



**MARMARA UNIVERSITY**  
**INSTITUTE FOR GRADUATE STUDIES**  
**IN PURE AND APPLIED SCIENCES**



**INTERNET SERVICES CAMPAIGN  
SELECTION BASED ON AN INTEGRATED  
DECISION MAKING APPROACH**

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ZEHRA NUR LAFCI

**MASTER THESIS**

Department of Industrial Engineering

**Thesis Supervisor**

Asst. Prof. Dr. Hüseyin Selçuk KILIÇ

ISTANBUL, 2016

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March, 2016

Zehra Nur Lafcı

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## ÖZET

### ENTEĞRE KARAR VERME YAKLAŞIMINA DAYALI İNTERNET SERVİS KAMPANYA SEÇİMİ

Bu çalışmada, internet servis sektöründe kampanya seçimi problemi ele alınmıştır. Firmalar kampanya oluşturmadan önce birçok pazar araştırması yapmakta ve kampanya ile başarıya ulaşabilmek için yüksek maliyetleri göze almaktadırlar. Bu kapsamda müşteriye doğru kampanyayı sunabilmek, harcanan eforun boşa gitmemesi adına oldukça önemlidir. Müşterinin ilgili ürünü alırken dikkat ettiği kriterler değerlendirilmeyerek oluşturulan bir kampanyanın başarılı olması güçtür.

Türkiye’de internet servisi sağlayan şirketler incelendiği zaman söz konusu sektörün oldukça küçük olduğu görülmektedir. Bu sebeple firmalar olabildiğince avantajlı ve agresif kampanyalar çıkararak, hem yeni müşterileri kendilerine çekmeyi hem de mevcut müşterilerini korumayı hedeflemektedirler. Teorik altyapı sağlandıktan sonra, çalışma kapsamında çok kriterli karar verme teknikleri kullanılarak internet servis sektöründe kampanya seçim modeli oluşturulmuştur. Bu model oluşturulurken Türkiye’nin lider internet servisi sağlayıcı firmasının kampanya bilgileri kullanılmıştır. Ayrıca, kriterler belirlenirken ve alternatifler seçilirken uzman görüşleri alınmıştır. Kriter ağırlıklarının belirlenmesinde analitik hiyerarşi süreci, bulanık yaklaşım ile beraber kullanılmıştır. Karar vericiler için her zaman bir belirsizlik ortamı söz konusudur ve bu belirsizlik bulanık mantık ile en az seviyeye indirilmiştir. Daha sonra çok kriterli karar verme teknikleri kapsamında popüler olarak kullanılmakta olan TOPSIS ve VIKOR yöntemleri alternatifleri sıralamak için ayrı ayrı kullanılmıştır. Elde edilen iki ayrı sıralama entegre edilerek tek bir sıralama oluşturulmuştur.

Alternatifler kapsamında 4 farklı kampanya ve bu kampanyalara ait toplam 15 paket ele alınmıştır. Sıralama paketler bazında yapılmış olup, birinci çıkan paketin kampanyası, müşteriler tarafından en çok tercih edilebilecek ve firma için lansmanı yapılması en uygun kampanya olarak seçilmiştir.

**Anahtar Sözcükler:** Çok Kriterli Karar Verme Teknikleri, FAHP, TOPSIS, VIKOR, İnternet

## **ABSTRACT**

### **INTERNET SERVICES CAMPAIGN SELECTION BASED ON AN INTEGRATED DECISION MAKING APPROACH**

In this study, the problem of campaign selection within the internet service industry is discussed. Companies make a lot of market research before creating a campaign and face high costs to reach success. In this context, providing customers the right campaign is very important for not wasting efforts. It is hard for a campaign to be successful, unless the criteria of the customer when purchasing the relevant product are taken into account.

Regarding the firms, the internet service sector in Turkey is quite small and there are few major brands competing strictly both to attract new customers and protect existing customers by providing advantageous and aggressive campaigns. Within the scope of work, after providing theoretical background, a campaign selection model in the internet service sector is established by using multi-criteria decision techniques. While creating this model, it is benefited from the campaign information of Turkey's leading Internet service provider. Besides, while determining the criteria and selecting alternatives, the opinions of experts were received. For determining criteria weights, AHP was used together with fuzzy approximations. For decision makers, there is always an environment of uncertainty in question and this uncertainty has been reduced to a minimum level with fuzzy logic. Later, within the scope of multi-criteria decision making techniques, the popular methods; TOPSIS and VIKOR were separately used to list alternatives. Afterwards, it has been established one listing by integrating two separate listings.

Within the scope of alternatives, 4 different campaigns and a total of 15 packages of these campaigns have been discussed. The listing has been made on the basis of packages, the campaign of the first ranked package, was selected as having the potential to be mostly preferred campaign by customers and as the most appropriate campaign for launching the market.

**Keywords:** Multicriteria Decision Making Techniques, FAHP, TOPSIS, VIKOR, Internet

## SYMBOLS

$i$	: Criterion
$j$	: Alternative
$\pi(a,b)$	: Outranking degree for pair (a,b)
$p_j$	: Alternative weight
$F(a,b)$	: Value between 0 and 1
$A^*$	: Positive ideal set
$A^-$	: Negative ideal set
$S_i^*$	: Positive ideal separation
$S_i^-$	: Negative ideal separation
$C_i^*$	: Relative proximity to the ideal solution
$L_{pj}$	: Ranking measure
$F_c$	: Feasible solution closest to ideal
$F^*$	: Ideal solution
$f_i^*$	: Best criterion
$f_i^-$	: Worst criterion
$w_i$	: Importance weight of criterion
$S_j$	: Utility measure
$R_j$	: Regret measure
$Q_j$	: Alternative values in VIKOR
$P1$	: First best alternative
$P2$	: Second best alternative
$CR$	: Consistency ratio
$CI$	: Consistency index
$RI$	: Random consistency index
$(l, m, u)$	: Triangular fuzzy number
$\mu_A(x)$	: Membership function
$\widetilde{d}_{nm}^k$	: $k^{\text{th}}$ decision makers preference of criterion m over criterion n
$\widetilde{d}_{ij}$	: Average for preference criteria
$\widetilde{r}_i$	: Geometric mean for preference criteria
$\widetilde{w}_i$	: Fuzzy weight for criterion i

- $M_i$  : Non- fuzzy number  
 $N_i$  : Normalized non-fuzzy number  
 $C_i^*$  : Proximity value for alternative i



## **ABBREVIATIONS**

<b>MCDM</b>	: Multi Criteria Decision Making Techniques
<b>TCP</b>	: Transmission Control Protocol
<b>IP</b>	: Internet Protocol
<b>WWW</b>	: World Wide Web
<b>ARPANET</b>	: Advanced Research Projects Agency Network
<b>DSL</b>	: Digital Subscriber Line
<b>OECD</b>	: Organization for Economic Co-operation and Development
<b>METU</b>	: The Middle East Technical University
<b>NSF</b>	: U.S National Science Foundation
<b>TÜBİTAK</b>	: Scientific and Technical Research Council
<b>ICTA</b>	: Information and Communication Technologies Authority
<b>YÖK</b>	: Council of Higher Education
<b>ÖSYM</b>	: Assessment Selection and Placement Center
<b>MADM</b>	: Multi-Attribute Decision-Making
<b>MODM</b>	: Multi Objective Decision-Making
<b>ELECTRE</b>	: ELimination Et Choix TRaduisant La REalit (Elimination and Choice Translating Reality)
<b>AHP</b>	: Analytic Hierarchy Process
<b>TOPSIS</b>	: Technique for Order Preference by Similarity to an Ideal Solution
<b>PROMETHEE</b>	: Preference Ranking Organization Method For Enrichment Evaluation
<b>ANP</b>	: Analytic Network Process
<b>VIKOR</b>	: Vise Kriterijumska Optimizacija I Kompromisno Resenje (Multi-Criteria Optimization and Compromise Solution)
<b>DEMATEL</b>	: Decision Making Trial and Evaluation Laboratory

<b>FAHP</b>	: Fuzzy Analytic Hierarchy Process
<b>FMCDM</b>	: Fuzzy Multiple Criteria Decision Making Techniques
<b>CR</b>	: Consistency Ratio
<b>CI</b>	: Consistency index
<b>RI</b>	: Random Index
<b>TFNs</b>	: Triangular fuzzy numbers
<b>ELV</b>	: End-of Life Vehicles
<b>LCD</b>	: Low Carbon Development
<b>KPI</b>	: Key Performance Indicator
<b>AFP</b>	: Accounting-Based Financial Performance
<b>VFP</b>	: Value-Based Financial Performance
<b>QOS</b>	: Quality of Service
<b>QFD</b>	: Quality Function Deployment
<b>ISP</b>	: Internet Service Provider

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# 1. INTRODUCTION

Human beings are deciding intrinsically in every area and getting the results of their decisions. Decisions reveal themselves in every area of life, from choosing the way you go, the clothes you wear up or to make a deal with a supplier. Although these decisions sometimes appear as trivial, actually every decision directly affects the life of humans. For example; if you choose thin clothes in cold weather, your decision may result with a disease. Or if you choose a supplier without doing research, it may cause being defrauded. For this reason, it is very important to make right decisions in every area of life in order to live a quality life and reach success.

In today's highly competitive environment, campaigns are among the most important elements to reach customers for institutions and organizations. With the rapidly developing technology, demands of customers have increased and become various. Companies have to satisfy customers for these demands and they have to get the biggest slice of the market share. Undoubtedly, the most effective weapon is well organized and effective campaign in competitive markets.

Lots of companies work for customer retention, gaining new customers and getting into new markets. Creating campaigns is the most efficient way to survive for companies. Creating a new and attractive campaign require many preparations. In this process many managers, experts and employees spend their times. Firstly, they should determine a campaign strategy and process. They should analyze customer behaviors in detail and determine customer's demands clearly. They should collect information about market and rival companies. Because of these reasons, it is obvious that this process is very costly and creating an efficient campaign is very important for not wasting efforts.

Internet is a very significant discovery in 20<sup>th</sup> century. Internet is providing connection between computers and this development ensures the existence of many new technologies. Also, this discovery provides the connection of people all around the world. Nowadays, a world without internet can't be imagined. This sector has limited features to present customers such as quota, speed. In addition, internet service market

has little shareholders and there are 3 strong firms in Turkey. Therefore, this market is very aggressive and companies should create very attractive campaigns.

In this thesis an internet service sector campaign selection model is proposed and a real case is handled using campaign information of the leader firm. Selected campaign is the most appropriate campaign to present customers. For this selection, multi-criteria decision making techniques (MCDM) are used. Furthermore, fuzzy approach is combined with MCDM techniques to decrease the judgments and uncertainties. Fuzzy AHP method is used to determine the importance weights of criteria and TOPSIS and VIKOR methods were used to rank alternative campaigns.

This thesis involves six chapters with this chapter. In the second section, internet service sector, campaigns and internet campaigns are handled. There are literature review for decision making, decision making process, MCDM techniques and hybrid MCDM techniques in the third section. Also, most used MCDM techniques are detailed with application steps in this part. In the fourth section, the proposed methodology is presented. In the fifth part, the problem definition is detailed and the model for campaign selection in internet service sector is created using the proposed methodology. The last section consists of conclusion.

According to the literature review in this study, the MCDM techniques utilized in the proposed methodology were used in lots of various areas. However, up to the knowledge of the author, there isn't any study using these MCDM techniques for the selection of internet service campaign.

## **2. INTERNET AND CAMPAIGNS**

### **2.1. A General Outlook to Internet**

Internet is an electronic communication network that provides the connection of computer systems. It is the global system of computer networks. Internet makes possible the communication and file transformation of two or more computers using the Internet protocol suite TCP/IP (Transmission Control Protocol/Internet Protocol). Internet contains lots of information resources and services for example applications of the World Wide Web (www), the inter-linked hypertext documents, electronic mail, telephony and peer-to-peer networks for file sharing.

The Internet has changed our lives much as electricity, press and phone. It isn't only a communication tool but also is a part of our daily lives for most of us. With this technology, people can have fast and safe access to lots of various information. In today's world, advertisers use the internet as a beneficial way to announce their brands to the world and become globalized rapidly.

The continuing development of computer technologies, new softwares, programs, websites, spreading usage of download and upload programs are the supporting matters of being aware of the importance of the internet.

Internet is an immense technology that can bring the world to our fingertips with a click and it can shrink the world. It is a cyber-world that involves millions of people who can express themselves in their own ways so it has millions of opinions, too. The most contributing factor for the internet's prevalence is the e-commerce. Thanks to the e-commerce people can order what they want from a virtual shopping center that can be anywhere in the world and they receive their product within a few days. Also, physically handicapped people can have a more easy shopping time and they can access and have a communication with the world by help of the internet and e-commerce.

With regard to wide spreading usage of internet, many different opinions are raised about its effects on people. Some people considered that the Internet alienates people from each other, prevents face to face communication and causes addiction to it. Also, in some areas people think that the addiction of the internet usage causes less productivity in offices. Therefore, they think it should be limited.

In the twenty-first century, internet leads to society. It provides to learn everything within seconds. Internet has changed the behavior and attitudes in different ways. Especially, younger generation can't spend their all time without internet. The clock never turns back to the pre-Internet world.

