47
A6	0,52	0,84	0,29	0,34	0,10	0,23	0,10	0,23	0,74	1,15	1,00	1,00	0,87	1,35	1,01	1,47
A7	0,74	1,15	0,74	1,15	0,74	1,15	0,20	0,52	0,90	1,31	0,74	1,15	1,00	1,00	1,93	5,10
A8	0,20	0,52	0,52	0,84	0,20	0,52	0,10	0,23	0,68	0,99	0,68	0,99	0,20	0,52	1,00	1,00

Table A.4: Priority Vector of attributes for the preferences of DM 1

Attribute	Priority	
A1	0,076	0,306
A2	0,052	0,144
A3	0,100	0,394
A4	0,142	0,586
A5	0,038	0,108
A6	0,036	0,097
A7	0,054	0,184
A8	0,028	0,082

Table A.6: Possibility degree matrix and weights of the attributes for the preferences of DM 1

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	***w***	***w^T***
A1	0,500	0,789	0,393	0,243	0,893	0,928	0,701	0,978	1,053	0,150
A2	0,211	0,500	0,114	0,004	0,655	0,706	0,406	0,794	0,799	0,114
A3	0,607	0,886	0,500	0,341	0,978	1,000	0,803	1,000	1,139	0,163
A4	0,757	0,996	0,659	0,500	1,000	1,000	0,927	1,000	1,230	**0,176**
A5	0,107	0,345	0,022	0,000	0,500	0,548	0,270	0,643	0,679	0,097
A6	0,072	0,294	0,000	0,000	0,452	0,500	0,226	0,599	0,643	0,092
A7	0,299	0,594	0,197	0,073	0,730	0,774	0,500	0,846	0,877	0,125
A8	0,022	0,206	0,000	0,000	0,357	0,401	0,154	0,500	0,580	0,083

Table A.7: Aggregated comparison matrix of alternatives for preferences of DM1

	ALT 1				**ALT 2**				**ALT 3**				**ALT 4**			
ALT 1	0,50	0,50	0,50	0,50	0,45	0,52	0,00	0,48	0,42	0,48	0,00	0,52	0,43	0,50	0,00	0,50
ALT 2	0,00	0,48	0,45	0,52	0,50	0,50	0,50	0,50	0,42	0,47	0,42	0,53	0,39	0,44	0,46	0,56
ALT 3	0,00	0,52	0,42	0,48	0,42	0,53	0,42	0,47	0,50	0,50	0,50	0,50	0,40	0,45	0,44	0,55
ALT 4	0,00	0,50	0,43	0,50	0,46	0,56	0,39	0,44	0,44	0,55	0,40	0,45	0,50	0,50	0,50	0,50

Table A.8: Score judgment matrix of alternatives based on criteria for the preferences of DM 1

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	-0,06	0,13	-0,17	-0,02	-0,12	0,05
	ALT 2	-0,13	0,06	0,00	0,00	-0,06	0,13	-0,17	-0,02
	ALT 3	0,02	0,17	-0,13	0,06	0,00	0,00	-0,12	0,05
	ALT 4	-0,05	0,12	0,07	0,06	-0,05	0,12	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,08	0,29	-0,06	0,13	0,17	0,63
	ALT 2	-0,16	0,31	0,00	0,00	-0,06	0,13	-0,06	0,13
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	-0,06	0,13
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,17	0,63	0,17	0,63	0,29	0,71
	ALT 2	-0,33	0,15	0,00	0,00	-0,17	-0,02	-0,17	-0,02
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	-0,17	-0,02
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	-0,06	0,13	-0,12	0,05	-0,21	-0,08
	ALT 2	0,05	0,57	0,00	0,00	-0,17	-0,02	-0,21	-0,08
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,21	-0,08
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	-0,12	0,05	-0,17	-0,02	-0,21	-0,08
	ALT 2	-0,28	0,19	0,00	0,00	-0,06	0,13	-0,17	-0,02
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	-0,17	-0,02
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	-0,12	0,05	-0,17	-0,02	-0,21	-0,08
	ALT 2	-0,61	0,00	0,00	0,00	-0,12	0,05	-0,17	-0,02
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	-0,12	0,05
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	-0,06	0,13	-0,17	-0,02	-0,21	-0,08
	ALT 2	-0,37	0,10	0,00	0,00	-0,12	0,05	-0,17	-0,02
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	-0,17	-0,02
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	-0,12	0,05	-0,17	-0,02	-0,21	-0,08
	ALT 2	-0,58	0,05	0,00	0,00	-0,17	-0,02	-0,21	-0,08
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	-0,17	-0,02
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table A.9: Interval multiplicative matrix of attributes on each criteria for the prefences of DM 1

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	0,87	1,35	0,68	0,95	0,77	1,11
	ALT 2	0,74	1,15	1,00	1,00	0,87	1,35	0,68	0,95
	ALT 3	1,06	1,47	0,74	1,15	1,00	1,00	0,77	1,11
	ALT 4	0,90	1,31	1,18	1,15	0,90	1,31	1,00	1,00
A2	**ALT 1**	1,00	1,00	1,20	1,93	0,87	1,35	1,47	4,28
	ALT 2	0,69	2,03	1,00	1,00	0,87	1,35	0,87	1,35
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	0,87	1,35
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	1,47	4,28	1,47	4,28	1,93	5,10
	ALT 2	0,47	1,42	1,00	1,00	0,68	0,95	0,68	0,95
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	0,68	0,95
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	0,87	1,35	0,77	1,11	0,61	0,82
	ALT 2	1,13	3,73	1,00	1,00	0,68	0,95	0,61	0,82
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,61	0,82
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	0,77	1,11	0,68	0,95	0,61	0,82
	ALT 2	0,53	1,54	1,00	1,00	0,87	1,35	0,68	0,95
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	0,68	0,95
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	0,77	1,11	0,68	0,95	0,61	0,82
	ALT 2	0,25	1,00	1,00	1,00	0,77	1,11	0,68	0,95
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	0,77	1,11
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	0,87	1,35	0,68	0,95	0,61	0,82
	ALT 2	0,43	1,27	1,00	1,00	0,77	1,11	0,68	0,95
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	0,68	0,95
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	0,77	1,11	0,68	0,95	0,61	0,82
	ALT 2	0,26	1,12	1,00	1,00	0,68	0,95	0,61	0,82
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	0,68	0,95
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table A.10: Priority vector of alternatives based on each attribute for the preferences of DM 1

		Priority	
A1	**ALT 1**	0,020	0,047
	ALT 2	0,020	0,047
	ALT 3	0,021	0,050
	ALT 4	0,024	0,050
A2	**ALT 1**	0,027	0,091
	ALT 2	0,021	0,061
	ALT 3	0,022	0,085
	ALT 4	0,025	0,117
A3	**ALT 1**	0,035	0,117
	ALT 2	0,017	0,155
	ALT 3	0,013	0,046
	ALT 4	0,009	0,041
A4	**ALT 1**	0,019	0,045
	ALT 2	0,020	0,069
	ALT 3	0,021	0,082
	ALT 4	0,018	0,087
A5	**ALT 1**	0,018	0,041
	ALT 2	0,018	0,051
	ALT 3	0,014	0,043
	ALT 4	0,009	0,033
A6	**ALT 1**	0,018	0,041
	ALT 2	0,016	0,043
	ALT 3	0,016	0,054
	ALT 4	0,009	0,032
A7	**ALT 1**	0,019	0,044
	ALT 2	0,017	0,046
	ALT 3	0,015	0,049
	ALT 4	0,010	0,040
A8	**ALT 1**	0,018	0,041
	ALT 2	0,015	0,041
	ALT 3	0,013	0,043
	ALT 4	0,008	0,027

Table A.11: Possibility degree matrix and weights of the alternatives with respect to attributes for the preferences of DM 1

		ALT 1	ALT 2	ALT 3	ALT 4	w	w^T
A1	**ALT 1**	0,500	0,498	0,457	0,429	0,721	0,240
	ALT 2	0,502	0,500	0,459	0,431	0,723	0,241
	ALT 3	0,543	0,541	0,500	0,475	0,765	0,255
	ALT 4	0,571	0,569	0,525	0,500	0,791	0,264
A2	**ALT 1**	0,783	0,781	0,752	0,742	1,015	0,263
	ALT 2	0,610	0,608	0,572	0,553	0,836	0,217
	ALT 3	0,723	0,721	0,693	0,682	0,955	0,248
	ALT 4	0,817	0,815	0,792	0,786	1,052	0,273
A3	**ALT 1**	0,894	0,891	0,865	0,860	1,128	0,329
	ALT 2	0,820	0,818	0,802	0,797	1,059	0,309
	ALT 3	0,433	0,432	0,396	0,369	0,657	0,192
	ALT 4	0,360	0,360	0,326	0,296	0,586	0,171
A4	**ALT 1**	0,484	0,482	0,440	0,411	0,704	0,204
	ALT 2	0,651	0,648	0,616	0,601	0,879	0,254
	ALT 3	0,707	0,704	0,676	0,664	0,938	0,271
	ALT 4	0,700	0,698	0,672	0,662	0,933	0,270
A5	**ALT 1**	0,428	0,427	0,384	0,351	0,647	0,257
	ALT 2	0,526	0,524	0,486	0,462	0,750	0,297
	ALT 3	0,418	0,417	0,379	0,350	0,641	0,254
	ALT 4	0,263	0,264	0,226	0,187	0,485	0,192
A6	**ALT 1**	0,428	0,427	0,384	0,351	0,647	0,256
	ALT 2	0,430	0,429	0,389	0,359	0,652	0,258
	ALT 3	0,531	0,529	0,494	0,473	0,757	0,299
	ALT 4	0,251	0,251	0,214	0,173	0,472	0,187
A7	**ALT 1**	0,461	0,460	0,418	0,387	0,681	0,257
	ALT 2	0,468	0,466	0,427	0,399	0,690	0,261
	ALT 3	0,477	0,476	0,440	0,415	0,702	0,265
	ALT 4	0,351	0,350	0,315	0,283	0,575	0,217
A8	**ALT 1**	0,428	0,427	0,384	0,351	0,647	0,284
	ALT 2	0,404	0,404	0,364	0,332	0,626	0,275
	ALT 3	0,410	0,409	0,372	0,343	0,634	0,278
	ALT 4	0,153	0,155	0,117	0,067	0,373	0,164

Table A.12: Possibilities of alternatives and predicted order for R_1 with respect to the preferences of DM 1

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	P_j	ALT_j	
	0,150	**0,114**	**0,163**	**0,176**	**0,097**	**0,092**	**0,125**	**0,083**			
ALT 1	0,240	0,263	0,329	0,204	0,257	0,256	0,257	0,284	0,260	600	156
ALT 2	0,241	0,217	0,309	0,254	0,297	0,258	0,261	0,275	0,264	1000	264
ALT 3	0,255	0,248	0,192	0,271	0,254	0,299	0,265	0,278	0,254	1200	305
ALT 4	0,264	0,273	0,171	0,270	0,192	0,187	0,217	0,164	0,223	2000	445
										ΔR_1	**1170**

Table A.13: Aggregated Comparison Matrix for the preferences of DM 2

	A1				**A2**				**A3**				**A4**			
A1	0,50	0,50	0,50	0,50	0,42	0,47	0,42	0,53	0,42	0,47	0,42	0,53	0,39	0,44	0,46	0,56
A2	0,42	0,53	0,42	0,47	0,50	0,50	0,50	0,50	0,50	0,58	0,29	0,42	0,39	0,44	0,46	0,56
A3	0,42	0,53	0,42	0,47	0,29	0,42	0,50	0,58	0,50	0,50	0,50	0,50	0,42	0,47	0,42	0,53
A4	0,46	0,56	0,39	0,44	0,46	0,56	0,39	0,44	0,42	0,53	0,42	0,47	0,50	0,50	0,50	0,50
A5	0,37	0,50	0,44	0,50	0,37	0,46	0,47	0,54	0,37	0,50	0,44	0,50	0,00	0,00	0,63	1,00
A6	0,50	0,58	0,37	0,42	0,42	0,53	0,39	0,44	0,42	0,53	0,42	0,47	0,00	0,29	0,58	0,71
A7	0,50	0,58	0,37	0,42	0,46	0,56	0,39	0,44	0,46	0,56	0,39	0,44	0,00	0,37	0,54	0,63
A8	0,37	0,46	0,47	0,54	0,37	0,50	0,44	0,50	0,50	0,58	0,37	0,42	0,29	0,42	0,50	0,58

	A5				**A6**				**A7**				**A8**			
A1	0,44	0,50	0,37	0,50	0,37	0,42	0,50	0,58	0,37	0,42	0,50	0,58	0,47	0,54	0,37	0,46
A2	0,47	0,54	0,37	0,46	0,39	0,44	0,46	0,56	0,39	0,44	0,46	0,56	0,44	0,50	0,37	0,50
A3	0,44	0,50	0,37	0,50	0,42	0,47	0,42	0,53	0,39	0,44	0,46	0,56	0,37	0,42	0,50	0,58
A4	0,63	1,00	0,00	0,00	0,58	0,71	0,00	0,29	0,54	0,63	0,00	0,37	0,50	0,58	0,29	0,42
A5	0,50	0,50	0,50	0,50	0,42	0,47	0,42	0,53	0,37	0,42	0,50	0,58	0,37	0,42	0,50	0,58
A6	0,42	0,53	0,42	0,47	0,50	0,50	0,50	0,50	0,44	0,50	0,37	0,50	0,47	0,54	0,37	0,46
A7	0,50	0,58	0,37	0,42	0,37	0,50	0,44	0,50	0,50	0,50	0,50	0,50	0,54	0,63	0,00	0,37
A8	0,50	0,58	0,37	0,42	0,37	0,46	0,47	0,54	0,00	0,37	0,54	0,63	0,50	0,50	0,50	0,50

Table A.14: Score judgment matrix of attributes with theprefence of DM 2

	A1		**A2**		**A3**		**A4**		**A5**		**A6**		**A7**		**A8**	
A1	0,00	0,00	-0,12	0,05	-0,12	0,05	-0,17	-0,02	-0,06	0,13	-0,21	-0,08	-0,21	-0,08	0,00	0,17
A2	-0,05	0,12	0,00	0,00	0,08	0,29	-0,17	-0,02	0,00	0,17	-0,17	-0,02	-0,17	-0,02	-0,06	0,13
A3	-0,05	0,12	-0,29	-0,08	0,00	0,00	-0,12	0,05	-0,06	0,13	-0,12	0,05	-0,17	-0,02	-0,21	-0,08
A4	0,02	0,17	0,02	0,17	-0,05	0,12	0,00	0,00	0,63	1,00	0,29	0,71	0,17	0,63	0,08	0,29
A5	-0,13	0,06	-0,17	0,00	-0,13	0,06	-1,00	-0,63	0,00	0,00	-0,12	0,05	-0,21	-0,08	-0,21	-0,08
A6	0,08	0,21	-0,02	0,14	-0,05	0,12	-0,71	-0,29	-0,05	0,12	0,00	0,00	-0,06	0,13	0,00	0,17
A7	0,08	0,21	0,02	0,17	0,02	0,17	-0,63	-0,17	0,08	0,21	-0,13	0,06	0,00	0,00	0,17	0,63
A8	-0,17	0,00	-0,13	0,06	0,08	0,21	-0,29	-0,08	0,08	0,21	-0,17	0,00	-0,63	-0,17	0,00	0,00