In the world, the first communication network between computers was Advanced Research Projects Agency Network (ARPANET) that was founded in 1969. The aim of this network involved military purpose. However, Nikola Tesla who was one of technology's leaders foresaw this technology's future with quote below in 1908 thanks to his great insight and vision;

*"It will be possible for a business an in New York to dictate instructions, and have them instantly appear in type at his office in London or elsewhere. He will be able to call up, from his desk, and talk to any telephone subscriber on the globe. An inexpensive instrument, not bigger than a watch, will enable its bearer to hear anywhere, on sea or land, music or song, the speech of a political leader, the address of an eminent man of science, or the sermon of an eloquent clergyman, delivered in some other place, however distant. In the same manner any picture, character, drawing, or print can be transferred from one to another place."* (Massie & Underhill, 1908).

High speed internet connection is expressed as broadband. The broadband access types have 4 different types. ([btmakaleleri.blogspot.com.tr/2014/12/genisbant-baglantisi-tipleri.html](http://btmakaleleri.blogspot.com.tr/2014/12/genisbant-baglantisi-tipleri.html), 2014)

- DSL (Digital Subscriber Line)

It is known as ADSL (Asymmetric Digital Subscriber Line) or SDSL (Symmetric Digital Subscriber Line). This type is the most used type in broadband access types. It provides internet using phone lines.

- Cable

People who have cable TV can benefit from internet with a special modem. Generally cable companies present to customer a bundle package. These packages involve cable TV and internet.

- Wireless

Wi-Fi provides to be online in anywhere (even though ADSL and SDSL cannot available

there) and it provides fast and easy data exchange. Because of this reasons, it is an attractive choice for users. The mobile modems which have a portable technology provide a coverage zone in rural and distant areas .

- Satellite

This type is a selection for people that live in rural and remote areas and can't get any broadband connection services.

Today, a significant portion of the world's population use internet actively. There are more than 3 billion (42.3% of population) internet users in the world. In Turkey, more than 46 million people (56.7% of the population) use the internet (Yelpaze & Ceyhan, 2015).

According to OECD (Organization for Economic Co-operation and Development) broadband statistics (ICTA/Information and Communication Technologies Authority, 2014), distribution by countries of fixed broadband subscriptions are given in Table 2.1 and mobile broadband subscriptions are given in Table 2.2.

**Table 2.1.** Fixed broadband subscriptions in 2014

<b>Rank</b>	<b>Countries</b>	<b>Fixed</b>
1	United States	100,192,000
2	Japan	36,261,653
3	Germany	29,572,818
4	France	25,969,000
5	United Kingdom	23,729,800
6	Korea	19,198,934
7	Italy	14,373,844
8	Mexico	12,838,093
9	Spain	12,834,049
10	Canada	12,569,087
11	Turkey	8,866,361
12	Poland	6,922,890
13	Netherlands	6,851,000
14	Australia	6,536,000
15	Belgium	4,011,201
16	Switzerland	3,990,200
17	Sweden	3,281,000
18	Greece	3,156,071
19	Czech Republic	2,979,400
20	Portugal	2,830,930
21	Hungary	2,580,537
22	Chile	2,489,717
23	Austria	2,351,905
24	Denmark	2,331,830
25	Israel	2,077,000
26	Norway	1,985,997
27	Finland	1,758,500
28	New Zealand	1,421,621

**Table 2.2.** Mobile broadband subscriptions in 2014

<b>Rank</b>	<b>Countries</b>	<b>Mobile broadband</b>
1	United States	331,373,000
2	Japan	157,812,151
3	United Kingdom	54,718,423
4	Korea	53,751,479
5	Germany	52,575,423
6	Mexico	50,913,677
7	Italy	43,104,410
8	France	42,810,000
9	Spain	36,267,330
10	Turkey	32,360,661
11	Australia	27,028,000
12	Poland	21,278,710
13	Canada	19,279,414
14	Netherlands	11,635,000
15	Sweden	11,204,000
16	Chile	8,885,792
17	Finland	7,537,800
18	Czech Republic	6,848,200
19	Switzerland	6,780,000
20	Denmark	6,518,062
21	Belgium	6,440,133
22	Austria	5,729,200
23	Portugal	4,755,599
24	Greece	4,559,958
25	Norway	4,520,385
26	New Zealand	4,440,948
27	Israel	4,090,000
28	Ireland	3,787,863

### **2.1.1 Internet Service Sector in Turkey**

Turkey which has an increasing growth rate in the last decade is also highly affected by

the developments in internet sector. The history of internet can be sorted chronologically as follows: (<http://www.internetarsivi.metu.edu.tr/tarihce.php>, 2005)

1993 – A dedicated 64 Kbps (kilo bit per second) Internet connection between The Middle East Technical University (METU) and the U.S National Science Foundation (NSF) was established by studies of Scientific and Technical Research Council (TÜBİTAK) and METU.

1994 – Ege University joined to internet connection.

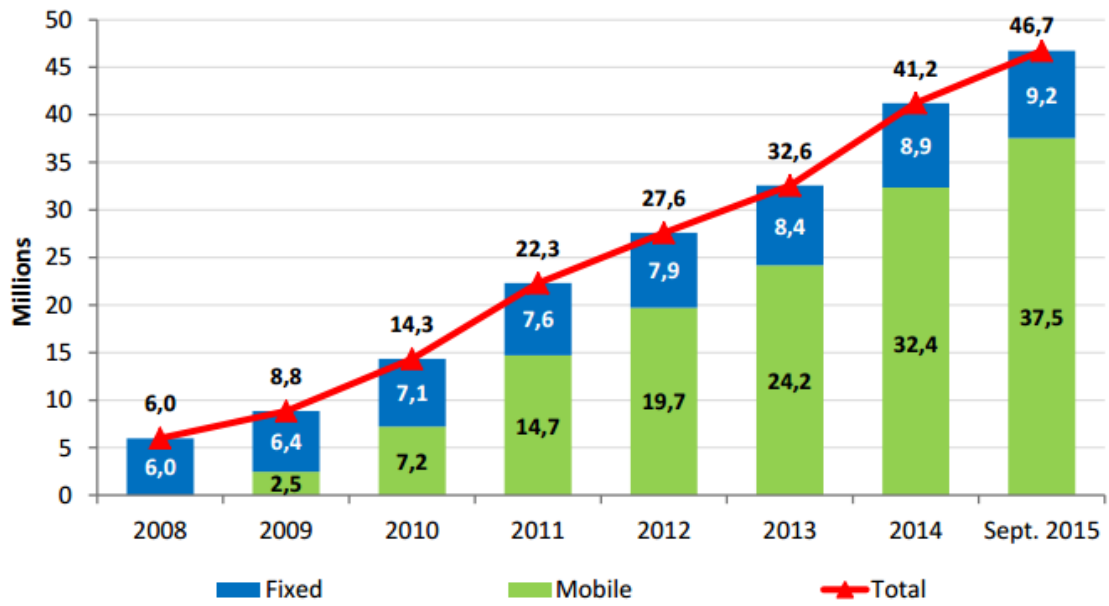
1995 – The speed of internet connection was reached to 128 Kbps. Bilkent and Boğaziçi University joined to internet connection.

1996 – The speed of internet connection was reached to 512 Kbps. İstanbul Technical University joined to internet connection.

1996 – ULAKNET was established to help to solve problems of education and research/development in Turkey. This network gave services to TUBİTAK, military schools, war academies, Council of Higher Education (YÖK), Assessment Selection and Placement Center (ÖSYM), Turkish Atomic Energy Authority and the research and development unit of Turkish Armed Forces.

1996 – The TURNET Project was implemented to provide benefit for commercial institutions and internet service providers of Turk Telekom. There were 3 commercial lines in İstanbul and Ankara. Thanks to this line, there was access to internet service providers.

The broadband internet subscription in Turkey according to years is given in Figure 2.1. (ICTA, 2015). This graph shows that number of internet subscriber increases up to 7 times.



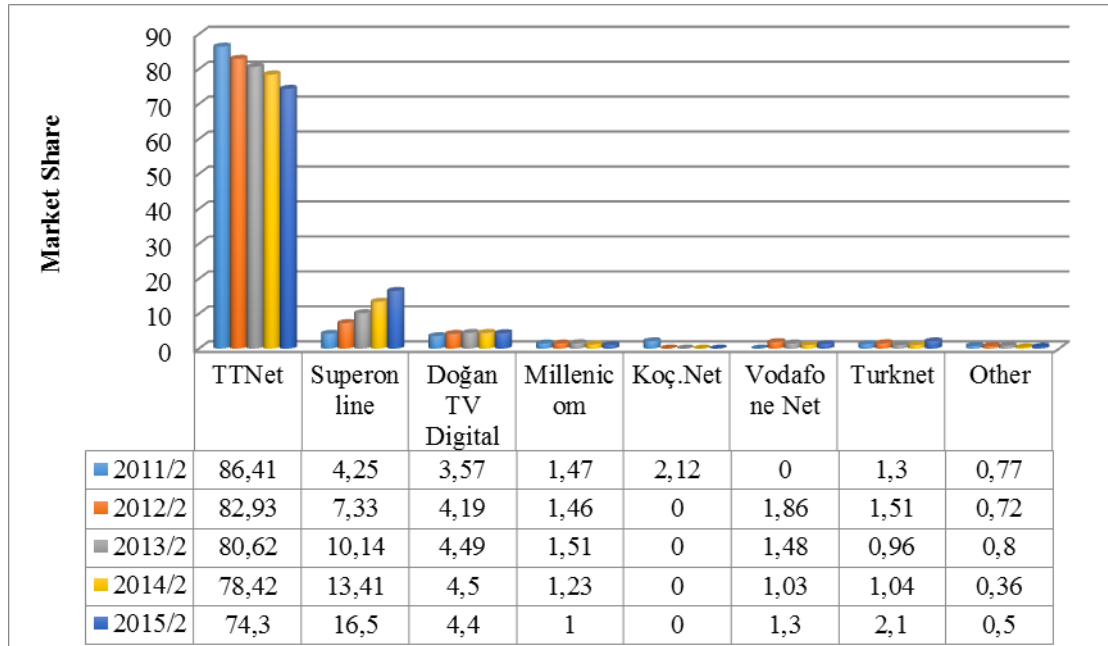
**Figure 2.1.** The number of internet subscriber yearly (ICTA, 2015)

The broadband internet subscription according to connection type in Turkey is given in Table 2.3. (ICTA, 2015).

**Table 2.3.** The broadband internet subscription according to connection type

2015/Q3 (July – August – September)	
xDSL	6,946,553
Mobile Internet from Computer	1,662,797
Mobile Internet from Mobile Handset	35,876,101
Cable Internet	596,06
Fiber	589,32
Other	1,106,306
<b>TOTAL</b>	<b>46,777,134</b>

The market share of leader firms in internet service provider sector according to years are given in Figure2.2. (ICTA, 2015)



**Figure 2.2.** The market share of leader firms in internet service provider sector

According to Figure 2.2, it is clear that TTNET has leading the field in internet provider sector. The major reason of low competition in this sector is continuousness dominance of TTNET owned by Turk Telekom which is the monopoly in the fixed-line market. Only 3G technology can change the competition of this sector (Yıldız, 2012).

## 2.2. Campaigns

Designing the specific activities to promote a product, service or business can be called as “Campaign”. A marketing campaign is required many different studies in sequence. These studies consist of promotion of a product using different media such as television, radio and print.

Campaign is a political, social and economic attempt of every kind within a given period of time to carry out an effort, business or work. This is referred to propaganda, as well. (<https://tr.wikipedia.org/wiki/Kampanya>, 2015)

The companies have to focus more on the campaign creation activities due to the fact that the distance between the producer and consumer is getting longer, there are many products with almost the same features, consumers are forced to contact with the

competition companies and the awareness of the customers are increased.

Advertisement Campaign means a set of advertisement events which are planned with all details to fulfill the special objective of the advertisement events and to reach the general marketing and sales targets by the business organizations. Derived from the Latin word of "Kampagne", the word of campaign was first used in World War II to define the military actions and then entered into the literature of "Marketing" and "Business Management" together with the other military concepts such as "Strategy" and "Operation" (Kienle, 1964).

In Turkey, firms' most common marketing tool is "product (selling) campaigns". Especially, the retail brands organize campaigns in particular periods for maximizing their product sales. Installments and discounts are the most attractive campaigns for the consumers.

### **2.2.1. Campaign Creation**

In order to reach the marketing targets or fulfill the special targets of the advertisement, a set of advertisement events which are planned in detail should come together and such events are referred to as "campaign creation". Campaign Creation is a long process which is based on the planning, implementation of many activities and control of them in line with the certain strategies and targets upon analyzing the current status on an original subject.

Considering in terms of the campaign events, we can consider it as a process which has been made up of a set of phases. As of its nature, campaign creation process is a decision making and problem solving process. For that reason, advertisement campaign is a process where problems are defined, goals are set, information and data are collected for the objectives. Alternative solution suggestions are developed. The alternatives are evaluated in line with the target criteria. An optimum alternative is selected to implement. This alternative is tested and controlled and if optimal results are not taken, reasons of deviations are examined (Teker, 2009).

Great deals of companies try to retain customers and find new ones and open to new markets with their campaigns. Organizing a campaign is one of the effective solutions for any company to exist. Creating a new and effective campaign definitely requires a

significant preliminary preparation.

The steps for advertisement campaign creation can be listed below. These steps are prepared with marketing experts.

- Situation assessment and data collection
- Determining the objectives of creating advertising campaigns
- Determining the campaign strategy
- Determining the campaign budget
- Making the studies
- Media selection and retrieval of media decisions
- Application of advertising campaigns
- Evaluation of advertising campaign effectiveness

### **2.2.2. Campaigns in Internet Service Sectors**

Service sector is different from other sectors for customers. This sector provides consumers intangible service like health, telecommunication etc. People can't touch what they buy, they can benefit from services. In this sector, people expect to get the best service all of time. Internet service sector is one of the service sectors and it is the part of the telecommunication sector.