Table A.15: Interval multiplicative matrix of attributes for the preferences of DM 2

	A1		**A2**		**A3**		**A4**		**A5**		**A6**		**A7**		**A8**	
A1	1,00	1,00	0,77	1,11	0,77	1,11	0,68	0,95	0,87	1,35	0,61	0,82	0,61	0,82	1,01	1,47
A2	0,90	1,31	1,00	1,00	1,20	1,93	0,68	0,95	1,01	1,47	0,68	0,95	0,68	0,95	0,87	1,35
A3	0,90	1,31	0,52	0,84	1,00	1,00	0,77	1,11	0,87	1,35	0,77	1,11	0,68	0,95	0,61	0,82
A4	1,06	1,47	1,06	1,47	0,90	1,31	1,00	1,00	4,28	10,00	1,93	5,10	1,47	4,28	1,20	1,93
A5	0,74	1,15	0,68	0,99	0,74	1,15	0,10	0,23	1,00	1,00	0,77	1,11	0,61	0,82	0,61	0,82
A6	1,22	1,64	0,96	1,38	0,90	1,31	0,20	0,52	0,90	1,31	1,00	1,00	0,87	1,35	1,01	1,47
A7	1,22	1,64	1,06	1,47	1,06	1,47	0,23	0,68	1,22	1,64	0,74	1,15	1,00	1,00	1,47	4,28
A8	0,68	0,99	0,74	1,15	1,22	1,64	0,52	0,84	1,22	1,64	0,68	0,99	0,23	0,68	1,00	1,00

Table A.16: Priority Vector of attributes for the preferences of DM 2

Attribute	Priority	
A1	0,068	0,147
A2	0,075	0,168
A3	0,066	0,144
A4	0,138	0,451
A5	0,056	0,124
A6	0,076	0,169
A7	0,086	0,226
A8	0,067	0,151

Table A.17: Possibility degree matrix and weights of the attributes for preferences of DM 2

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	***w***	w^T
A1	0,500	0,416	0,515	0,021	0,619	0,412	0,278	0,487	0,781	0,112
A2	0,584	0,500	0,598	0,073	0,699	0,496	0,353	0,570	0,859	0,123
A3	0,485	0,402	0,500	0,015	0,603	0,398	0,267	0,472	0,768	0,110
A4	0,979	0,927	0,985	0,500	1,000	0,924	0,806	0,967	1,261	**0,180**
A5	0,381	0,301	0,397	0,000	0,500	0,297	0,182	0,371	0,679	0,097
A6	0,588	0,504	0,602	0,076	0,703	0,500	0,357	0,573	0,863	0,123
A7	0,722	0,647	0,733	0,194	0,818	0,643	0,500	0,707	0,996	0,142
A8	0,513	0,430	0,528	0,033	0,629	0,427	0,293	0,500	0,794	0,113

Table A.18: Aggregated comparison matrix of alternatives for preferences of DM 2

	ALT 1				**ALT 2**				**ALT 3**				**ALT 4**			
ALT 1	0,50	0,50	0,50	0,50	0,53	0,63	0,00	0,37	0,53	0,63	0,00	0,37	0,58	1,00	0,00	0,00
ALT 2	0,00	0,37	0,53	0,63	0,50	0,50	0,50	0,50	0,51	0,60	0,00	0,40	0,56	1,00	0,00	0,00
ALT 3	0,00	0,37	0,53	0,63	0,00	0,40	0,51	0,60	0,50	0,50	0,50	0,50	0,52	0,62	0,00	0,38
ALT 4	0,00	0,00	0,58	1,00	0,00	0,00	0,56	1,00	0,00	0,38	0,52	0,62	0,50	0,50	0,50	0,50

Table A.19: Score judgment matrix of alternatives based on criteria for the preferences of DM 2

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	0,08	0,29	0,00	0,17	0,08	0,29
	ALT 2	-0,29	-0,08	0,00	0,00	0,08	0,29	0,00	0,17
	ALT 3	-0,17	0,00	-0,29	-0,08	0,00	0,00	0,00	0,17
	ALT 4	-0,29	-0,08	-0,10	0,04	-0,17	0,00	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,17	0,63	-0,06	0,13	0,63	1,00
	ALT 2	-0,16	0,31	0,00	0,00	-0,06	0,13	0,29	0,71
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	0,08	0,29
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,29	0,71	0,29	0,71	0,63	1,00
	ALT 2	-0,33	0,15	0,00	0,00	0,29	0,71	0,63	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	0,08	0,29
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	0,08	0,29	0,17	0,63	-0,21	-0,08
	ALT 2	0,05	0,57	0,00	0,00	-0,12	0,05	-0,17	-0,02
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,17	-0,02
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	0,17	0,63	0,29	0,71	0,63	1,00
	ALT 2	-0,28	0,19	0,00	0,00	0,17	0,63	0,29	0,71
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	0,29	0,71
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	0,17	0,63	0,00	0,17	0,63	1,00
	ALT 2	-0,61	0,00	0,00	0,00	0,17	0,63	0,29	0,71
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	0,29	0,71
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	0,17	0,63	0,17	0,63	0,29	0,71
	ALT 2	-0,37	0,10	0,00	0,00	0,08	0,29	0,29	0,71
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	0,17	0,63
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	0,17	0,63	0,29	0,71	0,63	1,00
	ALT 2	-0,58	0,05	0,00	0,00	0,17	0,63	0,63	1,00
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	0,29	0,71
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table A.20: Interval multiplicative matrix of attributes on each criteria for the prefences of DM 2

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	1,20	1,93	1,01	1,47	1,20	1,93
	ALT 2	0,52	0,84	1,00	1,00	1,20	1,93	1,01	1,47
	ALT 3	0,68	0,99	0,52	0,84	1,00	1,00	1,01	1,47
	ALT 4	0,52	0,84	0,79	1,10	0,68	0,99	1,00	1,00
A2	**ALT 1**	1,00	1,00	1,47	4,28	0,87	1,35	4,28	10,00
	ALT 2	0,69	2,03	1,00	1,00	0,87	1,35	1,93	5,10
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	1,20	1,93
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	1,93	5,10	1,93	5,10	4,28	10,00
	ALT 2	0,47	1,42	1,00	1,00	1,93	5,10	4,28	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	1,20	1,93
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	1,20	1,93	1,47	4,28	0,61	0,82
	ALT 2	1,13	3,73	1,00	1,00	0,77	1,11	0,68	0,95
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,68	0,95
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	1,47	4,28	1,93	5,10	4,28	10,00
	ALT 2	0,53	1,54	1,00	1,00	1,47	4,28	1,93	5,10
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	1,93	5,10
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	1,47	4,28	1,01	1,47	4,28	10,00
	ALT 2	0,25	1,00	1,00	1,00	1,47	4,28	1,93	5,10
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	1,93	5,10
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	1,47	4,28	1,47	4,28	1,93	5,10
	ALT 2	0,43	1,27	1,00	1,00	1,20	1,93	1,93	5,10
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	1,47	4,28
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	1,47	4,28	1,93	5,10	4,28	10,00
	ALT 2	0,26	1,12	1,00	1,00	1,47	4,28	4,28	10,00
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	1,93	5,10
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table A.21: Priority vector of alternatives based on each attribute for the preferences of DM 2

		Priority	
A1	**ALT 1**	0,014	0,045
	ALT 2	0,012	0,037
	ALT 3	0,010	0,030
	ALT 4	0,010	0,028
A2	**ALT 1**	0,025	0,117
	ALT 2	0,014	0,067
	ALT 3	0,013	0,061
	ALT 4	0,013	0,078
A3	**ALT 1**	0,029	0,078
	ALT 2	0,025	0,149
	ALT 3	0,009	0,123
	ALT 4	0,005	0,034
A4	**ALT 1**	0,014	0,056
	ALT 2	0,012	0,048
	ALT 3	0,011	0,055
	ALT 4	0,010	0,058
A5	**ALT 1**	0,028	0,143
	ALT 2	0,016	0,084
	ALT 3	0,012	0,058
	ALT 4	0,005	0,022
A6	**ALT 1**	0,025	0,118
	ALT 2	0,015	0,080
	ALT 3	0,012	0,064
	ALT 4	0,005	0,022
A7	**ALT 1**	0,019	0,103
	ALT 2	0,015	0,065
	ALT 3	0,010	0,056
	ALT 4	0,005	0,026
A8	**ALT 1**	0,028	0,143
	ALT 2	0,023	0,115
	ALT 3	0,011	0,058
	ALT 4	0,005	0,018

Table A.22: Possibility degree matrix and weights of the alternatives with respect to attributes for the preferences of DM 2

		ALT 1	**ALT 2**	**ALT 3**	**ALT 4**	w	w^T
A1	**ALT 1**	0,500	0,590	0,681	0,722	0,873	0,291
	ALT 2	0,410	0,500	0,593	0,635	0,785	0,262
	ALT 3	0,319	0,407	0,500	0,543	0,692	0,231
	ALT 4	0,278	0,365	0,457	0,500	0,650	0,217
A2	**ALT 1**	0,837	0,896	0,950	0,973	1,164	0,284
	ALT 2	0,636	0,710	0,782	0,813	0,985	0,240
	ALT 3	0,594	0,669	0,743	0,775	0,945	0,230
	ALT 4	0,672	0,738	0,801	0,828	1,010	0,246
A3	**ALT 1**	0,809	0,900	0,990	1,000	1,175	0,286
	ALT 2	0,872	0,919	0,962	0,980	1,183	0,288
	ALT 3	0,752	0,798	0,839	0,857	1,061	0,258
	ALT 4	0,336	0,410	0,484	0,518	0,687	0,167
A4	**ALT 1**	0,579	0,659	0,738	0,772	0,937	0,259
	ALT 2	0,504	0,586	0,667	0,703	0,865	0,239
	ALT 3	0,555	0,632	0,707	0,739	0,908	0,251
	ALT 4	0,556	0,628	0,699	0,729	0,903	0,250
A5	**ALT 1**	0,887	0,937	0,984	1,000	1,202	0,326
	ALT 2	0,709	0,774	0,837	0,864	1,046	0,284
	ALT 3	0,571	0,645	0,719	0,751	0,921	0,250
	ALT 4	0,166	0,240	0,317	0,354	0,519	0,141
A6	**ALT 1**	0,842	0,900	0,954	0,977	1,168	0,319
	ALT 2	0,690	0,757	0,821	0,848	1,029	0,281
	ALT 3	0,609	0,682	0,752	0,783	0,957	0,261
	ALT 4	0,156	0,230	0,307	0,344	0,509	0,139
A7	**ALT 1**	0,776	0,836	0,892	0,915	1,105	0,308
	ALT 2	0,632	0,707	0,780	0,812	0,983	0,274
	ALT 3	0,551	0,625	0,698	0,730	0,901	0,252
	ALT 4	0,238	0,314	0,392	0,429	0,593	0,166
A8	**ALT 1**	0,887	0,937	0,984	1,000	1,202	0,325
	ALT 2	0,822	0,879	0,933	0,955	1,147	0,310
	ALT 3	0,566	0,641	0,713	0,745	0,916	0,248
	ALT 4	0,082	0,152	0,225	0,261	0,430	0,116

Table A.23: Possibilities of alternatives and predicted order for R_1 with respect to the preferences of DM 2

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	P_j	ALT_j	
	0,112	0,123	0,110	0,180	0,097	0,123	0,142	0,113			
ALT 1	0,291	0,284	0,286	0,259	0,326	0,319	0,308	0,325	0,297	600	178
ALT 2	0,262	0,240	0,288	0,239	0,284	0,281	0,274	0,310	0,270	1000	270
ALT 3	0,231	0,230	0,258	0,251	0,250	0,261	0,252	0,248	0,248	1200	298
ALT 4	0,217	0,246	0,167	0,250	0,141	0,139	0,166	0,116	0,185	2000	371
										ΔR_1	**1116**

Table A.24: Aggregated Comparison Matrix for the preferences of DM 3

	A1				**A2**				**A3**				**A4**			
A1	0,50	0,50	0,50	0,50	0,39	0,44	0,46	0,56	0,54	0,63	0,00	0,37	0,44	0,50	0,37	0,50
A2	0,46	0,56	0,39	0,44	0,50	0,50	0,50	0,50	0,44	0,50	0,37	0,50	0,50	0,58	0,29	0,42
A3	0,00	0,37	0,54	0,63	0,37	0,50	0,44	0,50	0,50	0,50	0,50	0,50	0,44	0,50	0,37	0,50
A4	0,37	0,50	0,44	0,50	0,29	0,42	0,50	0,58	0,37	0,50	0,44	0,50	0,50	0,50	0,50	0,50
A5	0,42	0,53	0,42	0,47	0,37	0,50	0,44	0,50	0,46	0,56	0,39	0,44	0,37	0,50	0,44	0,50
A6	0,29	0,42	0,50	0,58	0,46	0,56	0,44	0,50	0,46	0,56	0,39	0,44	0,00	0,29	0,58	0,71
A7	0,50	0,58	0,37	0,42	0,37	0,50	0,44	0,50	0,46	0,56	0,39	0,44	0,37	0,46	0,47	0,54
A8	0,00	0,37	0,54	0,63	0,00	0,37	0,54	0,63	0,37	0,50	0,44	0,50	0,00	0,29	0,58	0,71

	A5				**A6**				**A7**				**A8**			
A1	0,42	0,47	0,42	0,53	0,50	0,58	0,29	0,42	0,37	0,42	0,50	0,58	0,54	0,63	0,00	0,37
A2	0,44	0,50	0,37	0,50	0,44	0,50	0,37	0,50	0,44	0,50	0,37	0,50	0,54	0,63	0,00	0,37
A3	0,39	0,44	0,46	0,56	0,39	0,44	0,46	0,56	0,39	0,44	0,46	0,56	0,44	0,50	0,37	0,50
A4	0,44	0,50	0,37	0,50	0,58	0,71	0,00	0,29	0,47	0,54	0,37	0,46	0,58	0,71	0,00	0,29
A5	0,50	0,50	0,50	0,50	0,58	0,71	0,00	0,29	0,58	0,71	0,00	0,29	0,63	1,00	0,00	0,00
A6	0,00	0,29	0,58	0,71	0,50	0,50	0,50	0,50	0,42	0,47	0,42	0,53	0,39	0,44	0,46	0,56
A7	0,00	0,29	0,58	0,71	0,42	0,53	0,42	0,47	0,50	0,50	0,50	0,50	0,58	0,71	0,00	0,29
A8	0,00	0,00	0,63	1,00	0,46	0,56	0,39	0,44	0,00	0,29	0,58	0,71	0,50	0,50	0,50	0,50

Table A.25: Score judgment matrix of attributes with the prefence of DM 3

	A1		**A2**		**A3**		**A4**		**A5**		**A6**		**A7**		**A8**	
A1	0,00	0,00	-0,17	-0,02	0,17	0,63	-0,06	0,13	-0,12	0,05	0,08	0,29	-0,21	-0,08	0,17	0,63
A2	0,02	0,17	0,00	0,00	-0,06	0,13	0,08	0,29	-0,06	0,13	-0,06	0,13	-0,06	0,13	0,17	0,63
A3	-0,63	-0,17	-0,13	0,06	0,00	0,00	-0,06	0,13	-0,17	-0,02	-0,17	-0,02	-0,17	-0,02	-0,06	0,13
A4	-0,13	0,06	-0,29	-0,08	-0,13	0,06	0,00	0,00	-0,06	0,13	0,29	0,71	0,00	0,17	0,29	0,71
A5	-0,05	0,12	-0,13	0,06	0,02	0,17	-0,13	0,06	0,00	0,00	0,29	0,71	0,29	0,71	0,63	1,00
A6	-0,29	-0,08	-0,04	0,12	0,02	0,17	-0,71	-0,29	-0,71	-0,29	0,00	0,00	-0,12	0,05	-0,17	-0,02
A7	0,08	0,21	-0,13	0,06	0,02	0,17	-0,17	0,00	-0,71	-0,29	-0,05	0,12	0,00	0,00	0,29	0,71
A8	-0,63	-0,17	-0,63	-0,17	-0,13	0,06	-0,71	-0,29	-1,00	-0,63	0,02	0,17	-0,71	-0,29	0,00	0,00

Table A.26: Interval multiplicative matrix of attributes for the preferences of DM 3

	A1		**A2**		**A3**		**A4**		**A5**		**A6**		**A7**		**A8**	
A1	1,00	1,00	0,68	0,95	1,47	4,28	0,87	1,35	0,77	1,11	1,20	1,93	0,61	0,82	1,47	4,28
A2	1,06	1,47	1,00	1,00	0,87	1,35	1,20	1,93	0,87	1,35	0,87	1,35	0,87	1,35	1,47	4,28
A3	0,23	0,68	0,74	1,15	1,00	1,00	0,87	1,35	0,68	0,95	0,68	0,95	0,68	0,95	0,87	1,35
A4	0,74	1,15	0,52	0,84	0,74	1,15	1,00	1,00	0,87	1,35	1,93	5,10	1,01	1,47	1,93	5,10
A5	0,90	1,31	0,74	1,15	1,06	1,47	0,74	1,15	1,00	1,00	1,93	5,10	1,93	5,10	4,28	10,00
A6	0,52	0,84	0,92	1,31	1,06	1,47	0,20	0,52	0,20	0,52	1,00	1,00	0,77	1,11	0,68	0,95
A7	1,22	1,64	0,74	1,15	1,06	1,47	0,68	0,99	0,20	0,52	0,90	1,31	1,00	1,00	1,93	5,10
A8	0,23	0,68	0,23	0,68	0,74	1,15	0,20	0,52	0,10	0,23	1,06	1,47	0,20	0,52	1,00	1,00

Table A.27: Priority Vector of attributes for the preferences of DM 3

Attribute	Priority	
A1	0,074	0,262
A2	0,076	0,234
A3	0,053	0,139
A4	0,080	0,285
A5	0,116	0,437
A6	0,049	0,128
A7	0,071	0,219
A8	0,035	0,104

Table A.28: Possibility degree matrix and weights of the attributes for preferences of DM 3

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	***w***	w^T
A1	0,500	0,537	0,762	0,462	0,287	0,797	0,568	0,884	0,975	0,139
A2	0,463	0,500	0,740	0,424	0,247	0,778	0,533	0,876	0,945	0,135
A3	0,238	0,260	0,500	0,202	0,058	0,545	0,292	0,673	0,721	0,103
A4	0,538	0,576	0,798	0,500	0,322	0,831	0,607	0,914	1,011	0,144
A5	0,713	0,753	0,942	0,678	0,500	0,968	0,780	1,000	1,167	**0,167**
A6	0,203	0,222	0,455	0,169	0,032	0,500	0,252	0,631	0,683	0,098
A7	0,432	0,467	0,708	0,393	0,220	0,748	0,500	0,849	0,915	0,131
A8	0,116	0,124	0,327	0,086	0,000	0,369	0,151	0,500	0,584	0,083

Table A.29: Aggregated comparison matrix of alternatives for preferences of DM 3

	ALT 1				**ALT 2**				**ALT 3**				**ALT 4**			
ALT 1	0,50	0,50	0,50	0,50	0,45	0,51	0,00	0,49	0,44	0,50	0,00	0,50	0,43	1,00	0,00	0,00
ALT 2	0,00	0,49	0,45	0,51	0,50	0,50	0,50	0,50	0,44	0,51	0,38	0,49	0,46	1,00	0,00	0,00
ALT 3	0,00	0,50	0,44	0,50	0,38	0,49	0,44	0,51	0,50	0,50	0,50	0,50	0,46	1,00	0,00	0,00
ALT 4	0,00	0,00	0,43	1,00	0,00	0,00	0,46	1,00	0,00	0,00	0,46	1,00	0,50	0,50	0,50	0,50

Table A.30: Score judgment matrix of alternatives based on criteria for the preferences of DM 3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	0,00	0,17	-0,12	0,05	-0,06	0,13
	ALT 2	-0,17	0,00	0,00	0,00	0,00	0,17	-0,12	0,05
	ALT 3	-0,05	0,12	-0,17	0,00	0,00	0,00	-0,06	0,13
	ALT 4	-0,13	0,06	0,01	0,07	-0,13	0,06	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,00	0,17	-0,06	0,13	-0,17	-0,02
	ALT 2	-0,16	0,31	0,00	0,00	0,08	0,29	0,17	0,63
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	0,17	0,63
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,17	0,63	0,29	0,71	0,63	1,00
	ALT 2	-0,33	0,15	0,00	0,00	0,08	0,29	0,63	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	0,63	1,00
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	-0,21	-0,08	-0,21	-0,08	-0,21	-0,08
	ALT 2	0,05	0,57	0,00	0,00	-0,17	-0,02	-0,21	-0,08
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,21	-0,08
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	-0,12	0,05	-0,12	0,05	-0,17	-0,02
	ALT 2	-0,28	0,19	0,00	0,00	-0,12	0,05	-0,12	0,05
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	-0,12	0,05
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	-0,06	0,13	-0,12	0,05	-0,17	-0,02
	ALT 2	-0,61	0,00	0,00	0,00	-0,06	0,13	-0,12	0,05
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	-0,12	0,05
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	-0,06	0,13	-0,12	0,05	-0,21	-0,08
	ALT 2	-0,37	0,10	0,00	0,00	-0,12	0,05	-0,12	0,05
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	-0,12	0,05
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	-0,12	0,05	-0,12	0,05	-0,17	-0,02
	ALT 2	-0,58	0,05	0,00	0,00	-0,12	0,05	-0,17	-0,02
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	-0,06	0,13
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table A.31: Interval multiplicative matrix of attributes on each criteria for the prefences of DM 3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	1,01	1,47	0,77	1,11	0,87	1,35
	ALT 2	0,68	0,99	1,00	1,00	1,01	1,47	0,77	1,11
	ALT 3	0,90	1,31	0,68	0,99	1,00	1,00	0,87	1,35
	ALT 4	0,74	1,15	1,02	1,17	0,74	1,15	1,00	1,00
A2	**ALT 1**	1,00	1,00	1,01	1,47	0,87	1,35	0,68	0,95
	ALT 2	0,69	2,03	1,00	1,00	1,20	1,93	1,47	4,28
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	1,47	4,28
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	1,47	4,28	1,93	5,10	4,28	10,00
	ALT 2	0,47	1,42	1,00	1,00	1,20	1,93	4,28	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	4,28	10,00
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	0,61	0,82	0,61	0,82	0,61	0,82
	ALT 2	1,13	3,73	1,00	1,00	0,68	0,95	0,61	0,82
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,61	0,82
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	0,77	1,11	0,77	1,11	0,68	0,95
	ALT 2	0,53	1,54	1,00	1,00	0,77	1,11	0,77	1,11
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	0,77	1,11
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	0,87	1,35	0,77	1,11	0,68	0,95
	ALT 2	0,25	1,00	1,00	1,00	0,87	1,35	0,77	1,11
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	0,77	1,11
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	0,87	1,35	0,77	1,11	0,61	0,82
	ALT 2	0,43	1,27	1,00	1,00	0,77	1,11	0,77	1,11
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	0,77	1,11
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	0,77	1,11	0,77	1,11	0,68	0,95
	ALT 2	0,26	1,12	1,00	1,00	0,77	1,11	0,68	0,95
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	0,87	1,35
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table A.32: Priority vector of alternatives based on each attribute for the preferences of DM 3

		Priority	
A1	**ALT 1**	0,019	0,046
	ALT 2	0,018	0,043
	ALT 3	0,017	0,044
	ALT 4	0,018	0,042
A2	**ALT 1**	0,018	0,045
	ALT 2	0,022	0,087
	ALT 3	0,021	0,103
	ALT 4	0,021	0,104
A3	**ALT 1**	0,044	0,104
	ALT 2	0,035	0,191
	ALT 3	0,029	0,135
	ALT 4	0,007	0,122
A4	**ALT 1**	0,014	0,033
	ALT 2	0,017	0,061
	ALT 3	0,018	0,073
	ALT 4	0,015	0,077
A5	**ALT 1**	0,016	0,039
	ALT 2	0,016	0,045
	ALT 3	0,012	0,040
	ALT 4	0,008	0,029
A6	**ALT 1**	0,017	0,041
	ALT 2	0,015	0,042
	ALT 3	0,014	0,048
	ALT 4	0,008	0,029
A7	**ALT 1**	0,016	0,040
	ALT 2	0,015	0,042
	ALT 3	0,013	0,045
	ALT 4	0,008	0,035
A8	**ALT 1**	0,016	0,039
	ALT 2	0,014	0,039
	ALT 3	0,012	0,042
	ALT 4	0,007	0,024

Table A.33: Possibility degree matrix and weights of the alternatives with respect to attributes for the preferences of DM 3

		ALT 1	ALT 2	ALT 3	ALT 4	w	w^T
A1	**ALT 1**	0,500	0,541	0,534	0,551	0,782	0,261
	ALT 2	0,459	0,500	0,493	0,509	0,740	0,247
	ALT 3	0,466	0,507	0,500	0,516	0,747	0,249
	ALT 4	0,449	0,491	0,484	0,500	0,731	0,244
A2	**ALT 1**	0,482	0,523	0,516	0,532	0,763	0,198
	ALT 2	0,738	0,769	0,763	0,778	1,012	0,262
	ALT 3	0,773	0,799	0,794	0,807	1,043	0,270
	ALT 4	0,772	0,798	0,793	0,806	1,042	0,270
A3	**ALT 1**	0,974	1,000	1,000	1,000	1,244	0,272
	ALT 2	0,940	0,958	0,954	0,963	1,204	0,263
	ALT 3	0,871	0,895	0,890	0,902	1,140	0,249
	ALT 4	0,725	0,745	0,741	0,750	0,990	0,216
A4	**ALT 1**	0,305	0,344	0,339	0,350	0,585	0,177
	ALT 2	0,594	0,630	0,623	0,638	0,871	0,263
	ALT 3	0,655	0,687	0,681	0,695	0,929	0,281
	ALT 4	0,654	0,683	0,678	0,691	0,927	0,280
A5	**ALT 1**	0,408	0,448	0,442	0,456	0,689	0,266
	ALT 2	0,460	0,498	0,492	0,507	0,739	0,286
	ALT 3	0,387	0,423	0,418	0,430	0,664	0,257
	ALT 4	0,221	0,254	0,250	0,257	0,496	0,191
A6	**ALT 1**	0,437	0,478	0,472	0,487	0,718	0,270
	ALT 2	0,425	0,463	0,457	0,470	0,704	0,265
	ALT 3	0,477	0,513	0,507	0,520	0,754	0,284
	ALT 4	0,209	0,242	0,238	0,244	0,483	0,182
A7	**ALT 1**	0,421	0,462	0,456	0,470	0,703	0,259
	ALT 2	0,430	0,469	0,463	0,477	0,710	0,262
	ALT 3	0,443	0,479	0,473	0,486	0,720	0,265
	ALT 4	0,306	0,339	0,335	0,343	0,581	0,214
A8	**ALT 1**	0,408	0,448	0,442	0,456	0,689	0,283
	ALT 2	0,389	0,427	0,421	0,434	0,668	0,275
	ALT 3	0,408	0,444	0,438	0,450	0,685	0,282
	ALT 4	0,118	0,148	0,146	0,148	0,390	0,160

Table A.34: Possibilities of alternatives and predicted order for R_1 with respect to the preferences of DM 3

	A1	A2	A3	A4	A5	A6	A7	A8	P_j	ALT_j	
	0,139	**0,135**	**0,103**	**0,144**	**0,167**	**0,098**	**0,131**	**0,083**			
ALT 1	0,261	0,198	0,272	0,177	0,266	0,270	0,259	0,283	0,245	600	147
ALT 2	0,247	0,262	0,263	0,263	0,286	0,265	0,262	0,275	0,265	1000	265
ALT 3	0,249	0,270	0,249	0,281	0,257	0,284	0,265	0,282	0,266	1200	319
ALT 4	0,244	0,270	0,216	0,280	0,191	0,182	0,214	0,160	0,224	2000	448
										ΔR_1	**1179**

Table A.35: Aggregated Comparison Matrix for the preferences of DM 1 and DM 2

	A1				**A2**				**A3**				**A4**			
A1	0,50	0,50	0,50	0,50	0,51	0,69	0,00	0,31	0,32	0,44	0,36	0,56	0,26	0,37	0,43	0,63
A2	0,00	0,31	0,51	0,69	0,50	0,50	0,50	0,50	0,39	0,53	0,27	0,47	0,29	0,41	0,39	0,59
A3	0,36	0,56	0,32	0,44	0,27	0,47	0,39	0,53	0,50	0,50	0,50	0,50	0,38	0,51	0,31	0,49
A4	0,43	0,63	0,26	0,37	0,39	0,59	0,29	0,41	0,31	0,49	0,38	0,51	0,50	0,50	0,50	0,50
A5	0,00	0,37	0,48	0,63	0,27	0,43	0,44	0,57	0,00	0,29	0,53	0,71	0,00	0,00	0,73	1,00
A6	0,29	0,49	0,37	0,51	0,00	0,00	0,35	0,48	0,00	0,00	0,57	1,00	0,00	0,00	0,69	1,00
A7	0,37	0,58	0,30	0,42	0,34	0,56	0,32	0,44	0,34	0,56	0,32	0,44	0,00	0,22	0,61	0,78
A8	0,00	0,27	0,55	0,73	0,22	0,42	0,44	0,58	0,00	0,34	0,47	0,66	0,00	0,00	0,63	1,00