Making campaign in service sector is also different from production sector. In production sector, firms can perform basic campaigns based on account like "buy one get one". This is the most basic example for this sector. Service sector isn't like this sector. People can't cast away if they don't like a service. For instance, a person makes reservation for hotel. If he doesn't like the hotel, he can't get money because of dissatisfaction except special cases. But when a person buys a detergent, if he doesn't like the detergent, he can cast away. Because of this reason, making campaign and influencing consumers in service sector is harder than in production sector. People can think again and again before buying a service. Persuading people for a service requires a good campaign.

In internet service sector, campaign structure has basic features in Turkey. When a person mentions about internet campaign, commitment is the first thing that coming to mind. Internet campaigns require 12 or 24 month commitment and based on this commitment, firms provide discount for customers. At the same time, firms can give free modem when

customers give commitment. Customers can't break the commitment. If they break the commitment, they must pay the penalty in direct proportion to how much they benefit from the discount. Because of this reason, generally customers prefer to wait till the end of the commitment even they aren't grateful from the service quality.

Internet service sector, campaigns involve lots of different packages based on internet infrastructure and quota. Internet infrastructure depends on customer location and it affects the speed of internet. Infrastructures provide customer limited speed which has maximum and minimum values. Customers can buy maximum speed paying more money. At the same time, quota amount depends on customer demand. Customers can buy more quota. Quota and price are directly proportional like speed and price. Customers can change their packages without breaking commitment in the same campaign.

In addition, internet campaigns can present free wi-fi or tv services on internet to create advantageous and attractive campaign. Internet campaign creators can't add very different thing to campaign because of limited structure of this service. The best way for campaign creators to make difference for customers is to provide low price with high quality service with minimum commitment.

In this sector campaigns are divided in two groups as below:

- Acquisition campaigns for new customers

Generally these campaigns present customers the lowest price with free modem. According to infrastructure of customer, suitable package is presented to customer.

- Retention campaigns for existing customers

Generally these campaigns are created as similar to customers' campaign. The market is so aggressive. Because of this reason, retention campaigns are important as much acquisition campaigns as to not decrease profit continuity.

In this sector, call centers are the most important elements for presenting campaigns to customers. People make application for internet connectivity via call centers or distributors. Generally, people prefer to buy a campaign because of low price. When their campaign commitment closes to end, call centers reach customers and they sell a new campaign with commitment. In this way, customers have commitment until they have internet connectivity. Furthermore, companies make special campaigns for customers

who use different internet brand. In this sector, people have commitment nearly all of time. If they break commitment, they have to pay penalty. Companies make transfer out campaigns to gain new customers and they accept to pay customer penalty instead of customers.



### **3. DECISION MAKING AND LITERATURE REVIEW**

#### **3.1. A General Outlook to Decision Making**

Decisions are a mirror of our experiments and expectations. People have to make decisions always and every decision making gives a final choice. Anybody doesn't know whether the final choice is the best choice exactly. Also, it isn't known strictly what happened if other choice was chosen. For the sake of example, decision making process isn't like adventure books in the real life. These adventure books give two ways to decision maker in the middle of book. If decision maker chooses first way, he reads from x. page but if he chooses second way, then reads from y. page. Generally, one of these decisions leads to die and the other leads to survive in the book. People can read the both of decision results even they don't choose but in real life, people can't return the moment of decision making. Another choice may be better or worst but it can't be ever known exactly. Because of that, people should take the optimum decision of all time. For the optimum decisions, people study with numerical data for decision making.

All these situations are valid for business life. Nowadays, competition in the markets increases and business environment becomes more aggressive day by day. In business life, decisions can bring profit or loss. To make correct decisions is very important and also it is very complex because of the difficulty of competitive environment, aggressive business life, and high number of alternatives and criteria. Also these difficulties can be summarized with 5 main matters. They are; uncertainty, complexity, multiple objectives, ambiguity and anxiety about consequences. Companies which can challenge and manage these 5 main points can make decisions truly and effectively and become superior to other firms.

There are three major elements for decision making which are information, objectives and alternatives. Objectives are very important to decision making. If there is no clear objective, it couldn't be talked about selection for the alternatives. If there is no information, alternatives couldn't be evaluated and sorted. Also, the number of alternatives must be more than one, because if there is one alternative, the choice will be this alternative (Howard 1988).

Making decisions correctly and effectively can be provided only by using quantitative measurement techniques. *"Psychologists and behavioral scientists have demonstrated*

*that good decision making is not a natural ability, “wired-in” following some evolutionary design.”* (Bratvold & Begg 2009). These actions bring decision making process and techniques.

A good decision has to depend on logic and a quantitative approach. Also it should consider all possible data and alternatives. Some decisions can have different features that it can be sensual or intuitional. They can be also good decisions. On the other hand, worst decisions do not depend on logic and they are not quantitative. Also these decisions are taken without using past data and considering all alternatives. In this setting, decision maker can make a bad decision but under favour of chance, the bad decision can produce good results. But, it doesn't change that it is a bad decision (Render & Stair, 1991).

### **3.2. Decision Making Process**

Frequently, too many alternatives and too many criteria are a matter of a choice. When increasing the number of alternatives and criteria, decision making becomes harder and more complex. On the other hand, criteria are divided into as tangible and intangible. In this case, intangible criteria must be returned measurable values. This hardness and complexity required a detail process for decision making. *“Decision theory is a body of knowledge and related analytical techniques of different degrees of formality designed to help a decision maker choose among a set of alternatives in light of their possible consequences.”* (Chen, 2005).

The main goal of this process defined like that decision making is a process to make a choice in many alternatives to catch the desired demand (Eisenfuhr, 2011).

Understanding the process of decision making is important to explain decision factors. The main difference of decision making process from person to person is decision making styles. In decision making studies, the bases of decisions and prior interests are keys for understanding the process (Deniz, 2002).

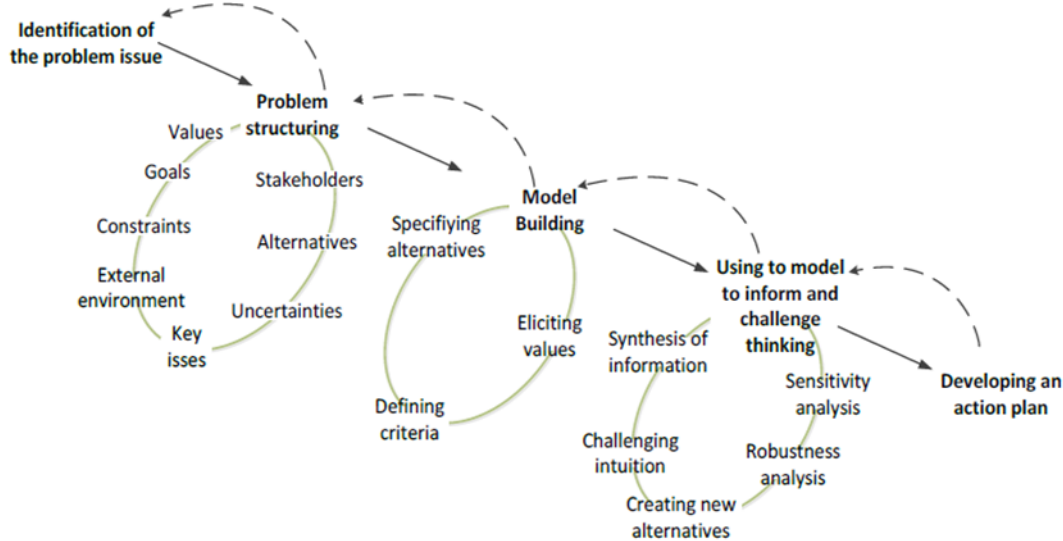
In decision making process, decision maker should get consistent and true data for the best and true choice. Otherwise, decision-maker can choose the wrong choice which can cause regrets and damages. If there is one constraint and one goal, decision making can be so easy, but when increasing the number of constraints, this process can be harder. Generally, some constraints need to be maximized and some constraints need to be minimized. In this situation, decision maker can use his logic and sense and they can

cause unintended consequences. In such circumstances, MCDM techniques can be used. These techniques are reformed to determine the best alternative along using consistent data (Steele et al., 2009). For choosing the best alternative, decision maker should pursue a decision making process.

Schoenfeld (2011) determine the decision making steps as below.

- Specifying the problem
- Generating the alternatives
- Evaluating the alternatives
- Selecting an alternative
- Making decision
- Evaluating decision effectiveness

Belton and Stewart (2002) determine the process of decision making which is illustrated in Figure 3.1.



**Figure 3.1.** Decision making process (Belton & Stewart, 2002)

The most important step is the first step in decision making process. In the first step, the main goal is to identify, determine and structure the problem unmitigated. After this step, all alternatives are determined and unnecessary alternatives can be removed. After problem definition and detected alternatives, the most suitable MCDM method is used and the decision is made.

Kepner and Tregoe (1976) indicated the importance of the first step. They developed a method for this suggestion. According to authors, the qualities of decision and definition problem are directly proportional. Their problem analysis includes these 4 steps:

- 1) Describing the problem,
- 2) Determining what the problem is and is not,
- 3) Prioritizing the problem,
- 4) Making tests for cause-effect relationships (Kepner & Tregoe, 1976)

### **3.3. Multi Criteria Decision Making**

Decisions are the keys for opening new doors. Some of them are good and some of them are bad. This action is special for humans and it is valid for personal life and professional life. Individuals generally have to face with problems. The problems become more complex in nowadays so decision making becomes harder evenly. At this time, existing methods for decision making may not be enough. Multi Criteria Decision Making (MCDM) techniques are improved to help decision maker with analytical and scientific side. Using MCDM techniques provide to open right doors.

The most famous branch of decision making is MCDM. It is a branch of a general class of operations research models regarding decisions problems under decision criteria. MCDM is methodological tool and it helps to struggle with complex engineering problems. This technique requires selection between decision alternatives described by their attributes. These problems have determined alternatives also their amount is limited. At the end of the solution of MCDM problems, decision maker gets sorting and ranking of alternatives. (Kahraman, 2008).

It is hard to make decisions when there are many parameters for the goal and there are many alternatives each of which has special advantages. In this situation, decision maker may choose an alternative without thinking that it's suitable or not for getting rid of instability uncaringly or decision maker can make doubtful decision at the end of the short and irrational analysis. The main purpose of using MDCM is to keep down decision making mechanism and reach to decision as far as possible easily and quickly when there are many alternatives and criteria (Heriřçakar, 1999).

When alternatives can't be compared and measured, MCDM methods offer solutions to decision maker that enables removing these incommensurable situations. In daily life, there are problems that have an alternative which can be superior to another alternative for a criterion. This alternative can be not superior for another criterion. This situation makes harder to make decision. MCDM methods support decision maker with various techniques for such problems (Urfalıoğlu & Genç, 2013).

MCDM is very important for decision making theory. According to the solution space of the problem, MCDM problems are divided into two classes: continuous and discrete. Multi Objective Decision Making (MODM) methods are improved for continuous alternatives. Furthermore, Multi-Attribute Decision Making (MADM) methods are improved for discrete alternatives. Existing literature, MADM is commonly used to describe the discrete MCDM (Babu et al., 2006).

When the decision space is continuous, MODM techniques are used. Mathematical programming problems are the examples of MODM problems. The one of the references to MODM problem is “vector-maximum” problem (Zimmermann, 1986). Furthermore, MCDM/MADM techniques include problems with discrete decision spaces. The set of decision alternatives has been destined in these problems (Triantaphyllou, 2000).

MCDM is making preference decisions (selecting, ranking, classifying, screening and prioritizing) over the available alternatives (finite number) that are characterized by attributes (multiple, conflicting, weighted and incommensurable) (Yoon & Hwang, 1995).

MADM may be considered as complex. It has dynamic two processes that involves managerial level and engineering level. Aims and alternatives are determined in managerial level. These aims and alternatives are called “optimal” and “satisfying”. MADM is focused at this managerial level. The engineering level of the MADM process includes ranking of alternatives on multiple attributes from the best to worst. Solution is created in the engineering level. Decision maker can accept or reject the solution (Li, 2009).

For decision problems in many different areas, various MCDM methods have been developed over the years and applied. There are many examples for MCDM problems in daily life and professional life. For example, a person who wants to buy a home has to

make decision in many criteria and alternatives. Also, these criteria and alternatives can't be directly proportional. In this situation, decision maker can't see the best or the optimum option. This person wants home that is near to the center, at the same time he wants economic home but houses which are near to the center are expensive. Also, this person wants a new home but new houses are more expensive than old. MCDM methods help the decision maker and it provides the optimum results.

### **3.4. Multi Criteria Decision Making Techniques**

Multi criteria decision making techniques are tools that provide to make the best decision in alternatives when there is more than one criterion. These techniques involve models that use the cardinal information (importance/weight) to solve complex problems which have conflicted criteria. These models are divided to subgroups according to their calculation principles. Hwang and Yoon composed these subgroups as scoring model, concordance/discordance model and compromising model in 1981 (Hwang & Yoon, 1981).

*“The aim of any multiple criteria decision making technique is to provide help and guidance to the decision maker in discovering his or her most desired solution to the problem (in the sense of that course of action which best achieves the decision maker's long term goals.)”* (Stewart, 1992).