	A5				**A6**				**A7**				**A8**			
A1	0,48	0,63	0,00	0,37	0,37	0,51	0,29	0,49	0,30	0,42	0,37	0,58	0,55	0,73	0,00	0,27
A2	0,44	0,57	0,27	0,43	0,35	0,48	0,34	0,52	0,32	0,44	0,34	0,56	0,44	0,58	0,22	0,42
A3	0,53	0,71	0,00	0,29	0,57	1,00	0,00	0,00	0,32	0,44	0,34	0,56	0,47	0,66	0,00	0,34
A4	0,73	1,00	0,00	0,00	0,69	1,00	0,00	0,00	0,61	0,78	0,00	0,22	0,63	1,00	0,00	0,00
A5	0,50	0,50	0,50	0,50	0,35	0,47	0,31	0,53	0,26	0,38	0,42	0,62	0,33	0,46	0,37	0,54
A6	0,31	0,53	0,35	0,47	0,50	0,50	0,50	0,50	0,37	0,50	0,27	0,50	0,44	0,57	0,27	0,43
A7	0,42	0,62	0,26	0,38	0,27	0,50	0,37	0,50	0,50	0,50	0,50	0,50	0,61	0,78	0,00	0,22
A8	0,37	0,54	0,33	0,46	0,27	0,43	0,44	0,57	0,00	0,22	0,61	0,78	0,50	0,50	0,50	0,50

Table A.36: Score judgment matrix of attributes with the prefence of DM 1 and DM 2

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	0,00	0,00	0,20	0,69	-0,25	0,08	-0,37	-0,06	0,11	0,63	-0,12	0,21	-0,29	0,05	0,28	0,73
A2	-0,69	-0,20	0,00	0,00	-0,08	0,26	-0,31	0,01	0,00	0,30	-0,17	0,14	-0,24	0,10	0,02	0,36
A3	-0,08	0,25	-0,26	0,08	0,00	0,00	-0,11	0,20	0,24	0,71	0,57	1,00	-0,24	0,10	0,13	0,66
A4	0,06	0,37	-0,01	0,31	-0,20	0,11	0,00	0,00	0,73	1,00	0,69	1,00	0,39	0,78	0,63	1,00
A5	-0,63	-0,11	-0,30	0,00	-0,71	-0,24	-1,00	-0,73	0,00	0,00	-0,19	0,16	-0,36	-0,04	-0,21	0,09
A6	-0,21	0,12	-0,48	-0,35	-1,00	-0,57	-1,00	-0,69	-0,16	0,19	0,00	0,00	-0,13	0,23	0,00	0,30
A7	-0,05	0,29	-0,10	0,24	-0,10	0,24	-0,78	-0,39	0,04	0,36	-0,23	0,13	0,00	0,00	0,39	0,78
A8	-0,73	-0,28	-0,36	-0,02	-0,66	-0,13	-1,00	-0,63	-0,09	0,21	-0,30	0,00	-0,78	-0,39	0,00	0,00

Table A.37: Interval multiplicative matrix of attributes for the preferences of DM 1 and DM 2

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	1,00	1,00	1,57	4,89	0,56	1,20	0,43	0,88	1,30	4,28	0,75	1,64	0,51	1,11	1,91	5,35
A2	0,20	0,64	1,00	1,00	0,83	1,81	0,49	1,03	1,01	1,98	0,68	1,38	0,58	1,26	1,04	2,31
A3	0,83	1,77	0,55	1,20	1,00	1,00	0,77	1,57	1,72	5,10	3,71	10,00	0,58	1,26	1,34	4,55
A4	1,14	2,32	0,97	2,02	0,64	1,30	1,00	1,00	5,35	10,00	4,89	10,00	2,47	6,09	4,28	10,00
A5	0,23	0,77	0,50	0,99	0,20	0,58	0,10	0,19	1,00	1,00	0,65	1,44	0,44	0,91	0,61	1,23
A6	0,61	1,33	0,33	0,44	0,10	0,27	0,10	0,20	0,70	1,53	1,00	1,00	0,75	1,69	1,01	1,98
A7	0,90	1,95	0,80	1,74	0,80	1,74	0,16	0,40	1,10	2,28	0,59	1,34	1,00	1,00	2,47	6,09
A8	0,19	0,52	0,43	0,96	0,22	0,75	0,10	0,23	0,82	1,63	0,50	0,99	0,16	0,40	1,00	1,00

Table A.38 : Priority Vector of attributes for the preferences of DM 1 and DM 2

Attribute	Priority	
A1	0,058	0,315
A2	0,042	0,176
A3	0,075	0,409
A4	0,149	0,661
A5	0,027	0,110
A6	0,033	0,131
A7	0,056	0,256
A8	0,025	0,100

Table A.39: Possibility degree matrix and weights of the attributes for the preferences of DM 1 and DM 2

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	***w***	w^T
A1	0,500	0,697	0,405	0,216	0,847	0,794	0,566	0,872	0,987	0,141
A2	0,303	0,500	0,216	0,043	0,688	0,617	0,360	0,722	0,806	0,115
A3	0,595	0,784	0,500	0,308	0,917	0,871	0,662	0,939	1,072	0,153
A4	0,784	0,957	0,692	0,500	1,000	1,000	0,850	1,000	1,223	**0,175**
A5	0,153	0,312	0,083	0,000	0,500	0,425	0,190	0,537	0,650	0,093
A6	0,206	0,383	0,129	0,000	0,575	0,500	0,251	0,612	0,707	0,101
A7	0,434	0,640	0,338	0,150	0,810	0,749	0,500	0,839	0,933	0,133
A8	0,128	0,278	0,061	0,000	0,463	0,388	0,161	0,500	0,622	0,089

Table A.40: Aggregated comparison matrix of alternatives for preferences of DM 1 and DM 2

	ALT 1				**ALT 2**				**ALT 3**				**ALT 4**			
ALT 1	0,50	0,50	0,50	0,50	0,49	0,64	0,00	0,36	0,45	0,61	0,00	0,39	0,52	1,00	0,00	0,00
ALT 2	0,00	0,36	0,49	0,64	0,50	0,50	0,50	0,50	0,43	0,57	0,00	0,43	0,47	1,00	0,00	0,00
ALT 3	0,00	0,39	0,45	0,61	0,00	0,43	0,43	0,57	0,50	0,50	0,50	0,50	0,43	0,59	0,00	0,41
ALT 4	0,00	0,00	0,52	1,00	0,00	0,00	0,47	1,00	0,00	0,41	0,43	0,59	0,50	0,50	0,50	0,50

Table A.41: Score judgment matrix of alternatives based on criteria for the preferences of DM 1 and DM 2

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	0,02	0,36	-0,17	0,14	-0,03	0,31
	ALT 2	-0,36	-0,02	0,00	0,00	0,02	0,36	-0,17	0,14
	ALT 3	-0,14	0,17	-0,36	-0,02	0,00	0,00	-0,11	0,20
	ALT 4	-0,31	0,03	-0,01	0,10	-0,20	0,11	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,23	0,69	-0,13	0,23	0,66	1,00
	ALT 2	-0,16	0,31	0,00	0,00	-0,13	0,23	0,24	0,71
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	0,02	0,36
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,39	0,78	0,39	0,78	0,69	1,00
	ALT 2	-0,33	0,15	0,00	0,00	0,16	0,67	0,55	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	-0,08	0,26
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	0,02	0,36	0,07	0,61	-0,48	-0,18
	ALT 2	0,05	0,57	0,00	0,00	-0,31	0,01	-0,42	-0,12
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,42	-0,12
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	0,07	0,61	0,16	0,67	0,54	1,00
	ALT 2	-0,28	0,19	0,00	0,00	0,11	0,63	0,16	0,67
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	0,16	0,67
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	0,07	0,61	-0,17	0,14	0,54	1,00
	ALT 2	-0,61	0,00	0,00	0,00	0,07	0,61	0,16	0,67
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	0,20	0,69
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	0,11	0,63	0,02	0,59	0,13	0,66
	ALT 2	-0,37	0,10	0,00	0,00	-0,03	0,31	0,16	0,67
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	0,02	0,59
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	0,07	0,61	0,16	0,67	0,54	1,00
	ALT 2	-0,58	0,05	0,00	0,00	0,02	0,59	0,54	1,00
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	0,16	0,67
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table A.42: Interval multiplicative matrix of attributes on each criteria for the prefences of DM 1 and DM 2

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	1,04	2,31	0,68	1,38	0,93	2,02
	ALT 2	0,43	0,96	1,00	1,00	1,04	2,31	0,68	1,38
	ALT 3	0,73	1,46	0,43	0,96	1,00	1,00	0,77	1,57
	ALT 4	0,50	1,08	0,97	1,25	0,64	1,30	1,00	1,00
A2	**ALT 1**	1,00	1,00	1,68	4,89	0,75	1,69	4,55	10,00
	ALT 2	0,69	2,03	1,00	1,00	0,75	1,69	1,72	5,10
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	1,04	2,31
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	2,47	6,09	2,47	6,09	4,89	10,00
	ALT 2	0,47	1,42	1,00	1,00	1,45	4,71	3,56	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	0,83	1,81
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	1,04	2,31	1,16	4,06	0,33	0,65
	ALT 2	1,13	3,73	1,00	1,00	0,49	1,03	0,38	0,76
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,38	0,76
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	1,16	4,06	1,45	4,71	3,43	10,00
	ALT 2	0,53	1,54	1,00	1,00	1,30	4,28	1,45	4,71
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	1,45	4,71
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	1,16	4,06	0,68	1,38	3,43	10,00
	ALT 2	0,25	1,00	1,00	1,00	1,16	4,06	1,45	4,71
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	1,57	4,89
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	1,30	4,28	1,05	3,87	1,34	4,55
	ALT 2	0,43	1,27	1,00	1,00	0,93	2,02	1,45	4,71
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	1,05	3,87
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	1,16	4,06	1,45	4,71	3,43	10,00
	ALT 2	0,26	1,12	1,00	1,00	1,05	3,87	3,43	10,00
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	1,45	4,71
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table A.43: Priority vector of alternatives based on each attribute for the preferences of DM 1 and DM 2

		Priority	
A1	**ALT 1**	0,012	0,052
	ALT 2	0,010	0,044
	ALT 3	0,009	0,039
	ALT 4	0,010	0,036
A2	**ALT 1**	0,026	0,137
	ALT 2	0,013	0,077
	ALT 3	0,012	0,070
	ALT 4	0,013	0,087
A3	**ALT 1**	0,035	0,087
	ALT 2	0,021	0,181
	ALT 3	0,007	0,134
	ALT 4	0,005	0,037
A4	**ALT 1**	0,011	0,063
	ALT 2	0,010	0,051
	ALT 3	0,011	0,060
	ALT 4	0,010	0,064
A5	**ALT 1**	0,023	0,154
	ALT 2	0,014	0,090
	ALT 3	0,010	0,061
	ALT 4	0,005	0,025
A6	**ALT 1**	0,020	0,128
	ALT 2	0,012	0,084
	ALT 3	0,011	0,070
	ALT 4	0,005	0,024
A7	**ALT 1**	0,015	0,107
	ALT 2	0,012	0,070
	ALT 3	0,009	0,059
	ALT 4	0,005	0,029
A8	**ALT 1**	0,023	0,154
	ALT 2	0,019	0,125
	ALT 3	0,010	0,061
	ALT 4	0,005	0,020

Table A.44: Possibility degree matrix and weights of the alternatives with respect to attributes for the preferences of DM 1 and DM 2

		ALT 1	ALT 2	ALT 3	ALT 4	w	w^T
A1	**ALT 1**	0,500	0,566	0,612	0,634	0,828	0,276
	ALT 2	0,434	0,500	0,546	0,567	0,762	0,254
	ALT 3	0,388	0,454	0,500	0,520	0,716	0,239
	ALT 4	0,366	0,433	0,480	0,500	0,695	0,232
A2	**ALT 1**	0,825	0,874	0,906	0,924	1,133	0,286
	ALT 2	0,625	0,685	0,725	0,746	0,945	0,238
	ALT 3	0,594	0,654	0,695	0,716	0,915	0,231
	ALT 4	0,658	0,714	0,751	0,771	0,974	0,245
A3	**ALT 1**	0,812	0,894	0,951	0,985	1,161	0,291
	ALT 2	0,843	0,881	0,905	0,918	1,137	0,285
	ALT 3	0,731	0,772	0,798	0,812	1,028	0,258
	ALT 4	0,348	0,407	0,447	0,463	0,666	0,167
A4	**ALT 1**	0,554	0,617	0,659	0,680	0,877	0,257
	ALT 2	0,479	0,543	0,586	0,607	0,804	0,236
	ALT 3	0,536	0,598	0,640	0,661	0,859	0,252
	ALT 4	0,552	0,612	0,652	0,672	0,872	0,256
A5	**ALT 1**	0,828	0,871	0,899	0,915	1,128	0,322
	ALT 2	0,670	0,725	0,762	0,781	0,985	0,281
	ALT 3	0,539	0,601	0,642	0,662	0,861	0,246
	ALT 4	0,212	0,268	0,307	0,317	0,526	0,150
A6	**ALT 1**	0,784	0,833	0,864	0,882	1,091	0,314
	ALT 2	0,644	0,700	0,738	0,757	0,960	0,276
	ALT 3	0,585	0,645	0,685	0,706	0,905	0,261
	ALT 4	0,203	0,259	0,298	0,308	0,517	0,149
A7	**ALT 1**	0,719	0,770	0,804	0,822	1,029	0,305
	ALT 2	0,593	0,654	0,695	0,716	0,914	0,271
	ALT 3	0,522	0,583	0,624	0,644	0,844	0,250
	ALT 4	0,272	0,331	0,371	0,385	0,590	0,175
A8	**ALT 1**	0,828	0,871	0,899	0,915	1,128	0,321
	ALT 2	0,770	0,818	0,850	0,867	1,076	0,306
	ALT 3	0,536	0,597	0,637	0,658	0,857	0,244
	ALT 4	0,143	0,195	0,230	0,235	0,451	0,128

Table A.45: Possibilities of alternatives and predicted order for R_1 with respect to the preferences of DM 1 and DM 2

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	P_j	ALT_j	
	0,141	**0,115**	**0,153**	**0,175**	**0,093**	**0,101**	**0,133**	**0,089**			
ALT 1	0,276	0,286	0,291	0,257	0,322	0,314	0,305	0,321	0,292	600	175
ALT 2	0,254	0,238	0,285	0,236	0,281	0,276	0,271	0,306	0,265	1000	265
ALT 3	0,239	0,231	0,258	0,252	0,246	0,261	0,250	0,244	0,248	1200	297
ALT 4	0,232	0,245	0,167	0,256	0,150	0,149	0,175	0,128	0,195	2000	390
									ΔR_1		**1127**