The most popular multi criteria decision making techniques are listed below:

- AHP (Analytic Hierarchy Process)
- TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution)
- VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje)
- PROMETHEE (Preference Ranking Organization Method For Enrichment Evaluation)
- ELECTRE (ELimination Et Choix TRaduisant La REalit)
- ANP (Analytic Network Process)
- DEMATEL (Decision Making Trial and Evaluation Laboratory)

AHP is an example method for scoring models, ELECTRE is an example for concordance/discordance models and VIKOR can be regarded as an example for compromising models.

In this section, ELECTRE I, TOPSIS, PROMETHEE, AHP and VIKOR techniques are explained. Since FAHP, TOPSIS and VIKOR techniques are used in this study, they are detailed. Also, their application steps are given.

Some multi criteria decision making techniques are combined with fuzzy logic. Fuzzy logic is generally used for imprecise information or indication of a preferred structure. The common feature of fuzzy logic and fuzzy sets is the ability of modelling (Kahraman et al., 2004). Fuzzy logic makes it easy to decide for systems with incomplete information.

Mardani et al. (2015) presented a literature review which involves fuzzy multiple criteria decision making techniques (FMCDM) and applications from 1994-2014. According to this study, the most popular FMCDM techniques are listed as below:

- Fuzzy AHP
- Fuzzy TOPSIS
- Fuzzy ANP
- Fuzzy VIKOR
- Fuzzy ELECTRE
- Fuzzy DEMATEL
- Fuzzy PROMETHEE

In this study, FAHP method is used to determine the criteria weights. Depending on this fact, only FAHP method is explained and detailed in this section.

The historical improvement of MCDM techniques is given in Figure 3.2. (Tzeng & Huang, 2011).



### **3.4.1 ELECTRE**

The ELECTRE I is one of the methods of the ELECTRE (ELimination Et Choix TRaduisant La REalit - Elimination and Choice Translating Reality) family. ELECTRE involves seven methods (ELECTRE I, ELECTRE Iv, ELECTRE IS, ELECTRE II, ELECTRE III, ELECTRE IV, ELECTRE TRI). ELECTRE family pertains to the outranking methods. These methods are depended on outranking relationships regarding the preferences by the decision maker (Fernandes et al., 2015).

The first ELECTRE method was presented by Benayoun and his colleagues who are Roy and Sussman in 1966. They worked in SEMA which is European consultancy firm. This team worked on real world problems of how to make decision. Although this method was presented in 1966, the first journal article was published in 1968 by Roy (Govindan & Jepsen, 2015).

The ELECTRE method is a highly improved multi-criteria analysis model. Uncertainty and vagueness in the decision process are considered and taken into account by this method (Papadopoulos & Karagiannidis, 2008).

The main aim of ELECTRE I is the selection of the best alternative for multi-criteria problems. When the alternatives have different scales, this method can be applied. Outranking binary relations are used when the preferences are modeled. Considering two actions, four situations can occur:

- $xSy$  and not  $ySx$ , i.e.,  $xPy$  ( $x$  is preferable than  $y$ )
- $ySx$  and not  $xSy$ , i.e.,  $yPx$  ( $y$  is preferable than  $x$ )
- $xSy$  and  $ySx$ , i.e.,  $xIy$  ( $x$  is indifferent according to  $y$ )
- not  $xSy$  and not  $ySx$ , i.e.,  $xRy$  ( $x$  is incomparable according to  $y$ )

An outranking relationship main structure depends on two major concepts which are concordance and discordance. This method have two procedures; construction of one or more outranking relationships, followed by a research of the procedure (Figueira et al., 2005).

### **3.4.2. PROMETHEE**

Brans proposed PROMETHEE (Preference Ranking Organization Method For Enrichment Evaluation) method in 1982 than it was improved again by Brans and Vincke

in 1985 (Macharis, 2004).

One of the most using MCDM techniques is PROMETHEE. It consists of a family like PROMETHEE I, II, III, IV, V and VI and they belong to outranking methods (Kılıç et al., 2015).

PROMETHEE is a very clear and understandable method for decision makers. The most important thing for this method is determining the criteria which represent preference weights. Because of this reason, decision maker can determine the criteria easily. There are two different ways which can be used in this method. PROMETHEE I is used to obtain partial outranking at the result of comparing between determining criteria. PROMETHEE II is used to obtain clear outranking at the result of comparing between determining criteria (Çelik & Ustasüleyman, 2014).

Decision-maker should establish a weight  $p_j$ . This value increases with the importance of the criteria. Outranking degree  $\pi(a,b)$  for each pair of alternatives (a,b) is calculated as shown in the Eq, 3.1 and Eq 3.2:

$$\pi(a, b) = \frac{1}{P} \sum_{j=1}^n p_j F_j(a, b) \quad (3.1)$$

$$P = \sum_{j=1}^n p_j \quad (3.2)$$

$F(a,b)$  is a value between 0 and 1. This number increases when the advantage of an alternative is better than another for a criterion (Costa & Almeida, 2001).

PROMETHEE I is weak when alternatives can't be compared. For example, an alternative is the best for a criterion and other alternatives are worst for the same criterion. But for another criterion, this alternative is the worst and other alternatives are the best. In this situation, it is hard to solve this problem with PROMETHEE I.

### 3.4.3. TOPSIS

TOPSIS method (Technique for Order Preference by Similarity to an Ideal Solution) is developed by Hwang and Yoon in 1981 and then presented by Chen and Hwang in 1992. The main principle of this technique is selecting the alternative which has the shortest distance from the ideal solution. Also, it has the farthest distance from the negative ideal solution (Opricovic & Tzeng, 2004).

In this method, the aim of positive ideal solution is to maximize the benefit criteria and also minimize the cost criteria. Furthermore, the aim of negative ideal solution is to maximize the cost criteria and minimize the benefit criteria (Ghosh, 2011).

In this method, alternatives are ranked based on ideal solution similarity. Alternative has a higher grade when it is closer to ideal solution. For measuring similarity of a design to ideal level and non-ideal level, distance of that design from ideal and non-ideal solution is considered (Bhutia & Phipon, 2012).

TOPSIS approach uses ELECTRE method approach. Both of these methods are based on the closeness of decision points to the ideal solution. The solution process of TOPSIS is shorter than ELECTRE. TOPSIS has 6 steps for solution, first and second steps are same.

The criteria consideration of TOPSIS can be categorized as below:

1. Qualitative benefit
2. Quantitative benefit
3. Cost

Alternatives can be categorized as below:

1. Ideal: The best one for all attributes considered.
2. Negative ideal: The worst one for all attributes considered.

TOPSIS assumes that there are n criteria/attributes and m alternatives. Also, there are weights of each choice regarding each criterion (Dodangeh et al., 2009).

Before solving the problem using TOPSIS method, TOPSIS decision matrix should be created. The TOPSIS matrix is shown in the Eq. 3.3.

$$D = \begin{matrix} & \begin{matrix} C_1 & C_2 & \dots & C_j & C_n \end{matrix} \\ \begin{matrix} A_1 \\ \vdots \\ A_i \\ A_m \end{matrix} & \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1j} & X_{1n} \\ \vdots & \vdots & \dots & \vdots & \vdots \\ X_{i1} & X_{i2} & \dots & X_{ij} & X_{in} \\ X_{m1} & X_{m2} & \dots & X_{mj} & X_{mn} \end{bmatrix} \end{matrix} \quad (3.3)$$

The traditional TOPSIS method steps are shown as below:

**Step 1:** Calculate the normalized decision matrix

TOPSIS method provides the evaluation criteria in different measurement units, in this situation it is required to normalize criteria values. The normalization process solves using Euclidean technique. The ideal and anti-ideal distances are calculated.  $X_{ij}$  which is the normalization of element of the decision matrix is calculated as shown in the Eq. 3.4:

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^n (X_{ij})^2}} \quad i=1,..n \text{ (\# of alternatives) and } j=1,..m \text{ (\#of criteria)} \quad (3.4)$$

**Step 2:** Calculate the weighted normalized decision matrix

Firstly, the weights of criteria are calculated according to the aim of problem. Calculation of the weighted normalized value  $v_{ij}$  is shown in the Eq 3.5. Then the weighted normalized decision matrix is created.

$$v_{ij} = w_{ij} * r_{ij} \quad (3.5)$$

**Step 3:** Determine the “positive ideal” and “negative ideal” alternatives

While creating the positive ideal solution set, the maximum value of each weighted criterion is chosen. In other saying, it is the biggest value of each column of V matrix. If the weighted criteria factor is inversely proportional like cost, the minimum value is chosen. The formulation of positive ideal set is shown like in the Eq. 3.6:

$$A^* = \{(max v_{ij} | j \in J), (min v_{ij} | j \in J')\} \quad (3.6)$$

Creating the negative ideal solution set, the minimum value of each weighted criterion is chosen. In other words, it is the minimum value of each column of V matrix. If the weighted criterion factor is inversely proportional like cost, the maximum value is chosen. The formulation of negative ideal set is shown like in the Eq. 3.7:

$$A^- = \{(min v_{ij} | j \in J), (max v_{ij} | j \in J')\} \quad (3.7)$$

The positive ideal set can be shown as:  $A^* = \{v_1^*, v_2^*, \dots, v_n^*\}$

The negative ideal set can be shown as:  $A^- = \{v_1^-, v_2^-, \dots, v_n^-\}$

$J$  is correlating with benefit criteria and  $J'$  is correlating with cost criteria in both of the formulations.

**Step 4:** Calculate the separation distances

The separation from the positive ideal and negative ideal for each alternative is calculated using Euclidean distance approach.

Positive ideal separation is calculated as shown in the Eq. 3.8:

$$S_i^* = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^*)^2} \quad (3.8)$$

Negative ideal separation is calculated as shown in the Eq. 3.9:

$$S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2} \quad (3.9)$$

**Step 5:** Calculate the relative proximity to the ideal solution

Positive and negative ideal separation values are used to calculate the relative proximity ( $C_i^*$ ). The formulation is given as shown in the Eq. 3.10:

$$C_i^* = \frac{S_i^-}{(S_i^* + S_i^-)}, 0 \leq C_i^* \leq 1 \quad (3.10)$$

$C_i^* = 1$  is shown as the closeness to positive ideal solution,

$C_i^* = 0$  is shown as the closeness to negative ideal solution.

**Step 6:** Preference order

$C_i^*$  is used to order the alternatives. The greater proximity value of  $C_i^*$  means higher

priority. In short, the maximum value of  $C_i^*$  is to refer the best alternative. According to these values, alternatives can be ranked.

#### **3.4.4. VIKOR**

VIKOR method (Vise Kriterijumska Optimizacija I Kompromisno Resenje, it is the Serbian name and has the meaning Multicriteria Optimization and Compromise Solution) was improved by Serafim Opricovic in 1998.

The aim of VIKOR method is to obtain a compromise sorting and a compromise solution under the determined weights. It is provide to select the most suitable alternative under conflict criteria. VIKOR method approach is based on closeness to ideal solution. When problems have conflicting criteria, compromise solution helps to decision makers for final decision (Ertuğrul & Karakaşoğlu, 2009.a).

A discrete decision problem under conflicting and non-commensurable criteria can be solved by VIKOR method. This method provides to sort a set of alternatives. Also, it suggests compromise solutions for problem in order to help decision maker to make a final decision. The closest to the ideal shows the feasible solution and it is the compromise solution. Reaching an agreement by making mutual concessions can be called as compromise (Hung & Tzeng, 2010).

On the assumption that alternatives are evaluated for each criterion, compromise sorting is determined regarding comparison closeness to ideal solution (Tayyar & Arslan, 2013).

The basic of compromise solution was found by Yu in 1973. The solution where is the closest to ideal is compromise solution. Compromise means that agreement on common admission (Opricovic & Tzeng, 2004).

Since compromise solution ensures maximum group utility for majority and provides minimum regret for opponent, decision maker can accept it (Opricovic & Tzeng, 2007).

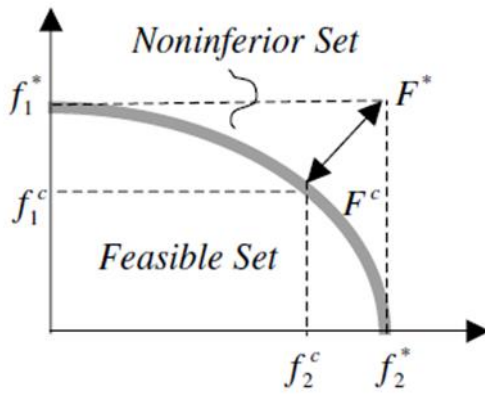
In the last decade, VIKOR has become a more popular decision support tool for real-life problems involving lots of criteria and alternatives (Lin et al., 2013).

The compromise ranking with multicriteria measure is based on  $L_p$ -metric. In compromise programming method, it is used as an aggregating function (Yu, 1973). The various  $j$  alternatives are shown as  $a_1, a_2, \dots, a_j$ .  $f_{ij}$  is the value of  $i$  th criterion for the

alternative  $a_j$ . It's formulated as shown in the Eq 3.11.

$$L_{p,j} = \left\{ \sum_{i=1}^n [w_i(f_i^* - f_{ij}) / (f_i^* - f_i^-)]^p \right\}^{1/p}, \quad 1 \leq p \leq \infty; j = 1, 2, \dots, J. \quad (3.11)$$

$L_{pj}$  (as  $S_j$  in Eq.(3.12)) and  $L_{\infty,j}$  (as  $R_j$  in Eq. (3.13)) are used to formulate ranking measure. Minimum value of  $R_j$  is equal to the minimum individual regret of the “opponent”. Minimum value of  $S_j$  is equal to the maximum group utility. The compromise solution represents  $F_c$  is a feasible solution that is the “closest” to the ideal  $F^*$ . It is illustrated in Fig. 3.3 by  $\Delta f_1 = f_1^* - f_1^c$  and  $\Delta f_2 = f_2^* - f_2^c$  (Opricovic & Tzeng, 2004).



**Figure 3.3.** Ideal and compromise solutions

The VIKOR method includes 5 main steps:

**Step 1:** Determine the positive ideal and negative-ideal solutions

For each criterion, the best  $f_i^*$  and the worst  $f_i^-$  values are obtained. If the criterion “i” can be accepted as benefit for model then:

“i” represents the criterion and “j” represents the alternative. They are shown in the Eq 3.12.

$$f_i^* = \begin{cases} \max_j f_{ij}, & f_i^* = \min_j f_{ij} \text{ if criterion is cost} \\ \min_i f_{ij}, & f_i^- = \max_j f_{ij} \text{ otherwise} \end{cases} \quad (3.12)$$

**Step 2:** Calculate the utility measure and the regret measure

For each alternative,  $S_j$  and  $R_j$  values are calculated as shown in Eq. 3.13 and 3.14.

“ $w_i$ ” represents the importance weight of the criterion then:

$$S_j = \sum_{i=1}^n w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \quad (3.13)$$

$$R_j = \max \left[ w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right] \quad (3.14)$$

**Step 3:** Calculate the VIKOR index

$Q_j$  values are computed for each alternative, as shown in Eq. 3.15

$$Q_j = v(S_j - S^*) / (S^- - S^*) + (1-v)(R_j - R^*) / (R^- - R^*) \quad (3.15)$$

Where;  $S^* = \min_j S_j$ ;  $S^- = \max_j S_j$ ;  $R^* = \min_j R_j$ ;  $R^- = \max_j R_j$

“ $v$ ” is the importance weight of the strategy for the maximum group utility. At the same time, “ $1-v$ ” represents the importance weight of the minimum individual regret of the “opponent”.

**Step 4:** Rank the order of preference according to  $Q_j$ ,  $S_j$  and  $R_j$

The obtained values of  $Q_j$ ,  $S_j$  and  $R_j$  are ranked increasingly. The alternative which has the lowest value of  $Q_j$  is the best alternative.

**Step 5:** Evaluate the results

Two conditions must be satisfied for the results to be valid. They are:

*Condition 1:* Acceptable advantage

When alternatives rank based on VIKOR index values ( $Q$ ), there must be considerable difference among the best alternative and the second alternative.

According to ranking of  $Q$  values increasingly,  $P1$  shows the first and  $P2$  shows the

second best alternative. The Eq. 3.16 satisfies this condition.

$$Q(P_2) - Q(P_1) \geq D(Q), D(Q) = 1/(j - 1) \quad (3.16)$$

*Condition 2: Acceptable stability in decision making*

This condition proves the stability of the compromise solution. The best Q value which represents as P1 must be in the first rank at least in one of the rankings regarding S and R.

This compromise solution becomes stable, where the strategy of maximum group utility (when  $v > 0.5$  is needed), or “by consensus”  $v \approx 0.5$ , or “with veto” ( $v < 0.5$ ). (Opricovic & Tzeng, 2007)

If one of the two conditions is not satisfied, the compromise solution set is proposed as follows:

- (i) If the second condition is not satisfied, the alternatives  $P_1$  and  $P_2$  are regarded.
- (ii) If the first condition is not satisfied, the alternatives  $P_1, P_2, \dots, P_m$  are regarded where  $P_m$  is determined by the Eq. 3.17.

$$Q(P_m) - Q(P_1) < D(Q) \quad (3.17)$$

VIKOR method provides solutions for MCDM problems which have attributes as the following (Opricovic & Tzeng, 2007):

- If there is conflict problem, compromising solution should be acceptable.
- The solution which is the closest to ideal is acceptable by decision maker and decision maker is willful to accept.
- Criteria have different units and they are conflict with each other.
- Each alternative should be evaluated with respect to each criterion.
- The preference is imported by weights by decision maker.
- Without the participation of the decision maker, problem can be solved with VIKOR method but decision maker should participate the final solution. The preference is specified by him/her.
- At the end of the solution, the recommended compromise solution has an

advantage rate. Compromise solution can be one or more.

### **3.4.5. AHP**

Thomas L. Saaty developed AHP (Analytic Hierarchy Process) in mid-1970's at the Wharton Business School of the University of Pennsylvania. It is a mathematical theory and provides contribution to decision making (Saaty & Niemira, 2006).

AHP method is one of the commonly used MCDM techniques. AHP is used in lots of decision making processes in various areas. Automobile selection (Byun, 2001), information system selection (Wei et al., 2005), vendor selection (Tam & Tummala, 2001), supplier selection (Parthiban et al., 2012) project selection (Amiri, 2010) are some of areas.

Many organizations and government managers used AHP method while making major policy decisions (Vivekanandan et al., 2009).

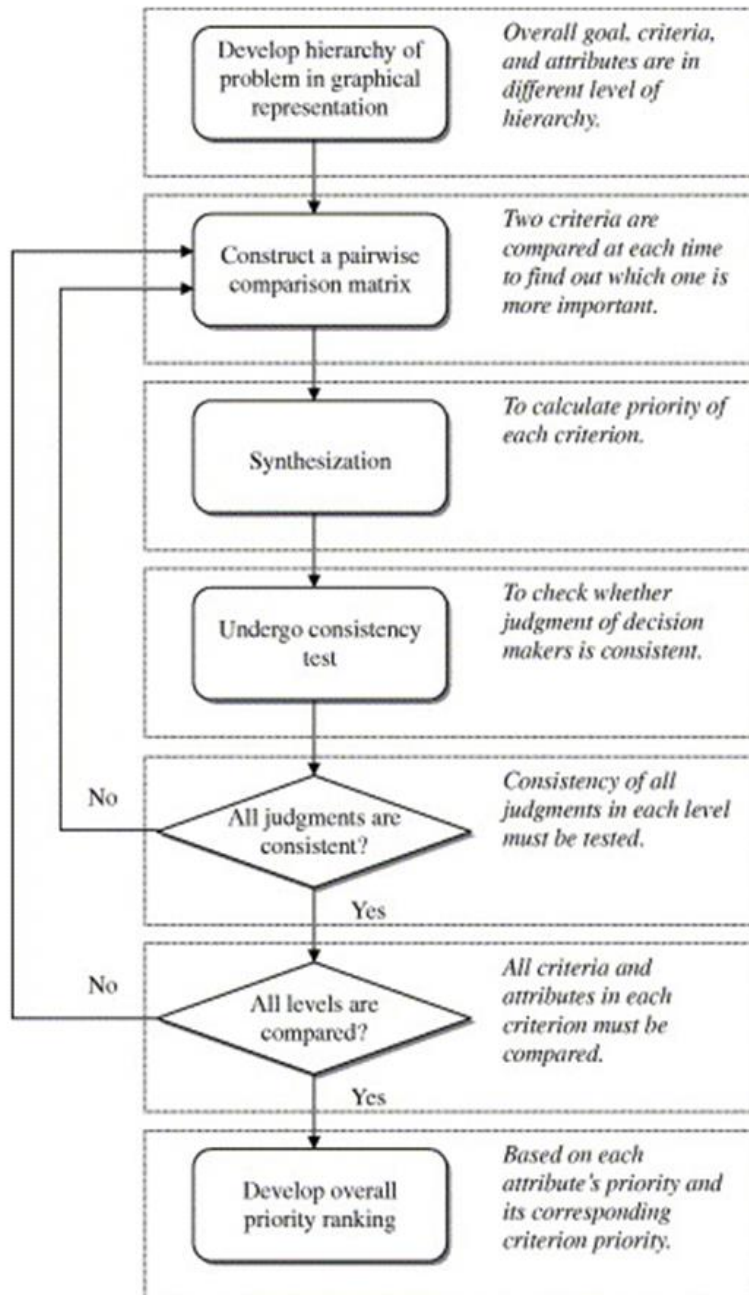
Decision maker must know and define: the problem, the requirements and aim of the decision, the criteria/sub criteria, alternatives, and stakeholders and groups affected to make a good decision. Criteria and sub criteria can be tangible or intangible (Saaty, 2008).

AHP is a useful method to reach a quantitative solution for decision making problems thanks to analytical thinking, manmade, and basic observation over measurements. AHP has flexible structure. This structure provides the ability to identify problem, to approach to cases individuals' or group's self-assumptions and share own ideas for solution. At the same time, in this method it is possible to test the sensitivity of result thereby change information by individuals. AHP is the process used for solution of complex politics, social and economic problems. It is designed for compromise. AHP compounds judgements and personal values logically. Also, it is designed as a process to understand, identify and judge the system completely (Saaty, 1990).

AHP is a beneficial and useful method for MCDM problems to determine the weights of each alternative and it has three main sections. They are hierarchy structure, pairwise comparison matrix and determining of weights. Human judgment is forefront in AHP method. The judgement comes from this calculation: decision maker calculates the pairwise comparison ratios according to strength of preference between factors of

comparison. Decreasing the subjective ratio of solution, more objective weights should be added to calculation (Xia & Vu, 2007).

Ho et al. (2006) summarized AHP steps in a flowchart as in Figure 3.4:



**Figure 3.4.** The flowchart of AHP (Ho et al., 2006)

Al-Harbi (2001) compiled and listed AHP steps from Saaty publications in 1980, 1985, 1990 and 1991.

**Step 1:** Definition of problem and goals

It is the most important step to reach the best selection. Problem and goal are determined and solution is shaped according to this definition.

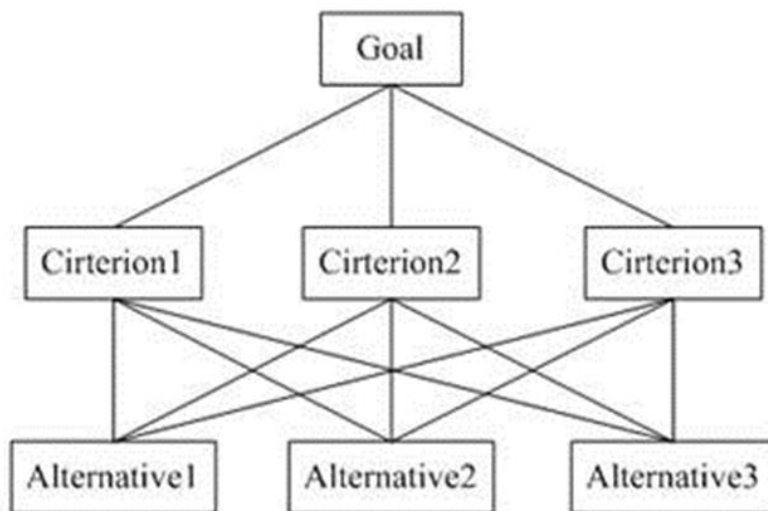
**Step 2:** Design of the AHP hierarchy

Goal, criteria and alternatives take part in this hierarchy structure. The goal of the decision making is on the top of the hierarchy. Criteria which are affected by goal are in the intermediate levels and finally, there are alternatives at the lowest level.

This structure is important to execute the relationship between criteria and alternatives. If there is no relationship, it can be understood from this hierarchy (its connection can't be done). Decision makers should take out alternatives which are impracticable and incompatible with any criteria (de FSM Russo & Camanho, 2015).

Determining the number of criteria and enable to define their effects truly is very important to make pairwise comparison properly and logically.

The structure of AHP hierarchy is shown in Figure 3.5 below:



**Figure 3.5.** The hierarchy of AHP

**Step 3:** Construct matrices to calculate a set of pairwise comparison

The pair-wise comparison matrices show criteria which dominate the other. The matrix size has n\*n structure. Matrices are created for all alternative which are in the lowest level. For these matrices, each criterion which is at intermediate level, is placed in both

of horizontal and vertical axis for comparison. These matrices are filled using “Pair-wise comparison scale for AHP preferences” as shown in Table 3.1.

**Table 3.1.** Pair-wise comparison scale for AHP preferences (Saaty, 1988)

Intensity	of	Definition	Explanation
1		Equal importance	Two activities contribute equally to the objective
3		Weak importance	Experience and judgment slightly favour one activity over another
5		Essential or strong importance	Experience and judgment strongly favour one activity over another
7		Demonstrated importance	An activity is strongly favoured and its dominance demonstrated in practice
9		Absolute importance	The evidence favoring one activity over another is of the highest possible order of
2,4,6,8		Intermediate	Where compromise is needed
Reciprocals of the nonzero	of	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

**Step 4:** Calculate the relative weight of the elements to each level

The principal eigenvalue of matrices is calculated after pair-wise comparison matrices are obtained. This is provided by normalization. For weighting the eigenvectors according to the weights of the criteria, hierarchical synthesis is used. The sum of all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy is used.

**Step 5:** Calculate the consistency ratio

The solution of AHP is based on pair-wise comparison of decision maker and it includes

individuals' judgements. It affects AHP consistency directly. AHP method suggests controlling the consistency in this step.