Table A.46: Aggregated Comparison Matrix for the preferences of DM 1 and DM 3

	A1				**A2**				**A3**				**A4**			
A1	0,50	0,50	0,50	0,50	0,49	0,67	0,00	0,33	0,46	0,61	0,00	0,39	0,32	0,44	0,34	0,56
A2	0,00	0,33	0,49	0,67	0,50	0,50	0,50	0,50	0,32	0,44	0,34	0,56	0,42	0,55	0,25	0,45
A3	0,00	0,39	0,46	0,61	0,34	0,56	0,32	0,44	0,50	0,50	0,50	0,50	0,41	0,54	0,27	0,46
A4	0,34	0,56	0,32	0,44	0,25	0,45	0,42	0,55	0,27	0,46	0,41	0,54	0,50	0,50	0,50	0,50
A5	0,00	0,39	0,46	0,61	0,27	0,46	0,41	0,54	0,00	0,33	0,49	0,67	0,00	0,00	0,59	1,00
A6	0,17	0,36	0,50	0,64	0,00	0,00	0,41	0,54	0,00	0,00	0,55	1,00	0,00	0,00	0,69	1,00
A7	0,37	0,58	0,30	0,42	0,27	0,50	0,37	0,50	0,34	0,56	0,32	0,44	0,00	0,27	0,55	0,73
A8	0,00	0,22	0,61	0,78	0,00	0,31	0,54	0,69	0,00	0,29	0,53	0,71	0,00	0,00	0,69	1,00

	A5				**A6**				**A7**				**A8**			
A1	0,46	0,61	0,00	0,39	0,50	0,64	0,17	0,36	0,30	0,42	0,37	0,58	0,61	0,78	0,00	0,22
A2	0,41	0,54	0,27	0,46	0,41	0,54	0,27	0,46	0,37	0,50	0,27	0,50	0,54	0,69	0,00	0,31
A3	0,49	0,67	0,00	0,33	0,55	1,00	0,00	0,00	0,32	0,44	0,34	0,56	0,53	0,71	0,00	0,29
A4	0,59	1,00	0,00	0,00	0,69	1,00	0,00	0,00	0,55	0,73	0,00	0,27	0,69	1,00	0,00	0,00
A5	0,50	0,50	0,50	0,50	0,53	0,71	0,00	0,29	0,51	0,69	0,00	0,31	0,61	1,00	0,00	0,00
A6	0,00	0,29	0,53	0,71	0,50	0,50	0,50	0,50	0,35	0,47	0,31	0,53	0,35	0,48	0,34	0,52
A7	0,00	0,31	0,51	0,69	0,31	0,53	0,35	0,47	0,50	0,50	0,50	0,50	0,64	0,83	0,00	0,17
A8	0,00	0,00	0,61	1,00	0,34	0,52	0,35	0,48	0,00	0,17	0,64	0,83	0,50	0,50	0,50	0,50

Table A.47: Score judgment matrix of attributes with the prefence of DM 1 and DM 3

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	0,00	0,00	0,16	0,67	0,07	0,61	-0,24	0,10	0,07	0,61	0,14	0,47	-0,29	0,05	0,39	0,78
A2	-0,67	-0,16	0,00	0,00	-0,24	0,10	-0,03	0,31	-0,06	0,26	-0,06	0,26	-0,13	0,23	0,23	0,69
A3	-0,61	-0,07	-0,10	0,24	0,00	0,00	-0,06	0,26	0,16	0,67	0,55	1,00	-0,24	0,10	0,24	0,71
A4	-0,10	0,24	-0,31	0,03	-0,26	0,06	0,00	0,00	0,59	1,00	0,69	1,00	0,28	0,73	0,69	1,00
A5	-0,61	-0,07	-0,26	0,06	-0,67	-0,16	-1,00	-0,59	0,00	0,00	0,24	0,71	0,20	0,69	0,61	1,00
A6	-0,47	-0,14	-0,54	-0,41	-1,00	-0,55	-1,00	-0,69	-0,71	-0,24	0,00	0,00	-0,19	0,16	-0,17	0,14
A7	-0,05	0,29	-0,23	0,13	-0,10	0,24	-0,73	-0,28	-0,69	-0,20	-0,16	0,19	0,00	0,00	0,47	0,83
A8	-0,78	-0,39	-0,69	-0,23	-0,71	-0,24	-1,00	-0,69	-1,00	-0,61	-0,14	0,17	-0,83	-0,47	0,00	0,00

Table A.48: Interval multiplicative matrix of attributes for the preferences of DM 1 and DM 3

	A1		A2		A3		A4		A5		A6		A7		A8	
A1	1,00	1,00	1,45	4,71	1,16	4,06	0,58	1,26	1,16	4,06	1,39	2,97	0,51	1,11	2,47	6,09
A2	0,21	0,69	1,00	1,00	0,58	1,26	0,93	2,02	0,87	1,84	0,87	1,84	0,75	1,69	1,68	4,89
A3	0,25	0,86	0,80	1,74	1,00	1,00	0,87	1,84	1,45	4,71	3,56	10,00	0,58	1,26	1,72	5,10
A4	0,80	1,74	0,50	1,08	0,54	1,14	1,00	1,00	3,87	10,00	4,89	10,00	1,91	5,35	4,89	10,00
A5	0,25	0,86	0,54	1,14	0,21	0,69	0,10	0,26	1,00	1,00	1,72	5,10	1,57	4,89	4,06	10,00
A6	0,34	0,72	0,29	0,39	0,10	0,28	0,10	0,20	0,20	0,58	1,00	1,00	0,65	1,44	0,68	1,38
A7	0,90	1,95	0,59	1,34	0,80	1,74	0,19	0,52	0,20	0,64	0,70	1,53	1,00	1,00	2,97	6,75
A8	0,16	0,40	0,20	0,60	0,20	0,58	0,10	0,20	0,10	0,25	0,73	1,46	0,15	0,34	1,00	1,00

Table A.49: Priority Vector of attributes for the preferences of DM 1 and DM 3

Attribute	Priority	
A1	0,062	0,371
A2	0,044	0,224
A3	0,065	0,390
A4	0,117	0,593
A5	0,060	0,352
A6	0,021	0,088
A7	0,047	0,227
A8	0,017	0,071

Table A.50: Possibility degree matrix and weights of the attributes for the preferences of DM 1 and DM 3

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	***w***	***w^T***
A1	0,500	0,669	0,483	0,324	0,518	0,930	0,662	0,974	1,008	0,144
A2	0,331	0,500	0,315	0,163	0,347	0,820	0,491	0,884	0,856	0,122
A3	0,517	0,685	0,500	0,341	0,534	0,941	0,679	0,984	1,023	0,146
A4	0,676	0,837	0,659	0,500	0,694	1,000	0,832	1,000	1,150	**0,164**
A5	0,482	0,653	0,466	0,306	0,500	0,922	0,646	0,968	0,993	0,142
A6	0,070	0,180	0,059	0,000	0,078	0,500	0,168	0,589	0,580	0,083
A7	0,338	0,509	0,321	0,168	0,354	0,832	0,500	0,896	0,865	0,124
A8	0,026	0,116	0,016	0,000	0,032	0,411	0,104	0,500	0,526	0,075

Table A.51: Aggregated comparison matrix of alternatives for preferences of DM 1 and DM 3

	ALT 1				**ALT 2**				**ALT 3**				**ALT 4**			
ALT 1	0,50	0,50	0,50	0,50	0,39	0,53	0,00	0,47	0,35	0,48	0,00	0,52	0,35	1,00	0,00	0,00
ALT 2	0,00	0,47	0,39	0,53	0,50	0,50	0,50	0,50	0,35	0,48	0,31	0,52	0,34	1,00	0,00	0,00
ALT 3	0,00	0,52	0,35	0,48	0,31	0,52	0,35	0,48	0,50	0,50	0,50	0,50	0,36	1,00	0,00	0,00
ALT 4	0,00	0,00	0,35	1,00	0,00	0,00	0,34	1,00	0,00	0,00	0,36	1,00	0,50	0,50	0,50	0,50

Table A.52: Score judgment matrix of alternatives based on criteria for the preferences of DM 1 and DM 3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	-0,06	0,26	-0,31	0,01	-0,19	0,16
	ALT 2	-0,26	0,06	0,00	0,00	-0,06	0,26	-0,31	0,01
	ALT 3	-0,01	0,31	-0,26	0,06	0,00	0,00	-0,19	0,16
	ALT 4	-0,16	0,19	0,10	0,13	-0,16	0,19	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,08	0,39	-0,13	0,23	0,02	0,59
	ALT 2	-0,16	0,31	0,00	0,00	0,02	0,36	0,11	0,63
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	0,11	0,63
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,30	0,73	0,39	0,78	0,69	1,00
	ALT 2	-0,33	0,15	0,00	0,00	-0,08	0,26	0,55	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	0,55	1,00
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	-0,29	0,05	-0,36	-0,04	-0,48	-0,18
	ALT 2	0,05	0,57	0,00	0,00	-0,37	-0,06	-0,48	-0,18
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,48	-0,18
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	-0,25	0,08	-0,31	0,01	-0,42	-0,12
	ALT 2	-0,28	0,19	0,00	0,00	-0,19	0,16	-0,31	0,01
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	-0,31	0,01
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	-0,19	0,16	-0,31	0,01	-0,42	-0,12
	ALT 2	-0,61	0,00	0,00	0,00	-0,19	0,16	-0,31	0,01
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	-0,25	0,08
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	-0,13	0,23	-0,31	0,01	-0,48	-0,18
	ALT 2	-0,37	0,10	0,00	0,00	-0,25	0,08	-0,31	0,01
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	-0,31	0,01
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	-0,25	0,08	-0,31	0,01	-0,42	-0,12
	ALT 2	-0,58	0,05	0,00	0,00	-0,31	0,01	-0,42	-0,12
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	-0,24	0,10
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table A.53: Interval multiplicative matrix of attributes on each criteria for the prefences of DM 1 and DM 3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	0,87	1,84	0,49	1,03	0,65	1,44
	ALT 2	0,54	1,14	1,00	1,00	0,87	1,84	0,49	1,03
	ALT 3	0,97	2,02	0,54	1,14	1,00	1,00	0,65	1,44
	ALT 4	0,70	1,53	1,27	1,35	0,70	1,53	1,00	1,00
A2	**ALT 1**	1,00	1,00	1,19	2,47	0,75	1,69	1,05	3,87
	ALT 2	0,69	2,03	1,00	1,00	1,04	2,31	1,30	4,28
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	1,30	4,28
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	1,98	5,35	2,47	6,09	4,89	10,00
	ALT 2	0,47	1,42	1,00	1,00	0,83	1,81	3,56	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	3,56	10,00
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	0,51	1,11	0,44	0,91	0,33	0,65
	ALT 2	1,13	3,73	1,00	1,00	0,43	0,88	0,33	0,65
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,33	0,65
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	0,56	1,20	0,49	1,03	0,38	0,76
	ALT 2	0,53	1,54	1,00	1,00	0,65	1,44	0,49	1,03
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	0,49	1,03
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	0,65	1,44	0,49	1,03	0,38	0,76
	ALT 2	0,25	1,00	1,00	1,00	0,65	1,44	0,49	1,03
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	0,56	1,20
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	0,75	1,69	0,49	1,03	0,33	0,65
	ALT 2	0,43	1,27	1,00	1,00	0,56	1,20	0,49	1,03
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	0,49	1,03
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	0,56	1,20	0,49	1,03	0,38	0,76
	ALT 2	0,26	1,12	1,00	1,00	0,49	1,03	0,38	0,76
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	0,58	1,26
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table A.54: Priority vector of alternatives based on each attribute for the preferences of DM 1 and DM 3

		Priority	
A1	**ALT 1**	0,015	0,054
	ALT 2	0,014	0,051
	ALT 3	0,015	0,057
	ALT 4	0,018	0,055
A2	**ALT 1**	0,019	0,092
	ALT 2	0,020	0,098
	ALT 3	0,020	0,112
	ALT 4	0,020	0,114
A3	**ALT 1**	0,050	0,114
	ALT 2	0,029	0,229
	ALT 3	0,025	0,145
	ALT 4	0,007	0,133
A4	**ALT 1**	0,011	0,038
	ALT 2	0,014	0,064
	ALT 3	0,016	0,078
	ALT 4	0,015	0,084
A5	**ALT 1**	0,012	0,041
	ALT 2	0,013	0,051
	ALT 3	0,010	0,043
	ALT 4	0,008	0,032
A6	**ALT 1**	0,012	0,043
	ALT 2	0,012	0,046
	ALT 3	0,012	0,053
	ALT 4	0,007	0,031
A7	**ALT 1**	0,013	0,045
	ALT 2	0,012	0,046
	ALT 3	0,011	0,048
	ALT 4	0,008	0,038
A8	**ALT 1**	0,012	0,041
	ALT 2	0,010	0,040
	ALT 3	0,010	0,045
	ALT 4	0,007	0,026

Table A.55: Possibility degree matrix and weights of the alternatives with respect to attributes for the preferences of DM 1 and DM 3

		ALT 1	ALT 2	ALT 3	ALT 4	w	w^T
A1	**ALT 1**	0,500	0,523	0,477	0,473	0,743	0,248
	ALT 2	0,477	0,500	0,454	0,448	0,720	0,240
	ALT 3	0,523	0,546	0,500	0,497	0,766	0,255
	ALT 4	0,527	0,552	0,503	0,500	0,770	0,257
A2	**ALT 1**	0,690	0,711	0,670	0,675	0,937	0,242
	ALT 2	0,707	0,727	0,688	0,693	0,953	0,247
	ALT 3	0,738	0,757	0,720	0,726	0,985	0,255
	ALT 4	0,743	0,762	0,725	0,731	0,990	0,256
A3	**ALT 1**	0,961	0,990	0,933	0,950	1,209	0,276
	ALT 2	0,893	0,904	0,881	0,887	1,142	0,261
	ALT 3	0,814	0,831	0,799	0,805	1,062	0,243
	ALT 4	0,713	0,728	0,699	0,703	0,961	0,220
A4	**ALT 1**	0,346	0,368	0,324	0,309	0,587	0,188
	ALT 2	0,551	0,573	0,529	0,528	0,795	0,254
	ALT 3	0,619	0,640	0,599	0,601	0,865	0,276
	ALT 4	0,637	0,656	0,617	0,620	0,882	0,282
A5	**ALT 1**	0,381	0,404	0,359	0,346	0,623	0,251
	ALT 2	0,470	0,492	0,448	0,441	0,713	0,288
	ALT 3	0,390	0,412	0,369	0,357	0,632	0,255
	ALT 4	0,271	0,291	0,251	0,230	0,511	0,206
A6	**ALT 1**	0,405	0,427	0,383	0,372	0,647	0,255
	ALT 2	0,421	0,443	0,399	0,390	0,663	0,262
	ALT 3	0,479	0,501	0,458	0,452	0,723	0,285
	ALT 4	0,262	0,281	0,242	0,220	0,501	0,198
A7	**ALT 1**	0,419	0,441	0,396	0,387	0,661	0,255
	ALT 2	0,426	0,448	0,404	0,395	0,668	0,258
	ALT 3	0,437	0,459	0,416	0,408	0,680	0,263
	ALT 4	0,339	0,359	0,318	0,303	0,580	0,224
A8	**ALT 1**	0,381	0,404	0,359	0,346	0,623	0,270
	ALT 2	0,366	0,388	0,345	0,331	0,607	0,263
	ALT 3	0,406	0,428	0,385	0,375	0,648	0,281
	ALT 4	0,191	0,209	0,172	0,143	0,429	0,186