In this step CR (Consistency Ratio) is calculated and this ratio provides to control the pairwise comparison among the criteria. CR can be found by this following Eq. 3.18.

$$CR = \frac{CI}{RI} \tag{3.18}$$

Consistency Index (CI) is calculated with this ratio;  $(\lambda_{max}/n)/(n/1)$  where max is the maximum eigenvalue of the judgement matrix. Then CI compares Random Index (RI) values. RI values regarding the number of factors are given in Table.3.2.

**Table 3.2.** Average random index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

The CR shouldn't exceed 0,10. If it exceeds, it means that matrix is inconsistent. In this case, judgments should be reviewed and improved.

**Step 6: Ranking options**

The rating of all alternative separately is multiplied by the weights of the sub-criteria. They are aggregated to get local ratings regarding each criterion. The next step is to multiply the local ratings by the weights of the criteria and to aggregate to provide global ratings. Weight values for each alternative are calculated by AHP depended on the judged importance values of one alternative than another regarding a common criterion.

**3.4.6. Fuzzy AHP**

Fuzzy set theory was developed by Lotfali Askar Zadeh in 1965 to deal with vagueness of human thought. This theory bases on rationality of uncertainty because of imprecision. Fuzzy logic involves approximate values which are not certain. Values are shown between 0-1 and information is expressed like big, middle, very and low. This method is very suitable for problems which have hard mathematical model (Dağdeviren, 2005).

In classical logic, there are right and wrong. If it is right, it is expressed as “1”, if it is

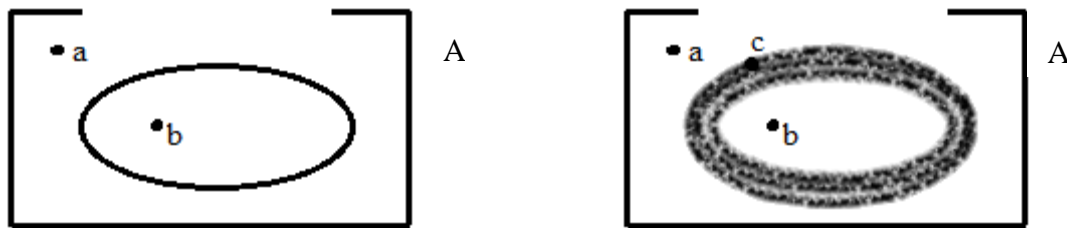
wrong it is accepted as “0”. But in real life, when people evaluate something, they don’t express their thoughts like absolute right and absolute wrong because of perceptive difference. For instance, the weather is so hot according to some people and it is little hot according to other people. This situation is originated from perceptive difference and there is uncertainty. Which air temperature is so hot or little hot can’t be designated. Everyone achieved the same result with information in everywhere; it can be mentioned about certainty. But information is perceived and interpreted differently from person to person, it can be mentioned about uncertainty. This linguistic uncertainty is solved with fuzzy logic. These linguistic expressions, words and sentences that cause linguistic uncertainty, are known as “linguistic variables” (Zadeh, 1987). “Fuzzy Set Theory” was developed to make the linguistic uncertainty meaningful.

The “uncertainty” concept which is used continuously in daily life can be made meaningful with “fuzzy set theory”. In other words, a fuzzy set provides to express linguistic uncertainty mathematically. Uncertainty is that what happened is known but there is not enough information about possibility of what happens. Furthermore, in uncertainty situation, it isn’t known which alternative involves the result (Terceno et al., 2003).

For instance, “middle age” concept is differing from person to person. This concept can’t be formalized mathematically easily because there are no exact boundaries. Generally, 35 and 55 ages can be boundaries of middle age. When this concept is expressed graphically, the curve is named as “belonging curve”. This curve shows interval of values. Objects can belong to fuzzy set infinitely with varying degrees simultaneously. The only limitation is that this should be one of two membership degrees. For example, the weather is cool with the ratio of 20%, it should be not cool with ratio of 80%. In classical logic, the weather is cool or not. Because of this reason, this logic loses reality. In fuzzy logic, linguistic variables are also important. Linguistic variables express variables like “cool” or “hot” (Tekindal & Erümit, 2007).

In fuzzy set, all elements are represented by their member degree (Saaty, 2000). In classical sets, there are only white and black areas and they are separated by exact boundaries. But in the fuzzy sets there are grey areas. The white areas are used to show not element of cluster. The black areas are used to show element of cluster. The grey

areas express to partial membership. It is illustrated in Figure 3.6 (a) and (b)(Ross, 2004).



**Figure 3.6.** (a) Classic cluster boundaries and membership (b) Fuzzy cluster and membership

In fuzzy logic, the membership degree of elements of cluster is shown by  $\mu(x)$ . It is expressed as the ratio of belonging to the cluster.

Yager studied on fuzzy AHP in 1978 firstly. In this study, Yager suggested a method for multi criteria decision making problems (Yager, 1978). This method makes easier to make evaluation and make a decision in uncertainty situations.

According to Zadeh (1965), fuzzy logic has 3 different features (McNeill&Freiberger, 1994):

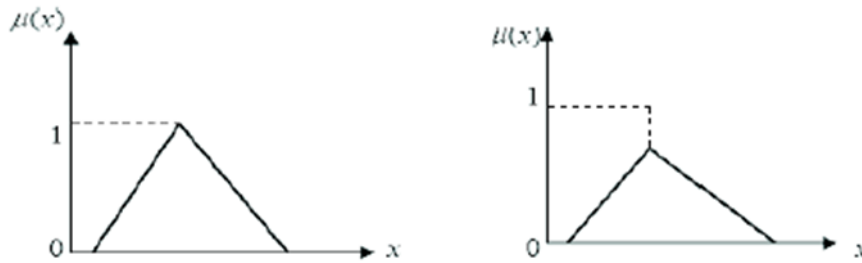
- 1) The truth value of fuzzy logic are words, not numbers.
- 2) These words are like very right, bit right, bit wrong, etc. The tables of fuzzy logic don't involve certainties.
- 3) It isn't mentioned about exact right.

The best advantage of FAHP is that it makes decision making easier for multi criteria problems. It is hard to create the deterministic preference for decision maker but in this method perception-based judge intervals can be used by decision maker. Also in AHP method, it can be mentioned about judgements all of time. Because of this reason, fuzzy logic completes the decision making process more accurately for AHP (Kuo et al.kuo, 2012).

### *Fuzzy numbers*

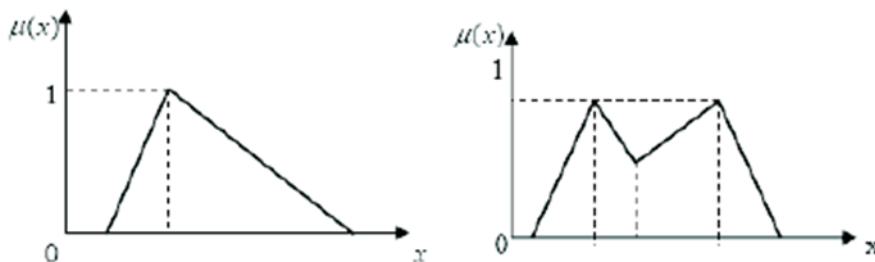
A fuzzy number is generalization of a regular, real number. It doesn't refer to a single value. It has connected set of possible values. Each possible value takes own weight which is between 0 and 1 and it means the membership function. Extensions of real numbers are fuzzy numbers.

If the weight equals to 1 for at least one element of fuzzy sets, that is to say that it is element of fuzzy set exactly, these sets are normal fuzzy sets. Membership weight is "1", which is the main example of the cluster members. The Fig.3.7 shows normal fuzzy cluster (a) and not normal fuzzy clusters.



**Figure 3.7.** (a) Normal fuzzy cluster (b) Not normal fuzzy cluster

If the fuzzy cluster has membership that their weights increase or decrease in a monotonous way, it is convex. Also these weights can increase than decrease in a monotonous way. It makes the fuzzy cluster to convex. The Fig.3.8 shows convex fuzzy cluster (a) and non-convex fuzzy clusters (b).



**Figure 3.8.**(a) Convex fuzzy cluster (b) Non-convex fuzzy cluster

If a fuzzy cluster is convex and close, the parameters of the fuzzy cluster can be expressed “fuzzy numbers”.

Triangular fuzzy numbers (TFN) have computational simplicity and it provides to use TFNs in applications (Moon & Kang, 2001). In a fuzzy environment, TFNs are convenient to promote representation and process information (Liang & Wang, 1993). Because of these advantages, they were used in this study.

A TFN can be represented by a triplet (l, m, u). Its membership function  $\mu_A(x)$  can be defined by Eq. 3.19 as below (Chang, 1996).

$$\mu_A(x) = \begin{cases} \frac{x-l}{m-l}, & l \leq x \leq m \\ \frac{u-x}{u-m}, & m \leq x \leq u \\ 0, & \text{otherwise} \end{cases} \quad (3.19)$$

There are various operations on TFNs. In this study, three important operations are used and they are shown as below:

$l, m, u$  are real numbers.  $A$  and  $B$  are the TFNs  $A=(l_1, m_1, u_1)$  and  $B=(l_2, m_2, u_2)$ . Then:

1) *Addition:*

$$\begin{aligned} A(+ )B &= (l_1, m_1, u_1)(+)(l_2, m_2, u_2) \\ &= (l_1+l_2, m_1+m_2, u_1+u_2) \end{aligned}$$

2) *Multiplication:*

$$\begin{aligned} A.B &= (l_1, m_1, u_1).(l_2, m_2, u_2) \\ &= (l_1l_2, m_1m_2, u_1u_2) \end{aligned}$$

3) *Inverse:*

$$(l_1, m_1, u_1)^{-1} \approx \left( \frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1} \right)$$

### *Steps of FAHP*

**Step 1:** Decision maker compares the criteria according to linguistic terms

The pairwise comparison matrix is a square matrix that shows the relative importance of compared factors (Saaty, 2000). In AHP method, comparison should be done by experts because results depend on judgements of decision makers in this method. These judgements are converted to numerical values. At the end, pairwise comparison matrixes

are created. The decision is taken with numerical values using linguistic expressions. Saaty provided the scale to convert the pairwise comparison to quantitative data in Table 3.3. Linguistic expressions are converted to triangular numbers.

**Table 3.3.** Linguistic Terms and The Corresponding Triangular Fuzzy Numbers (Saaty, 1988)

Saaty scale	Definition	Fuzzy Triangular Scale
1	Equally important	(1, 1, 1)
3	Weakly important	(2, 3, 4)
5	Fairly important	(4, 5, 6)
7	Strongly important	(6, 7, 8)
9	Absolutely important	(9, 9, 9)
2		(1, 2, 3)
4	The intermittent values between two adjacent scales	(3, 4, 5)
6		(5, 6, 7)
8		(7, 8, 9)

The pair-wise contribution matrix is given in Eq. 3.20 according to the TFNs of these linguistic terms.  $\widetilde{d}_{ij}^k$  shows the  $k^{\text{th}}$  decision maker's preference of  $i^{\text{th}}$  criterion over  $j^{\text{th}}$  criterion through TFNs.

The triangular number demonstration is represented by "Tilde". For instance,  $\widetilde{d}_{12}^1$  shows the first decision maker's preference of first criterion than second criterion.

$$\widetilde{A}^k = \begin{bmatrix} \widetilde{d}_{11}^k & \widetilde{d}_{12}^k & \dots & \widetilde{d}_{1n}^k \\ \widetilde{d}_{21}^k & \dots & \dots & \widetilde{d}_{2n}^k \\ \dots & \dots & \dots & \dots \\ \widetilde{d}_{n1}^k & \widetilde{d}_{n2}^k & \dots & \widetilde{d}_{nn}^k \end{bmatrix} \quad (3.20)$$

Preferences of each decision maker  $\tilde{d}_{ij}^k$  are averaged and  $\tilde{d}_{ij}$  values are calculated as in the Eq. 3.21 when the number of decision maker is more than one.

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^K \tilde{d}_{ij}^k}{K} \quad (3.21)$$

**Step 2:** Aggregate the Group Decisions

Pair wise contribution matrix is created depending on averaged preferences and it is shown in Eq. 3.22.

$$\tilde{A} = \begin{bmatrix} \tilde{d}_{11} & \cdots & \tilde{d}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{d}_{n1} & \cdots & \tilde{d}_{nn} \end{bmatrix} \quad (3.22)$$

**Step 3:** As shown in Eq. 3.23, Buckley (1985) calculated the geometric mean of fuzzy comparison values of each criterion.  $\tilde{r}_i$  shows triangular values.

$$\tilde{r}_i = \left( \prod_{j=1}^n \tilde{d}_{ij} \right)^{1/n}, i=1, 2, \dots, n \quad (3.23)$$

**Step 4:** Each criterion fuzzy weights can be calculated by incorporating next 3 sub steps. The formulation is given in Eq. 3.24.

**Step 4a:** Find the vector summation of each  $\tilde{r}_i$ .

**Step 4b:** Find the reciprocal of summation vector. Replace the fuzzy triangular number, to make it in an increasing order.

**Step 4c:** To find the fuzzy weight of criterion i  $\tilde{w}_i$  multiply each  $\tilde{r}_i$  with this reciprocal vector. The formulation is given in Eq.(3.24).

$$\begin{aligned}\tilde{w}_i &= \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \dots \oplus \tilde{r}_n)^{-1} \\ &= (lw_i, mw_i, uw_i)\end{aligned}\quad (3.24)$$

**Step 5:** Since  $\tilde{w}_i$  are still fuzzy triangular numbers. Chou and Chang (2008) de-fuzzified these numbers by Centre of area method, through the Eq. 3.25.

$$M_i = \frac{lw_i + mw_i + uw_i}{3}\quad (3.25)$$

**Step 6:** Since  $M_i$  is a non fuzzy number, it must be normalized with Eq. 3.26.

$$N_i = \frac{M_i}{\sum_{i=1}^n M_i}\quad (3.26)$$

At the end of the 6 steps, the normalized weights of criteria are handled. Each alternative weight is multiplied with related criteria to calculate the scores for each. Decision maker should prefer the alternative with the highest score.

### 3.5. Hybrid Multicriteria Decision Making Techniques

MCDM techniques are used in various areas with different combination. According to a literature review study, 215 Hybrid MCDM techniques were applied from 1994 to 2014 in different areas (Mardani et al., 2015).

In this section, only the techniques used in this study are analyzed in detail. Hence, the studies involving FAHP – TOPSIS, FAHP – VIKOR and FAHP – TOPSIS- VIKOR methods are examined and summarized in Table 3.4.

#### 3.5.1. FUZZY AHP – TOPSIS

There are 11 summaries of studies which are used in FAHP-TOPSIS methodologies integratedly.

Ertuğrul and Karakaşoğlu (2009.b) evaluated cement firms in Turkey by using these two methods. Cement demand has increased regarding construction sector and cement firm selection has become more important for this sector. For decision making, financial ratio

tables of alternative firms were used. 5 main different financial ratio and 18 sub ratio were evaluated as criteria and 15 Turkish cement firms in the İstanbul Stock Exchange consisted of alternatives for the evaluation. FAHP method was used to calculate importance weights of criteria and TOPSIS was used to rank the alternatives. There were decision makers from different areas such as investors, shareholders etc. to calculate the importance weights. Because of this reason, results show general ranking and this ranking can be different for specific areas like for investors or shareholders.

Gümüş (2009) evaluated hazardous waste transportation firms. Waste management in developing countries is complex and very important for future. In this paper, hazardous waste management was detailed and 8 main criteria were chosen to calculate the importance weight. These criteria were determined using modified Delphi method by 15 experts. 5 alternative firms were handled for evaluation. At the same time, using linguistic variables was provided to make realistic evaluation.

Ballı and Korukoğlu (2009) proposed a model for selection of computer operating system. All computers have an operating system to run programs and applications. Selection of the right operating system is very important for companies to decrease cost, time efficiency and increase quality. There were 7 main criteria and 21 sub criteria to create a model. Also, there were 3 alternative. There were subjective and uncertain judgements because of this reason FAHP method was used to determine the importance weight. TOPSIS method was used to rank the 3 operating systems.

Seçme et al. (2009) proposed a fuzzy MCDM model to evaluate the performance of Turkish banks. Bank performance is very important for creditors, investors and stakeholders. Largest five banks were chosen and examined to create model. They were evaluated using FAHP according to financial and non-financial indicators separately. Non-financial criteria had subjectivity and fuzzy numbers helped to convert this subjectivity to numerical values.

Tadić et al. (2010) proposed a method for End-of Life Vehicles (ELV) dismantling selection. Main goal of this study was to make a sequence for ELVs dismantling in dismantling center. ELV recycling process is very important for car manufacturers. There were 6 main criteria. In this paper alternatives weren't given, there was only proposed model for dismantling ranking of vehicles in dismantling center. These

vehicles will be alternatives for the model when it will be used.

Mikaeil et al. (2011) proposed a hierarchical model to evaluate and rank the sawability (power consumption) of carbonate rock. This model is important for stone factories to make cost estimation and planning. There were 12 main criteria and 7 alternatives. FAHP method was used to determine the criteria weights and TOPSIS method was used to calculate sawability of carbonate rock ranking. Also, this study was supported with a questionnaire.

Jia et al. (2012) evaluated the low carbon development (LCD) level in 47 countries. FAHP method was used to determine the criteria weights of the 47 countries' LCD level. There were 5 main indicators and 10 sub indicators. While calculating the importance weights of criteria, experts' opinions were given and they converted to triangular numbers. After calculating the importance weights, TOPSIS method was used to rank alternatives.

Parsaei et al. (2012) proposed a MCDM model to order acceptance. In some situations orders exceed the capacity of factory and employees can be irresolute which order has the priority. The model which was developed in this study helps to decide which orders will be processed and which orders will be rejected. This model is useful for factories which have limited production capacity. 4 main criteria's importance weights were determined with FAHP method and 18 alternatives were ranked by TOPSIS.

Amile et al. (2013) proposed a fuzzy MCDM to evaluate the performance of State-owned Banks, Partially Private and Private Banks in Iran. For this evaluation, criteria were divided in two groups that financial and non-financial. FAHP method was used to determine criteria's and sub criteria's importance weights. TOPSIS method was used to rank 3 banks. At the end of the study, there were two different rankings according to financial and non-financial criteria. Also there was a unique ranking which involved these two criteria weights integratedly.

Pavani et al. (2013) evaluated teachers using FAHP and TOPSIS methodologies integratedly. When criteria were determined, experts' opinions were considered. Criteria importance weights were determined by FAHP method and 10 teachers were ranked by TOPSIS method. The teacher which had the highest value was selected as the best alternative for school.

Kılıç et al. (2014) developed a hybrid methodology for enterprise resource planning system (ERP) selection. In this study, there was a case study in Turkish Airlines. Selection of the right ERP system is very important for companies to compete and achieve the success in the market. A focus group was composed to determine the criteria and alternatives. There were 3 main criteria and 12 sub criteria. Also there were 4 alternatives. FAHP method was used to determine the weights and TOPSIS method was used to rank these 4 alternatives.

Table 3.4. shows the summary of these literature reviews.



**Table 3.4.** Literature review of integrated FAHP – TOPSIS model

Authors	Study Area	Aim of Study	Case	
			Hypothetical	Real Life
Ertuğrul & Karakaşoğlu (2009.b)	Construction	Evaluating the performance Turkish cement firms		X
Gümüş (2009)	Environment	Evaluating hazardous waste transportation firms		X
Ballı & Korukoğlu (2009)	Software	Selection of computer operating system	X	
Seçme et al. (2009)	Banking	Evaluating the performances of banks		X
Tadić et al. (2010)	Environment	Determining the dismantling order of coming End-of-Life Vehicles (ELV)	X	
Mikaeil et al. (2011)	Environment	Evaluating the sawability of carbonate rock	X	
Jia et al. (2012)	Environment	Evaluating the kind of low carbon development (LCD)		X
Parsaei et al. (2012)	Production	Constructing order acceptance model		X
Amile et al. (2013)	Banking	Evaluating the banks in Iran		X
Pavani et al. (2013)	Education	Evaluating teachers		X
Kılıç et al. (2014)	Software	Selection of ERP system		X

### 3.5.2. Fuzzy AHP – VIKOR

There are 9 summaries of studies which are used in FAHP-VIKOR methodologies integratedly.

Mohaghar et al. (2012) proposed a method for selecting marketing strategy. In order to survive in competition environment, decision makers should choose the best marketing strategy for their companies. Marketing strategies have lots of criteria because of this reason, choosing the best strategy required numerical method. In this paper, a model was provided to select the best strategy by using FAHP and VIKOR methods. FAHP method was used to calculate the importance weights of criteria and sub criteria. VIKOR method was used to rank alternatives. There were 6 criteria and 3 alternatives.

Kuo et al. (2012) made a case study to select business strategy management. In this paper, a mid-scale profitable Taiwan wireless solution firm was evaluated. The company should choose an appropriate business strategy regarding reliability in production management, the company's limited capabilities for solution designs, etc. There were 3 criteria and 9 sub-criteria. Importance of these criteria was calculated by FAHP method and 2 alternatives were ranked by VIKOR method according to these criteria weights.

Fouladgar et al. (2012) proposed a method to select project portfolio. It is a very important selection for investments' success. In this problem, there were many uncertain and conflict criteria. Because of this reason FAHP method was used to determine the criteria weights and VIKOR method was used to rank the feasible projects in descending order.

Thipparat and Thaseepetch (2013.a) presented an application of MCDM model for dwelling selection. Also there was an application example of the dwelling house heat system selection regarding 10 criteria and 8 alternatives. VIKOR and FAHP methodologies were used to select alternative buildings and their heating system. FAHP method was used to calculate the weights of criteria by pairwise comparison. The VIKOR method was used to rank alternatives by computing the total score of the criteria.

Thipparat and Thaseepetch (2013.b) made a case study to assess a sustainable project. Sustainable research projects required multidirectional evaluation. The result is benefit for university administrators in order to develop a policy for preventing pollution and hazards generated from research projects. In this paper, this evaluation was provided

using MCDM techniques with fuzzy approach. Criteria weights were determined by FAHP method and alternatives were ranked using VIKOR method. This model was implemented on a case study in Thailand for research projects. There were 4 main criteria, 22 sub criteria and 4 alternatives.

Rezaie et al. (2014) presented a model using FAHP and VIKOR methodologies to evaluate financial performance of cement firms. In this paper, a real case study was done for 27 Iranian cement firms in the Tehran. The financial ratios of firms were used to present the model. The financial performance of cement firms is important for investors, stakeholders and creditors. There were 4 criteria and thirteen sub criteria. FAHP method was used to determine the weights of criteria and sub criteria. VIKOR method was used to rank 27 cement firms.

Pourebahim et al. (2014) made a case study to select conservation development area for coastal lands. Qualitative and quantitative evaluations were required. Because of this reason MCDM techniques were used. There were 17 criteria and 6 alternatives. The importance weights of criteria were calculated by FAHP so different criteria could be evaluated healthily. VIKOR method was used to rank 6 coastal areas. This model was applied in Iran.

Chaghooshi and Zarchi (2014) presented an integrated approach for selecting the best green supply chain management strategy. Nowadays, firms have recognized the importance of environmental issues for competition with other companies. FAHP and VIKOR method integrated for selection. In this paper, key performance indicator (KPI) was used for criteria. There were 7 criteria and 4 alternatives. FAHP method was used to determine importance weights of criteria and VIKOR method was used to rank the alternatives.

Ren and Lützen (2015) described a methodology to select technology for emission reduction from shipping under uncertainties. Emission reduction is very important for future of environment. FAHP and VIKOR methods were combined to create this model. There were 9 criteria and 3 alternative technologies for selection. FAHP method was used to determine the importance weights of criteria and VIKOR method was used to rank alternatives and select the best technology.

Table 3.5 shows the summary of these literature reviews.

**Table 3.5.** Literature review of integrated FAHP – VIKOR model

Authors	Study Area	Aim of Study	Case	
			Hypothetical	Real Life
Mohaghar et al., (2012)	Marketing	Selection of marketing strategy	X	
Kuo et al., (2012)	Technology	Evaluation of business strategies		X
Fouladgar et al., (2012)	Business	Selection of project portfolio	X	
Thipparat& Thaseepetch (2013.a)	Construction	Demonstrating a model of dwelling selection	X	
Thipparat&Thaseepetch (2013.b)	Environment	Assessing a sustainable research projects.		X
Rezaie et al., (2014)	Construction	Evaluating the performance of cement firms		X
Pourebrahim et al., (2014)	Environment	Evaluating the conservation priority assessment in coastal areas		X
Chaghooshi & Zarchi (2014)	Environment	Selection of the best strategy in green supply chain management	X	
Ren & Lützen (2015)	Environment	Selection of technology for emissions reduction	X	

### 3.5.3. Fuzzy AHP – TOPSIS and fuzzy AHP – VIKOR Comparatively

There are 3 summaries of studies in which FAHP-VIKOR and FAHP-TOPSIS methodologies are used integrately.

Yalçın et al. (2012) proposed a new financial performance evaluation approach for Turkish manufacturing industries. This evaluation is important for managers, potential investors and creditors. The criteria which were accounting-based financial performance (AFP) and value-based financial performance (VFP) measures were used to evaluate.

FAHP method was used to calculate importance weights of criteria and sub criteria. There were 2 main criteria and 8 sub criteria. After determination of criteria and sub-criteria weights, TOPSIS and VIKOR methods were used to rank the selected Turkish manufacturing companies in 7 different sectors separately. For some sector, ranking of the companies can be different according to these 2 methods.

Sasirekha and Ilanzkumaran (2013) described a novel MCDM method to evaluate and select the suitable network for heterogeneous wireless network environment. Heterogeneous wireless network is very important to provide the best quality of service (QOS) for users. There were 5 alternative heterogeneous wireless networks and 10 criteria to evaluate these alternatives. FAHP method was used to calculate the importance weights of criteria. Alternatives were ranked according to TOPSIS and VIKOR method separately. Results showed that these two methods provided the same ranking.

Anojkumar et al. (2014) used MCDM methods integratedly that were FAHP – TOPSIS, FAHP – VIKOR, FAHP – ELECTRE and FAHP – PROMETHEE. The aim of this application was the selection of pipe material in sugar industry. Selection of right pipe material is very important to get better performance and decrease the cost in sugar factories. There were 7 criteria and 5 alternative pipe materials. FAHP method was used to determine importance weights of criteria. Then 5 alternatives were ranked according to different 4 integrated MCDM techniques. When the results were viewed, ranking of TOPSIS and VIKOR method were same. ELECTRE and PROMETHEE methods had different rankings.

Table 3.6 shows the summary of these literature reviews.