Table A.56: Possibilities of alternatives and predicted order for R_1 with respect to the preferences of DM 1 and DM 3

	A1	A2	A3	A4	A5	A6	A7	A8	P_j	ALT_j	
	0,144	**0,122**	**0,146**	**0,164**	**0,142**	**0,083**	**0,124**	**0,075**			
ALT 1	0,248	0,242	0,276	0,188	0,251	0,255	0,255	0,270	0,292	600	147
ALT 2	0,240	0,247	0,261	0,254	0,288	0,262	0,258	0,263	0,265	1000	259
ALT 3	0,255	0,255	0,243	0,276	0,255	0,285	0,263	0,281	0,248	1200	315
ALT 4	0,257	0,256	0,220	0,282	0,206	0,198	0,224	0,186	0,195	2000	468
										ΔR_1	**1188**

Table A.57: Aggregated Comparison Matrix for the preferences of DM 2 and DM 3

	A1				**A2**				**A3**				**A4**			
A1	0,50	0,50	0,50	0,50	0,29	0,41	0,39	0,59	0,46	0,61	0,00	0,39	0,32	0,44	0,34	0,56
A2	0,39	0,59	0,29	0,41	0,50	0,50	0,50	0,50	0,44	0,58	0,22	0,42	0,39	0,53	0,27	0,47
A3	0,00	0,39	0,46	0,61	0,22	0,42	0,44	0,58	0,50	0,50	0,50	0,50	0,35	0,47	0,31	0,53
A4	0,34	0,56	0,32	0,44	0,27	0,47	0,39	0,53	0,31	0,53	0,35	0,47	0,50	0,50	0,50	0,50
A5	0,31	0,53	0,35	0,47	0,27	0,46	0,41	0,54	0,34	0,56	0,32	0,44	0,00	0,00	0,59	1,00
A6	0,29	0,49	0,37	0,51	0,39	0,59	0,32	0,44	0,39	0,59	0,29	0,41	0,00	0,17	0,64	0,83
A7	0,50	0,68	0,21	0,32	0,34	0,56	0,32	0,44	0,43	0,63	0,26	0,37	0,00	0,34	0,51	0,66
A8	0,00	0,34	0,51	0,66	0,00	0,37	0,48	0,63	0,37	0,58	0,30	0,42	0,00	0,25	0,58	0,75
	A5				**A6**				**A7**				**A8**			
A1	0,35	0,47	0,31	0,53	0,37	0,51	0,29	0,49	0,21	0,32	0,50	0,68	0,51	0,66	0,00	0,34
A2	0,41	0,54	0,27	0,46	0,32	0,44	0,34	0,56	0,32	0,44	0,34	0,56	0,48	0,63	0,00	0,37
A3	0,32	0,44	0,34	0,56	0,29	0,41	0,39	0,59	0,26	0,37	0,43	0,63	0,30	0,42	0,37	0,58
A4	0,59	1,00	0,00	0,00	0,64	0,83	0,00	0,17	0,51	0,66	0,00	0,34	0,58	0,75	0,00	0,25
A5	0,50	0,50	0,50	0,50	0,51	0,69	0,00	0,31	0,47	0,66	0,00	0,34	0,54	1,00	0,00	0,00
A6	0,00	0,31	0,51	0,69	0,50	0,50	0,50	0,50	0,35	0,47	0,31	0,53	0,35	0,48	0,34	0,52
A7	0,00	0,34	0,47	0,66	0,31	0,53	0,35	0,47	0,50	0,50	0,50	0,50	0,61	0,78	0,00	0,22
A8	0,00	0,00	0,54	1,00	0,34	0,52	0,35	0,48	0,00	0,22	0,61	0,78	0,50	0,50	0,50	0,50

Table A.58: Score judgment matrix of attributes with the prefence of DM 2 and DM 3

	A1		**A2**		**A3**		**A4**		**A5**		**A6**		**A7**		**A8**	
A1	0,00	0,00	-0,31	0,01	0,07	0,61	-0,24	0,10	-0,19	0,16	-0,12	0,21	-0,48	-0,18	0,16	0,66
A2	-0,01	0,31	0,00	0,00	0,02	0,36	-0,08	0,26	-0,06	0,26	-0,24	0,10	-0,24	0,10	0,11	0,63
A3	-0,61	-0,07	-0,36	-0,02	0,00	0,00	-0,19	0,16	-0,24	0,10	-0,31	0,01	-0,37	-0,06	-0,29	0,05
A4	-0,10	0,24	-0,26	0,08	-0,16	0,19	0,00	0,00	0,59	1,00	0,47	0,83	0,16	0,66	0,33	0,75
A5	-0,16	0,19	-0,26	0,06	-0,10	0,24	-1,00	-0,59	0,00	0,00	0,20	0,69	0,13	0,66	0,54	1,00
A6	-0,21	0,12	-0,05	0,27	-0,01	0,31	-0,83	-0,47	-0,69	-0,20	0,00	0,00	-0,19	0,16	-0,17	0,14
A7	0,18	0,48	-0,10	0,24	0,06	0,37	-0,66	-0,16	-0,66	-0,13	-0,16	0,19	0,00	0,00	0,39	0,78
A8	-0,66	-0,16	-0,63	-0,11	-0,05	0,29	-0,75	-0,33	-1,00	-0,54	-0,14	0,17	-0,78	-0,39	0,00	0,00

Table A.59: Interval multiplicative matrix of attributes for the preferences of DM 2 and DM 3

	A1		**A2**		**A3**		**A4**		**A5**		**A6**		**A7**		**A8**	
A1	1,00	1,00	0,49	1,03	1,16	4,06	0,58	1,26	0,65	1,44	0,75	1,64	0,33	0,65	1,46	4,55
A2	0,97	2,02	1,00	1,00	1,04	2,31	0,83	1,81	0,87	1,84	0,58	1,26	0,58	1,26	1,30	4,28
A3	0,25	0,86	0,43	0,96	1,00	1,00	0,65	1,44	0,58	1,26	0,49	1,03	0,43	0,88	0,51	1,11
A4	0,80	1,74	0,55	1,20	0,70	1,53	1,00	1,00	3,87	10,00	2,97	6,75	1,46	4,55	2,15	5,67
A5	0,70	1,53	0,54	1,14	0,80	1,74	0,10	0,26	1,00	1,00	1,57	4,89	1,34	4,55	3,43	10,00
A6	0,61	1,33	0,89	1,88	0,97	2,02	0,15	0,34	0,20	0,64	1,00	1,00	0,65	1,44	0,68	1,38
A7	1,53	3,00	0,80	1,74	1,14	2,32	0,22	0,68	0,22	0,75	0,70	1,53	1,00	1,00	2,47	6,09
A8	0,22	0,68	0,23	0,77	0,90	1,95	0,18	0,47	0,10	0,29	0,73	1,46	0,16	0,40	1,00	1,00

Table A.60: Priority Vector of attributes for the preferences of DM 2 and DM 3

Attribute	Priority	
A1	0,049	0,271
A2	0,054	0,273
A3	0,033	0,148
A4	0,103	0,562
A5	0,072	0,435
A6	0,039	0,174
A7	0,061	0,297
A8	0,027	0,122

Table A.61: Possibility degree matrix and weights of the attributes for preferences of DM 2 and DM 3

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	***w***	w^T
A1	0,500	0,491	0,706	0,247	0,340	0,650	0,458	0,770	0,895	0,128
A2	0,509	0,500	0,720	0,252	0,346	0,662	0,467	0,785	0,905	0,129
A3	0,294	0,280	0,500	0,079	0,159	0,436	0,247	0,577	0,697	0,100
A4	0,753	0,748	0,921	0,500	0,596	0,880	0,721	0,965	1,135	0,162
A5	0,660	0,654	0,841	0,404	0,500	0,796	0,625	0,891	1,046	0,149
A6	0,350	0,338	0,564	0,120	0,204	0,500	0,304	0,640	0,752	0,107
A7	0,542	0,533	0,753	0,279	0,375	0,696	0,500	0,817	0,937	0,134
A8	0,230	0,215	0,423	0,035	0,109	0,360	0,183	0,500	0,632	0,090

Table A.62: Aggregated comparison matrix of alternatives for preferences of DM 2 and DM 3

	ALT 1				**ALT 2**				**ALT 3**				**ALT 4**			
ALT 1	0,50	0,50	0,50	0,50	0,48	0,64	0,00	0,36	0,47	0,63	0,00	0,37	0,53	1,00	0,00	0,00
ALT 2	0,00	0,36	0,48	0,64	0,50	0,50	0,50	0,50	0,45	0,60	0,00	0,40	0,52	1,00	0,00	0,00
ALT 3	0,00	0,37	0,47	0,63	0,00	0,40	0,45	0,60	0,50	0,50	0,50	0,50	0,49	1,00	0,00	0,00
ALT 4	0,00	0,00	0,53	1,00	0,00	0,00	0,52	1,00	0,00	0,00	0,49	1,00	0,50	0,50	0,50	0,50

Table A.63: Score judgment matrix of alternatives based on criteria for the preferences of DM 2 and DM 3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	0,08	0,39	-0,11	0,20	0,02	0,36
	ALT 2	-0,39	-0,08	0,00	0,00	0,08	0,39	-0,11	0,20
	ALT 3	-0,20	0,11	-0,39	-0,08	0,00	0,00	-0,06	0,26
	ALT 4	-0,36	-0,02	-0,07	0,10	-0,26	0,06	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,16	0,66	-0,13	0,23	0,55	1,00
	ALT 2	-0,16	0,31	0,00	0,00	0,02	0,36	0,39	0,78
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	0,23	0,69
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,39	0,78	0,47	0,83	0,73	1,00
	ALT 2	-0,33	0,15	0,00	0,00	0,33	0,75	0,73	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	0,63	1,00
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	-0,12	0,21	-0,02	0,57	-0,48	-0,18
	ALT 2	0,05	0,57	0,00	0,00	-0,31	0,01	-0,42	-0,12
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,42	-0,12
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	0,07	0,61	0,20	0,69	0,55	1,00
	ALT 2	-0,28	0,19	0,00	0,00	0,07	0,61	0,20	0,69
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	0,20	0,69
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	0,11	0,63	-0,11	0,20	0,55	1,00
	ALT 2	-0,61	0,00	0,00	0,00	0,11	0,63	0,20	0,69
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	0,20	0,69
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	0,11	0,63	0,07	0,61	0,13	0,66
	ALT 2	-0,37	0,10	0,00	0,00	-0,03	0,31	0,20	0,69
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	0,07	0,61
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	0,07	0,61	0,20	0,69	0,55	1,00
	ALT 2	-0,58	0,05	0,00	0,00	0,07	0,61	0,55	1,00
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	0,24	0,71
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table A.64: Interval multiplicative matrix of attributes on each criteria for the prefences of DM 2 and DM 3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	1,19	2,47	0,77	1,57	1,04	2,31
	ALT 2	0,40	0,84	1,00	1,00	1,19	2,47	0,77	1,57
	ALT 3	0,64	1,30	0,40	0,84	1,00	1,00	0,87	1,84
	ALT 4	0,43	0,96	0,86	1,26	0,54	1,14	1,00	1,00
A2	**ALT 1**	1,00	1,00	1,46	4,55	0,75	1,69	3,56	10,00
	ALT 2	0,69	2,03	1,00	1,00	1,04	2,31	2,47	6,09
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	1,68	4,89
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	2,47	6,09	2,97	6,75	5,35	10,00
	ALT 2	0,47	1,42	1,00	1,00	2,15	5,67	5,35	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	4,28	10,00
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	0,75	1,64	0,96	3,71	0,33	0,65
	ALT 2	1,13	3,73	1,00	1,00	0,49	1,03	0,38	0,76
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,38	0,76
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	1,16	4,06	1,57	4,89	3,56	10,00
	ALT 2	0,53	1,54	1,00	1,00	1,16	4,06	1,57	4,89
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	1,57	4,89
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	1,30	4,28	0,77	1,57	3,56	10,00
	ALT 2	0,25	1,00	1,00	1,00	1,30	4,28	1,57	4,89
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	1,57	4,89
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	1,30	4,28	1,16	4,06	1,34	4,55
	ALT 2	0,43	1,27	1,00	1,00	0,93	2,02	1,57	4,89
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	1,16	4,06
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	1,16	4,06	1,57	4,89	3,56	10,00
	ALT 2	0,26	1,12	1,00	1,00	1,16	4,06	3,56	10,00
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	1,72	5,10
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table A.65: Priority vector of alternatives based on each attribute for the preferences of DM 2 and DM 3

		Priority	
A1	**ALT 1**	0,012	0,054
	ALT 2	0,010	0,043
	ALT 3	0,009	0,036
	ALT 4	0,009	0,032
A2	**ALT 1**	0,021	0,126
	ALT 2	0,016	0,083
	ALT 3	0,014	0,084
	ALT 4	0,013	0,081
A3	**ALT 1**	0,036	0,081
	ALT 2	0,028	0,174
	ALT 3	0,018	0,132
	ALT 4	0,004	0,094
A4	**ALT 1**	0,009	0,051
	ALT 2	0,009	0,048
	ALT 3	0,010	0,056
	ALT 4	0,009	0,060
A5	**ALT 1**	0,022	0,145
	ALT 2	0,013	0,084
	ALT 3	0,010	0,059
	ALT 4	0,005	0,023
A6	**ALT 1**	0,020	0,123
	ALT 2	0,013	0,081
	ALT 3	0,011	0,065
	ALT 4	0,005	0,022
A7	**ALT 1**	0,015	0,101
	ALT 2	0,012	0,067
	ALT 3	0,009	0,057
	ALT 4	0,005	0,027
A8	**ALT 1**	0,022	0,145
	ALT 2	0,018	0,118
	ALT 3	0,010	0,060
	ALT 4	0,004	0,018

Table A.66: Possibility degree matrix and weights of the alternatives with respect to attributes for the preferences of DM 2 and DM 3

		ALT 1	**ALT 2**	**ALT 3**	**ALT 4**	w	w^T
A1	**ALT 1**	0,500	0,586	0,651	0,697	0,858	0,286
	ALT 2	0,414	0,500	0,567	0,614	0,774	0,258
	ALT 3	0,349	0,433	0,500	0,547	0,707	0,236
	ALT 4	0,303	0,386	0,453	0,500	0,661	0,220
A2	**ALT 1**	0,776	0,840	0,883	0,914	1,103	0,272
	ALT 2	0,654	0,731	0,786	0,825	0,999	0,246
	ALT 3	0,644	0,717	0,769	0,807	0,984	0,243
	ALT 4	0,627	0,701	0,754	0,791	0,968	0,239
A3	**ALT 1**	0,799	0,915	1,000	1,000	1,179	0,268
	ALT 2	0,861	0,915	0,950	0,975	1,175	0,267
	ALT 3	0,769	0,829	0,869	0,897	1,091	0,248
	ALT 4	0,626	0,686	0,728	0,758	0,949	0,216
A4	**ALT 1**	0,467	0,549	0,610	0,653	0,820	0,246
	ALT 2	0,443	0,525	0,588	0,632	0,797	0,239
	ALT 3	0,502	0,582	0,642	0,685	0,853	0,256
	ALT 4	0,518	0,596	0,654	0,694	0,866	0,260
A5	**ALT 1**	0,811	0,869	0,908	0,936	1,131	0,324
	ALT 2	0,638	0,712	0,764	0,800	0,979	0,280
	ALT 3	0,515	0,594	0,653	0,695	0,864	0,247
	ALT 4	0,178	0,247	0,306	0,344	0,519	0,149
A6	**ALT 1**	0,769	0,834	0,878	0,909	1,097	0,316
	ALT 2	0,628	0,702	0,754	0,791	0,969	0,279
	ALT 3	0,552	0,630	0,687	0,728	0,899	0,259
	ALT 4	0,170	0,239	0,297	0,334	0,510	0,147
A7	**ALT 1**	0,696	0,764	0,811	0,844	1,029	0,305
	ALT 2	0,568	0,647	0,705	0,747	0,917	0,272
	ALT 3	0,498	0,577	0,636	0,677	0,847	0,251
	ALT 4	0,237	0,311	0,371	0,411	0,582	0,173
A8	**ALT 1**	0,811	0,869	0,908	0,936	1,131	0,321
	ALT 2	0,750	0,815	0,859	0,891	1,079	0,306
	ALT 3	0,522	0,601	0,660	0,701	0,871	0,247
	ALT 4	0,110	0,173	0,229	0,261	0,443	0,126

Table A.67: Possibilities of alternatives and predicted order for R_1 with respect to the preferences of DM 2 and DM 3

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	P_j	ALT_j	
	0,128	**0,129**	**0,100**	**0,162**	**0,149**	**0,107**	**0,134**	**0,090**			
ALT 1	0,286	0,272	0,268	0,246	0,324	0,316	0,305	0,321	0,290	600	174
ALT 2	0,258	0,246	0,267	0,239	0,280	0,279	0,272	0,306	0,266	1000	266
ALT 3	0,236	0,243	0,248	0,256	0,247	0,259	0,251	0,247	0,248	1200	298
ALT 4	0,220	0,239	0,216	0,260	0,149	0,147	0,173	0,126	0,195	2000	390
									ΔR_1		**1129**

Appendix B. Comparisons of different retailers

Table B.1: Pairwise comparison of alternatives with respect to attribute for R_2

		DM1				DM2				DM3			
		ALT 1	**ALT 2**	**ALT 3**	**ALT 4**	**ALT 1**	**ALT 2**	**ALT 3**	**ALT 4**	**ALT 1**	**ALT 2**	**ALT 3**	**ALT 4**
A1	**ALT 1**	EE	AL	AL	AL	EE	VL	VL	AL	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	AL	AL		EE	AL	AL
	ALT 3			EE	AL			EE	AL			EE	AL
	ALT 4				EE				EE				EE
A2	**ALT 1**	EE	AL	AL	AL	EE	VL	AL	AL	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	AL	AL		EE	AL	AL
	ALT 3			EE	AL			EE	AL			EE	AL
	ALT 4				EE				EE				EE
A3	**ALT 1**	EE	AL	AL	AL	EE	L	VH	VH	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	VH	AH		EE	VL	AL
	ALT 3			EE	AL			EE	AH			EE	AL
	ALT 4				EE				EE				EE
A4	**ALT 1**	EE	AL	AL	AL	EE	AL	AL	AL	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	VL	VL		EE	AL	AL
	ALT 3			EE	AL			EE	VL			EE	VL
	ALT 4				EE				EE				EE
A5	**ALT 1**	EE	AL	AL	AL	EE	VL	VL	AL	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	VL	AL		EE	AL	AL
	ALT 3			EE	AL			EE	AL			EE	L
	ALT 4				EE				EE				EE
A6	**ALT 1**	EE	AL	AL	AL	EE	VL	VL	AL	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	VL	AL		EE	VL	AL
	ALT 3			EE	AL			EE	AL			EE	AL
	ALT 4				EE				EE				EE
A7	**ALT 1**	EE	AL	AL	AL	EE	AL	AL	AL	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	AL	AL		EE	AL	AL
	ALT 3			EE	AL			EE	AL			EE	AL
	ALT 4				EE				EE				EE
A8	**ALT 1**	EE	AL	AL	AL	EE	VL	AL	AL	EE	AL	AL	AL
	ALT 2		EE	AL	AL		EE	VL	AL		EE	AL	AL
	ALT 3			EE	AL			EE	VL			EE	VL
	ALT 4				EE				EE				EE

Table B.2: Aggregated comparison matrix of alternatives for R_2

	ALT 1				ALT 2				ALT 3				ALT 4			
ALT 1	0,50	0,50	0,50	0,50	0,03	0,23	0,47	0,77	0,06	0,28	0,00	0,72	0,05	0,27	0,00	0,73
ALT 2	0,47	0,77	0,03	0,23	0,50	0,50	0,50	0,50	0,07	0,29	0,00	0,71	0,07	1,00	0,00	0,00
ALT 3	0,00	0,72	0,06	0,28	0,00	0,71	0,07	0,29	0,50	0,50	0,50	0,50	0,09	1,00	0,00	0,00
ALT 4	0,00	0,73	0,05	0,27	0,00	0,00	0,07	1,00	0,00	0,00	0,09	1,00	0,50	0,50	0,50	0,50

Table B.3: Score judgment matrix of alternatives based on criteria for R_2

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	-0,73	-0,23	-0,73	-0,23	-0,80	-0,30
	ALT 2	0,23	0,73	0,00	0,00	-0,80	-0,30	-0,80	-0,30
	ALT 3	0,23	0,73	0,30	0,80	0,00	0,00	-0,80	-0,30
	ALT 4	0,30	0,80	0,50	0,00	0,30	0,80	0,00	0,00
A2	**ALT 1**	0,00	0,00	-0,73	-0,23	-0,80	-0,30	-0,80	-0,30
	ALT 2	-0,16	0,31	0,00	0,00	-0,80	-0,30	-0,80	-0,30
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	-0,80	-0,30
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	-0,66	-0,15	-0,07	0,60	-0,07	0,60
	ALT 2	-0,33	0,15	0,00	0,00	-0,03	0,62	0,42	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	0,42	1,00
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	-0,80	-0,30	-0,80	-0,30	-0,80	-0,30
	ALT 2	0,05	0,57	0,00	0,00	-0,73	-0,23	-0,73	-0,23
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	-0,66	-0,16
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	-0,73	-0,23	-0,73	-0,23	-0,80	-0,30
	ALT 2	-0,28	0,19	0,00	0,00	-0,73	-0,23	-0,80	-0,30
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	-0,66	-0,15
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	-0,73	-0,23	-0,73	-0,23	-0,80	-0,30
	ALT 2	-0,61	0,00	0,00	0,00	-0,66	-0,16	-0,80	-0,30
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	-0,80	-0,30
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	-0,80	-0,30	-0,80	-0,30	-0,80	-0,30
	ALT 2	-0,37	0,10	0,00	0,00	-0,80	-0,30	-0,80	-0,30
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	-0,80	-0,30
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	-0,73	-0,23	-0,80	-0,30	-0,80	-0,30
	ALT 2	-0,58	0,05	0,00	0,00	-0,73	-0,23	-0,80	-0,30
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	-0,66	-0,16
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table B.4: Interval multiplicative matrix of attributes for each criteria for R_2

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	0,19	0,59	0,19	0,59	0,16	0,50
	ALT 2	1,70	5,38	1,00	1,00	0,16	0,50	0,16	0,50
	ALT 3	1,70	5,38	2,00	6,31	1,00	1,00	0,16	0,50
	ALT 4	2,00	6,31	3,16	1,00	2,00	6,31	1,00	1,00
A2	**ALT 1**	1,00	1,00	0,19	0,59	0,16	0,50	0,16	0,50
	ALT 2	0,69	2,03	1,00	1,00	0,16	0,50	0,16	0,50
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	0,16	0,50
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	0,22	0,71	0,85	3,98	0,85	3,98
	ALT 2	0,47	1,42	1,00	1,00	0,94	4,14	2,60	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	2,60	10,00
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	0,16	0,50	0,16	0,50	0,16	0,50
	ALT 2	1,13	3,73	1,00	1,00	0,19	0,59	0,19	0,59
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	0,22	0,69
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	0,19	0,59	0,19	0,59	0,16	0,50
	ALT 2	0,53	1,54	1,00	1,00	0,19	0,59	0,16	0,50
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	0,22	0,71
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	0,19	0,59	0,19	0,59	0,16	0,50
	ALT 2	0,25	1,00	1,00	1,00	0,22	0,69	0,16	0,50
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	0,16	0,50
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	0,16	0,50	0,16	0,50	0,16	0,50
	ALT 2	0,43	1,27	1,00	1,00	0,16	0,50	0,16	0,50
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	0,16	0,50
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	0,19	0,59	0,16	0,50	0,16	0,50
	ALT 2	0,26	1,12	1,00	1,00	0,19	0,59	0,16	0,50
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	0,22	0,69
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table B.5: Priority vector of alternatives based on each attribute for R_2

		Priority	
A1	**ALT 1**	0,008	0,034
	ALT 2	0,017	0,094
	ALT 3	0,027	0,169
	ALT 4	0,045	0,187
A2	**ALT 1**	0,008	0,033
	ALT 2	0,011	0,052
	ALT 3	0,016	0,092
	ALT 4	0,023	0,142
A3	**ALT 1**	0,016	0,142
	ALT 2	0,028	0,124
	ALT 3	0,022	0,212
	ALT 4	0,008	0,166
A4	**ALT 1**	0,008	0,032
	ALT 2	0,014	0,076
	ALT 3	0,017	0,098
	ALT 4	0,017	0,105
A5	**ALT 1**	0,008	0,034
	ALT 2	0,010	0,046
	ALT 3	0,010	0,049
	ALT 4	0,009	0,040
A6	**ALT 1**	0,008	0,034
	ALT 2	0,009	0,041
	ALT 3	0,012	0,058
	ALT 4	0,008	0,039
A7	**ALT 1**	0,008	0,032
	ALT 2	0,010	0,042
	ALT 3	0,011	0,054
	ALT 4	0,009	0,048
A8	**ALT 1**	0,008	0,033
	ALT 2	0,009	0,041
	ALT 3	0,009	0,049
	ALT 4	0,008	0,032

Table B.6: Possibility degree matrix and weights of the alternatives with respect to attributes for R_2

		ALT 1	ALT 2	ALT 3	ALT 4	w	w^T
A1	**ALT 1**	0,500	0,171	0,045	0,000	0,429	0,143
	ALT 2	0,829	0,500	0,308	0,225	0,716	0,239
	ALT 3	0,955	0,692	0,500	0,436	0,896	0,299
	ALT 4	1,000	0,775	0,564	0,500	0,960	0,320
A2	**ALT 1**	0,487	0,161	0,039	0,000	0,422	0,169
	ALT 2	0,650	0,296	0,136	0,036	0,530	0,212
	ALT 3	0,821	0,491	0,300	0,216	0,707	0,283
	ALT 4	0,921	0,637	0,442	0,372	0,843	0,337
A3	**ALT 1**	0,880	0,616	0,430	0,362	0,822	0,240
	ALT 2	0,945	0,616	0,407	0,331	0,825	0,241
	ALT 3	0,945	0,731	0,559	0,504	0,935	0,273
	ALT 4	0,856	0,633	0,464	0,403	0,839	0,245
A4	**ALT 1**	0,474	0,152	0,032	0,000	0,414	0,164
	ALT 2	0,766	0,423	0,240	0,150	0,645	0,255
	ALT 3	0,838	0,511	0,318	0,236	0,726	0,287
	ALT 4	0,845	0,533	0,341	0,262	0,745	0,294
A5	**ALT 1**	0,500	0,171	0,045	0,000	0,429	0,225
	ALT 2	0,613	0,262	0,111	0,009	0,499	0,262
	ALT 3	0,631	0,281	0,125	0,025	0,515	0,271
	ALT 4	0,552	0,215	0,077	0,000	0,461	0,242
A6	**ALT 1**	0,500	0,171	0,045	0,000	0,429	0,224
	ALT 2	0,560	0,220	0,081	0,000	0,465	0,243
	ALT 3	0,685	0,333	0,166	0,069	0,563	0,294
	ALT 4	0,543	0,208	0,072	0,000	0,456	0,238
A7	**ALT 1**	0,474	0,152	0,032	0,000	0,414	0,215
	ALT 2	0,575	0,229	0,087	0,000	0,473	0,245
	ALT 3	0,656	0,307	0,146	0,048	0,539	0,279
	ALT 4	0,610	0,269	0,118	0,018	0,504	0,261
A8	**ALT 1**	0,487	0,161	0,039	0,000	0,422	0,232
	ALT 2	0,562	0,223	0,083	0,000	0,467	0,257
	ALT 3	0,620	0,276	0,123	0,022	0,510	0,281
	ALT 4	0,474	0,154	0,034	0,000	0,416	0,229

Table B.7: Possibilities of alternatives and predicted order for R_2

	A1	A2	A3	A4	A5	A6	A7	A8	P_j	ALT_j	
	0,138	**0,121**	**0,140**	**0,165**	**0,136**	**0,090**	**0,132**	**0,078**			
ALT 1	0,143	0,169	0,240	0,164	0,225	0,224	0,215	0,232	0,198	600	119
ALT 2	0,239	0,212	0,241	0,255	0,262	0,243	0,245	0,257	0,244	1000	244
ALT 3	0,299	0,283	0,273	0,287	0,271	0,294	0,279	0,281	0,283	1200	340
ALT 4	0,320	0,337	0,245	0,294	0,242	0,238	0,261	0,229	0,275	2000	549
									ΔR_2		**1252**

Table B.8: Pairwise comparison of alternatives with respect to attribute for R_3

		DM1				DM2				DM3			
		ALT 1	**ALT 2**	**ALT 3**	**ALT 4**	**ALT 1**	**ALT 2**	**ALT 3**	**ALT 4**	**ALT 1**	**ALT 2**	**ALT 3**	**ALT 4**
A1	**ALT 1**	EE	AH	AH	AH	EE	AH	AH	AH	EE	VH	VH	AH
	ALT 2		EE	VH	AH		EE	AH	AH		EE	VH	AH
	ALT 3			EE	AH			EE	AH			EE	AH
	ALT 4				EE				EE				EE
A2	**ALT 1**	EE	VH	AH	AH	EE	VH	AH	AH	EE	H	AH	AH
	ALT 2		EE	VH	AH		EE	AH	AH		EE	VH	AH
	ALT 3			EE	AH			EE	AH			EE	VH
	ALT 4				EE				EE				EE
A3	**ALT 1**	EE	AH	AH	AH	EE	MH	AH	AH	EE	VH	AH	AH
	ALT 2		EE	AH	AH		EE	VH	AH		EE	AH	AH
	ALT 3			EE	AH			EE	AH			EE	AH
	ALT 4				EE				EE				EE
A4	**ALT 1**	EE	AH	AH	AH	EE	AH	AH	AH	EE	VH	VH	AH
	ALT 2		EE	VH	AH		EE	AH	AH		EE	AH	AH
	ALT 3			EE	AH			EE	AH			EE	AH
	ALT 4				EE				EE				EE
A5	**ALT 1**	EE	VH	VH	VH	EE	VH	AH	AH	EE	VH	AH	AH
	ALT 2		EE	AH	VH		EE	AH	AH		EE	AH	AH
	ALT 3			EE	AH			EE	AH			EE	AH
	ALT 4				EE				EE				EE
A6	**ALT 1**	EE	VH	VH	AH	EE	AH	AH	AH	EE	AH	AH	AH
	ALT 2		EE	VH	AH		EE	AH	AH		EE	AH	AH
	ALT 3			EE	VH			EE	AH			EE	AH
	ALT 4				EE				EE				EE
A7	**ALT 1**	EE	AH	AH	AH	EE	AH	AH	AH	EE	VH	AH	AH
	ALT 2		EE	AH	AH		EE	AH	AH		EE	AH	AH
	ALT 3			EE	AH			EE	AH			EE	AH
	ALT 4				EE				EE				EE
A8	**ALT 1**	EE	AH	AH	AH	EE	AH	AH	AH	EE	H	VH	AH
	ALT 2		EE	AH	AH		EE	AH	AH		EE	VH	AH
	ALT 3			EE	AH			EE	AH			EE	AH
	ALT 4				EE				EE				EE

Table B.9: Aggregated comparison matrix of alternatives for R_3

	ALT 1				ALT 2				ALT 3				ALT 4			
ALT 1	0,50	0,50	0,50	0,50	0,74	1,00	0,00	0,00	0,78	1,00	0,00	0,00	0,80	1,00	0,00	0,00
ALT 2	0,00	0,00	0,74	1,00	0,50	0,50	0,50	0,50	0,77	1,00	0,00	0,00	0,80	1,00	0,00	0,00
ALT 3	0,00	0,00	0,78	1,00	0,00	0,00	0,77	1,00	0,50	0,50	0,50	0,50	0,79	1,00	0,00	0,00
ALT 4	0,00	0,00	0,80	1,00	0,00	0,00	0,80	1,00	0,00	0,00	0,79	1,00	0,50	0,50	0,50	0,50

Table B.10: Score judgment matrix of alternatives based on criteria for R_3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	0,00	0,00	0,77	1,00	0,77	1,00	0,80	1,00
	ALT 2	-1,00	-0,77	0,00	0,00	0,74	1,00	0,80	1,00
	ALT 3	-1,00	-0,77	-1,00	-0,74	0,00	0,00	0,80	1,00
	ALT 4	-1,00	-0,80	-0,80	0,00	-1,00	-0,80	0,00	0,00
A2	**ALT 1**	0,00	0,00	0,54	0,87	0,80	1,00	0,80	1,00
	ALT 2	-0,16	0,31	0,00	0,00	0,74	1,00	0,80	1,00
	ALT 3	0,00	0,51	-0,12	0,39	0,00	0,00	0,77	1,00
	ALT 4	0,05	0,57	0,05	0,57	-0,05	0,42	0,00	0,00
A3	**ALT 1**	0,00	0,00	0,69	1,00	0,80	1,00	0,80	1,00
	ALT 2	-0,33	0,15	0,00	0,00	0,77	1,00	0,80	1,00
	ALT 3	-0,56	0,10	-0,70	-0,15	0,00	0,00	0,80	1,00
	ALT 4	-1,00	-0,44	-0,64	-0,02	-1,00	-0,58	0,00	0,00
A4	**ALT 1**	0,00	0,00	0,77	1,00	0,77	1,00	0,80	1,00
	ALT 2	0,05	0,57	0,00	0,00	0,77	1,00	0,80	1,00
	ALT 3	0,15	0,66	-0,33	0,15	0,00	0,00	0,80	1,00
	ALT 4	0,16	0,66	-0,50	0,24	-0,65	-0,05	0,00	0,00
A5	**ALT 1**	0,00	0,00	0,60	0,90	0,77	1,00	0,77	1,00
	ALT 2	-0,28	0,19	0,00	0,00	0,80	1,00	0,77	1,00
	ALT 3	-0,65	-0,05	-0,37	0,10	0,00	0,00	0,80	1,00
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,65	-0,05	0,00	0,00
A6	**ALT 1**	0,00	0,00	0,77	1,00	0,77	1,00	0,80	1,00
	ALT 2	-0,61	0,00	0,00	0,00	0,77	1,00	0,80	1,00
	ALT 3	-0,16	0,31	-0,61	0,00	0,00	0,00	0,77	1,00
	ALT 4	-1,00	-0,44	-0,65	-0,05	-0,67	-0,09	0,00	0,00
A7	**ALT 1**	0,00	0,00	0,77	1,00	0,80	1,00	0,80	1,00
	ALT 2	-0,37	0,10	0,00	0,00	0,80	1,00	0,80	1,00
	ALT 3	-0,56	0,10	-0,32	0,16	0,00	0,00	0,80	1,00
	ALT 4	-0,60	0,07	-1,00	-0,48	-0,56	0,10	0,00	0,00
A8	**ALT 1**	0,00	0,00	0,75	1,00	0,77	1,00	0,80	1,00
	ALT 2	-0,58	0,05	0,00	0,00	0,77	1,00	0,80	1,00
	ALT 3	-0,65	-0,05	-0,56	0,10	0,00	0,00	0,80	1,00
	ALT 4	-1,00	-0,44	-1,00	-0,44	-0,67	-0,10	0,00	0,00

Table B.11: Interval multiplicative matrix of attributes for each criteria for R_3

		ALT1		ALT2		ALT3		ALT4	
A1	**ALT 1**	1,00	1,00	5,90	10,00	5,90	10,00	6,31	10,00
	ALT 2	0,10	0,17	1,00	1,00	5,47	10,00	6,31	10,00
	ALT 3	0,10	0,17	0,10	0,18	1,00	1,00	6,31	10,00
	ALT 4	0,10	0,16	0,16	1,00	0,10	0,16	1,00	1,00
A2	**ALT 1**	1,00	1,00	3,50	7,48	6,31	10,00	6,31	10,00
	ALT 2	0,69	2,03	1,00	1,00	5,47	10,00	6,31	10,00
	ALT 3	0,99	3,25	0,76	2,46	1,00	1,00	5,90	10,00
	ALT 4	1,13	3,73	1,13	3,73	0,89	2,64	1,00	1,00
A3	**ALT 1**	1,00	1,00	4,89	10,00	6,31	10,00	6,31	10,00
	ALT 2	0,47	1,42	1,00	1,00	5,90	10,00	6,31	10,00
	ALT 3	0,27	1,25	0,20	0,71	1,00	1,00	6,31	10,00
	ALT 4	0,10	0,37	0,23	0,97	0,10	0,26	1,00	1,00
A4	**ALT 1**	1,00	1,00	5,90	10,00	5,90	10,00	6,31	10,00
	ALT 2	1,13	3,73	1,00	1,00	5,90	10,00	6,31	10,00
	ALT 3	1,41	4,52	0,47	1,42	1,00	1,00	6,31	10,00
	ALT 4	1,45	4,61	0,32	1,74	0,22	0,89	1,00	1,00
A5	**ALT 1**	1,00	1,00	3,98	7,94	5,90	10,00	5,90	10,00
	ALT 2	0,53	1,54	1,00	1,00	6,31	10,00	5,90	10,00
	ALT 3	0,22	0,89	0,43	1,27	1,00	1,00	6,31	10,00
	ALT 4	0,10	0,37	0,22	0,89	0,22	0,89	1,00	1,00
A6	**ALT 1**	1,00	1,00	5,90	10,00	5,90	10,00	6,31	10,00
	ALT 2	0,25	1,00	1,00	1,00	5,90	10,00	6,31	10,00
	ALT 3	0,69	2,03	0,25	1,00	1,00	1,00	5,90	10,00
	ALT 4	0,10	0,37	0,22	0,89	0,21	0,81	1,00	1,00
A7	**ALT 1**	1,00	1,00	5,90	10,00	6,31	10,00	6,31	10,00
	ALT 2	0,43	1,27	1,00	1,00	6,31	10,00	6,31	10,00
	ALT 3	0,27	1,25	0,48	1,45	1,00	1,00	6,31	10,00
	ALT 4	0,25	1,17	0,10	0,33	0,27	1,25	1,00	1,00
A8	**ALT 1**	1,00	1,00	5,60	10,00	5,90	10,00	6,31	10,00
	ALT 2	0,26	1,12	1,00	1,00	5,90	10,00	6,31	10,00
	ALT 3	0,22	0,89	0,27	1,25	1,00	1,00	6,31	10,00
	ALT 4	0,10	0,37	0,10	0,37	0,21	0,80	1,00	1,00

Table B.12: Priority vector of alternatives based on each attribute for R_3

		Priority	
A1	**ALT 1**	0,033	0,092
	ALT 2	0,022	0,063
	ALT 3	0,013	0,034
	ALT 4	0,002	0,007
A2	**ALT 1**	0,030	0,084
	ALT 2	0,024	0,068
	ALT 3	0,015	0,049
	ALT 4	0,007	0,033
A3	**ALT 1**	0,032	0,033
	ALT 2	0,024	0,092
	ALT 3	0,014	0,066
	ALT 4	0,002	0,038
A4	**ALT 1**	0,033	0,092
	ALT 2	0,025	0,073
	ALT 3	0,016	0,050
	ALT 4	0,005	0,024
A5	**ALT 1**	0,029	0,086
	ALT 2	0,024	0,067
	ALT 3	0,014	0,039
	ALT 4	0,003	0,009
A6	**ALT 1**	0,033	0,092
	ALT 2	0,024	0,065
	ALT 3	0,014	0,041
	ALT 4	0,003	0,009
A7	**ALT 1**	0,034	0,092
	ALT 2	0,025	0,066
	ALT 3	0,014	0,041
	ALT 4	0,003	0,011
A8	**ALT 1**	0,033	0,092
	ALT 2	0,024	0,065
	ALT 3	0,014	0,039
	ALT 4	0,002	0,007

Table B.13: Possibility degree matrix and weights of the alternatives with respect to attributes for R_3

		ALT 1	**ALT 2**	**ALT 3**	**ALT 4**	w	w^T
A1	**ALT 1**	0,500	0,703	0,998	1,000	1,050	0,430
	ALT 2	0,297	0,500	0,817	1,000	0,654	0,281
	ALT 3	0,002	0,183	0,500	1,000	0,411	0,186
	ALT 4	0,000	0,000	0,000	0,500	0,275	0,103
A2	**ALT 1**	0,451	0,654	0,951	1,000	1,014	0,445
	ALT 2	0,338	0,539	0,846	1,000	0,610	0,224
	ALT 3	0,173	0,362	0,663	1,000	0,459	0,186
	ALT 4	0,000	0,157	0,428	1,000	0,346	0,145
A3	**ALT 1**	0,000	0,255	0,940	1,000	0,799	0,424
	ALT 2	0,462	0,641	0,890	1,000	0,428	0,239
	ALT 3	0,297	0,472	0,727	1,000	0,384	0,195
	ALT 4	0,053	0,209	0,448	0,892	0,280	0,142
A4	**ALT 1**	0,500	0,703	0,998	1,000	1,050	0,410
	ALT 2	0,374	0,574	0,876	1,000	0,656	0,234
	ALT 3	0,181	0,372	0,678	1,000	0,568	0,204
	ALT 4	0,000	0,032	0,284	0,931	0,462	0,151
A5	**ALT 1**	0,456	0,655	0,945	1,000	1,014	0,412
	ALT 2	0,330	0,534	0,848	1,000	0,728	0,280
	ALT 3	0,066	0,252	0,567	1,000	0,521	0,205
	ALT 4	0,000	0,000	0,000	0,625	0,306	0,102
A6	**ALT 1**	0,500	0,703	0,998	1,000	1,050	0,424
	ALT 2	0,317	0,521	0,838	1,000	0,719	0,252
	ALT 3	0,094	0,280	0,588	1,000	0,540	0,194
	ALT 4	0,000	0,000	0,000	0,616	0,324	0,130
A7	**ALT 1**	0,503	0,708	1,000	1,000	1,053	0,426
	ALT 2	0,326	0,532	0,854	1,000	0,688	0,251
	ALT 3	0,084	0,271	0,584	1,000	0,515	0,204
	ALT 4	0,000	0,000	0,000	0,686	0,341	0,119
A8	**ALT 1**	0,498	0,699	0,991	1,000	1,047	0,431
	ALT 2	0,320	0,524	0,839	1,000	0,571	0,230
	ALT 3	0,066	0,251	0,564	1,000	0,540	0,214
	ALT 4	0,000	0,000	0,000	0,538	0,275	0,125

Table B.14: Possibilities of alternatives and predicted order for R_3

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	P_j	ALT_j	
	0,138	**0,121**	**0,140**	**0,165**	**0,136**	**0,090**	**0,132**	**0,078**			
ALT 1	0,430	0,445	0,424	0,410	0,412	0,424	0,426	0,431	0,424	600	255
ALT 2	0,281	0,224	0,239	0,234	0,280	0,252	0,251	0,230	0,250	1000	250
ALT 3	0,186	0,186	0,195	0,204	0,205	0,194	0,204	0,214	0,198	1200	238
ALT 4	0,103	0,145	0,142	0,151	0,102	0,130	0,119	0,125	0,128	2000	255
									ΔR_3		**998**

BIOGRAPHICAL SKETCH

Ekin Merdan was born in Gölcük, Kocaeli. He was graduated from Gölcük İhsaniye Anatolian High School in 2007. He started his undergraduate education in Kocaeli University and received his Bachelor of Science degree from there in 2011. After the graduation, he was accepted to MSc Program in Industrial Engineering at Galatasaray University. He wrote the paper titled " A proposed order prediction methodology for vendor managed inventory system in FMCG sector based on interval-valued intuitionistic fuzzy sets" based on his MSc thesis work.