**Table 3.6.** Literature review of integrated FAHP – VIKOR and FAHP – TOPSIS model

Authors	Study Area	Aim of Study	Case	
			Hypothetical	Real Life
Yalçın et al., (2012)	Manufacturing	Evaluation of Turkish manufacturing industries		X
Sasirekha & Ilanzkumaran (2013)	Technology	Selection of heterogeneous wireless network	X	
Anojkumar et al. (2014)	Material	Selection of pipe material in sugar industry	X	

### 3.5.4. Decision Making Techniques for ISP Selection

In this section, the studies about internet service provider (ISP) selection are examined in literature. Internet has used intensely in last 20 years. Because of this reason, there is a little study for this selection. There are 2 papers about this issue in literature.

Amin and Razmi (2009) proposed a model for ISP selection. In this model criteria were divided in two groups as qualitative and quantitative. In order to rank best ISPs, quality function deployment (QFD) method was used for qualitative criteria. The fuzzy logic and triangular fuzzy numbers were used for this method to reduce vagueness. For quantitative criteria a different model was adopted. These two models were combined and a novel algorithm for ISP evaluation was proposed. It provides the identification of the weaknesses and assesses the performance of each ISP. In addition, a case study was applied to illustrate the stages of ISP selection and evaluation. In this paper ISP selection was evaluated as supplier selection and literature was reviewed for supplier selection.

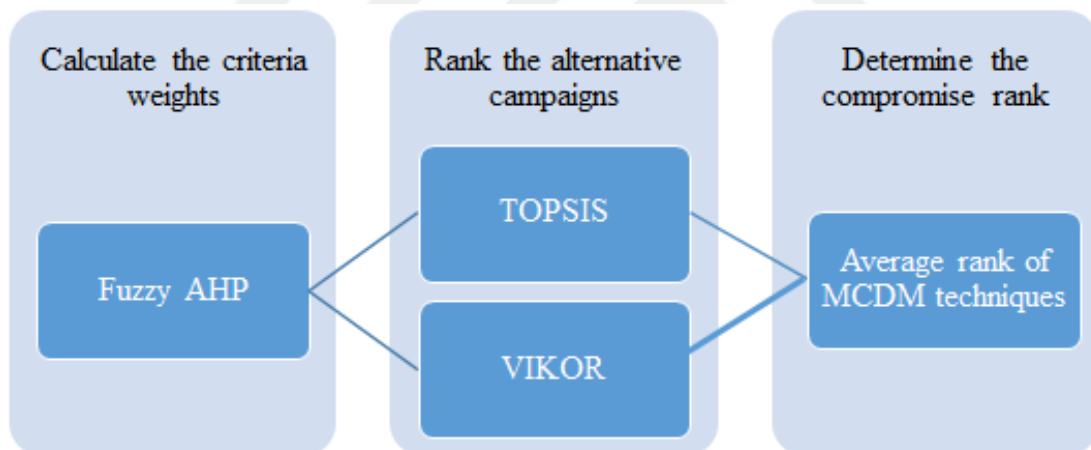
Ramarao et al. (2011) proposed a method for prioritization of best internet service providers for e-manufacturing sector. For creating the model, Phi- FUZZY method was used. The main goal of using this method is to reduce the vagueness. The proposed model was tested with correlation test. Also, sensitivity analysis was applied for this model.

## 4. PROPOSED METHODOLOGY

In this study, there are two main parts; one of them is to calculate the criteria weights and the other is to rank the alternatives. In the first part, the internet campaign selection criteria weights are obtained with fuzzy AHP technique. These importance weights are then used in TOPSIS and VIKOR techniques to obtain the rank of the campaigns in the second part.

After obtaining these two rankings, a unique ranking is created. In order to obtain this unique sequence, rank values of these two methods are averaged. Based on the averaged ranking values, the packages with campaigns can be listed from the best to worst. The package which has the lowest ranking value is the best package to present customers. At the same time, the campaign of this package is the best campaign to launch. It shows the best campaign strategy.

The structure of the methodology is given in Figure 4.1:



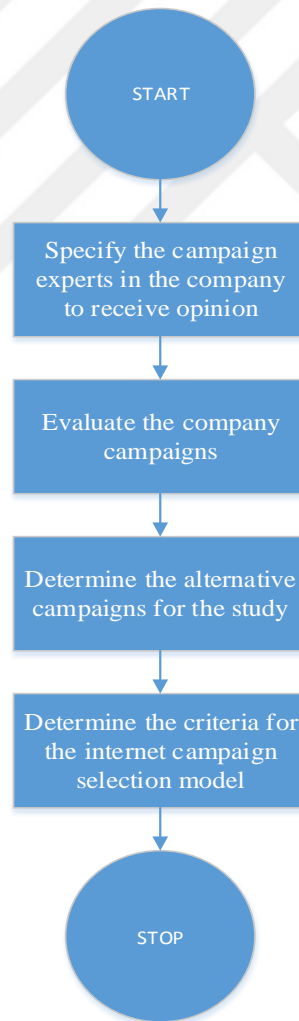
**Figure 4.1.** The brief methodology

The proposed methodology consists of 4 stages that are pre-evaluation stage, FAHP stage to find the weight of each criterion, TOPSIS and VIKOR stages to rank the alternatives and final stage to compose a unique ranking. Flows of these stages are given in Figure 4.2, 4.3, 4.4, and Figure 4.5 and they are detailed separately.

### 1) Pre-evaluation stage

The main purpose of this stage is to determine the criteria and alternatives accurately. For this determination, it is important to take marketing experts' opinions. This model is prepared for general use in internet service sector to present the best campaign. Because of this reason, their experiences enable to determine the most suitable criteria for this model.

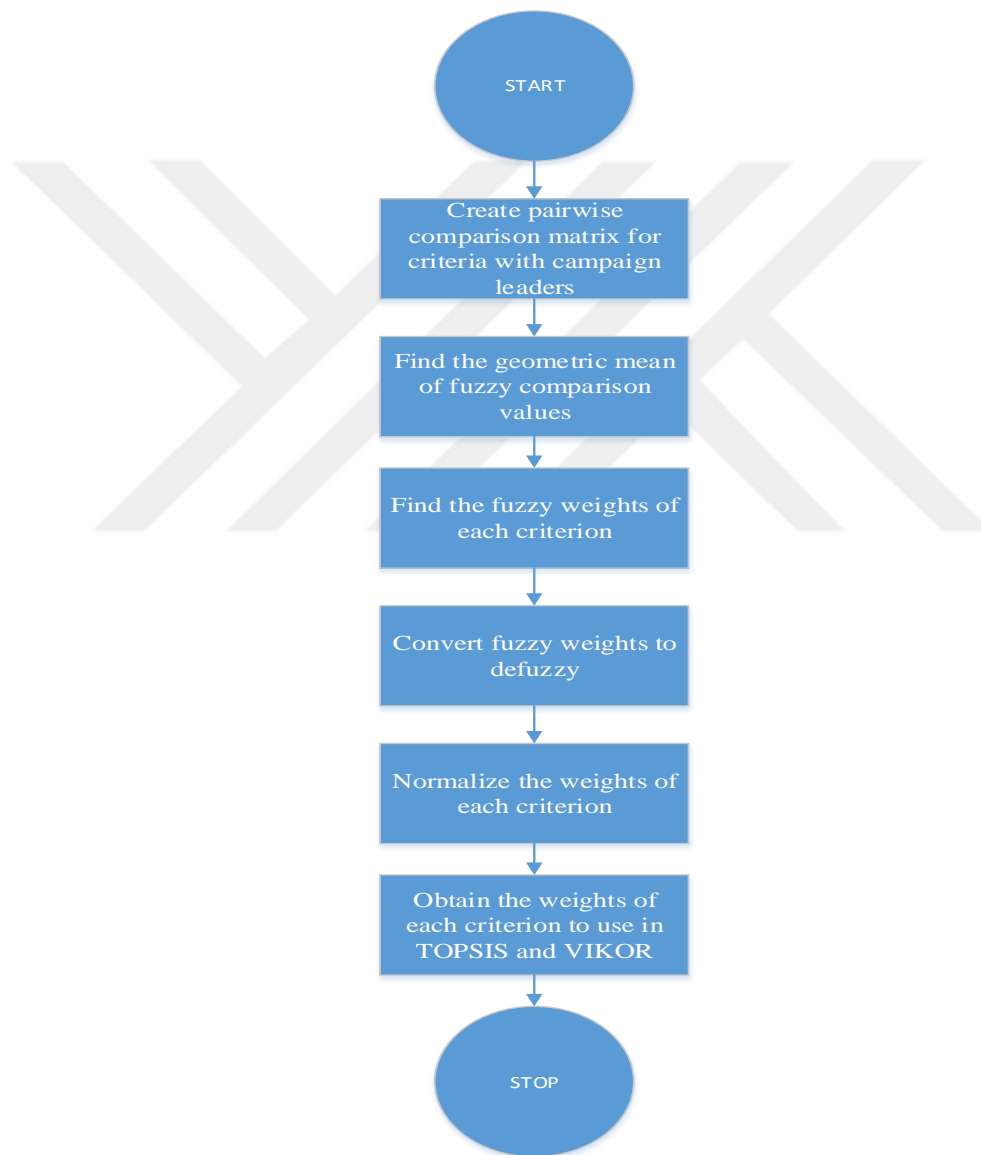
First of all, the experts who work in the leader company in internet service sector are selected to obtain the internet campaign selection criteria. Afterwards, the internet site of the leader company in internet service sector is examined to determine the most suitable campaigns. In this way, internet campaign selection criteria and alternative campaigns are obtained for this problem in this stage.



**Figure 4.2.** Pre-evaluation stage

## 2) FAHP stage to find the weight of each criterion

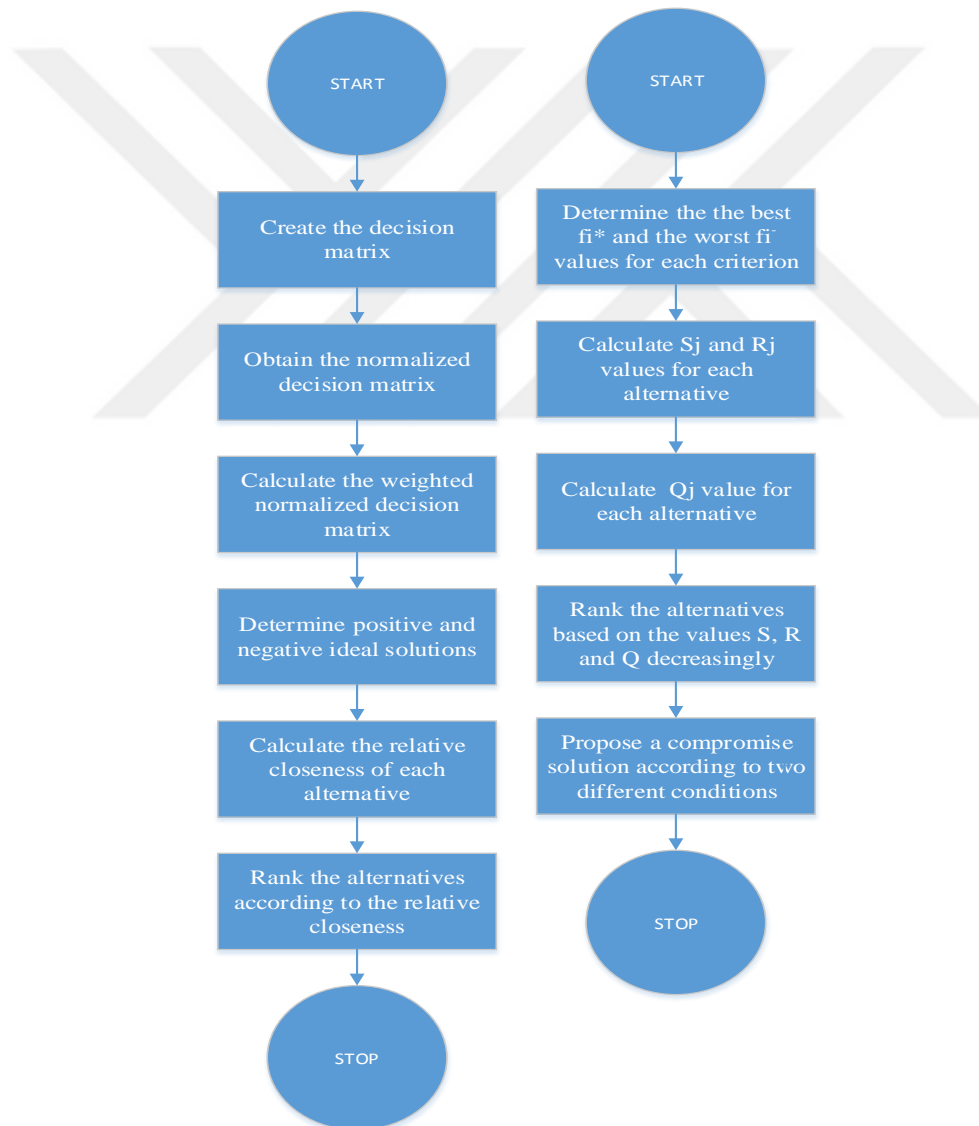
In this stage, the importance weights of the criteria are calculated using Fuzzy AHP method. AHP is the most popular technique to calculate the importance weights. By courtesy of combination of fuzzy logic and AHP, subjectivity and vagueness level reduce. In this way, more healthy importance weights can be obtained. The steps of FAHP are applied one by one and the obtained weights are used to rank alternatives in third stage. The application steps of FAHP method is given in Figure 4.3.



**Figure 4.3.** FAHP stage to find the weight of each criterion

### 3) TOPSIS and VIKOR stages to rank alternatives

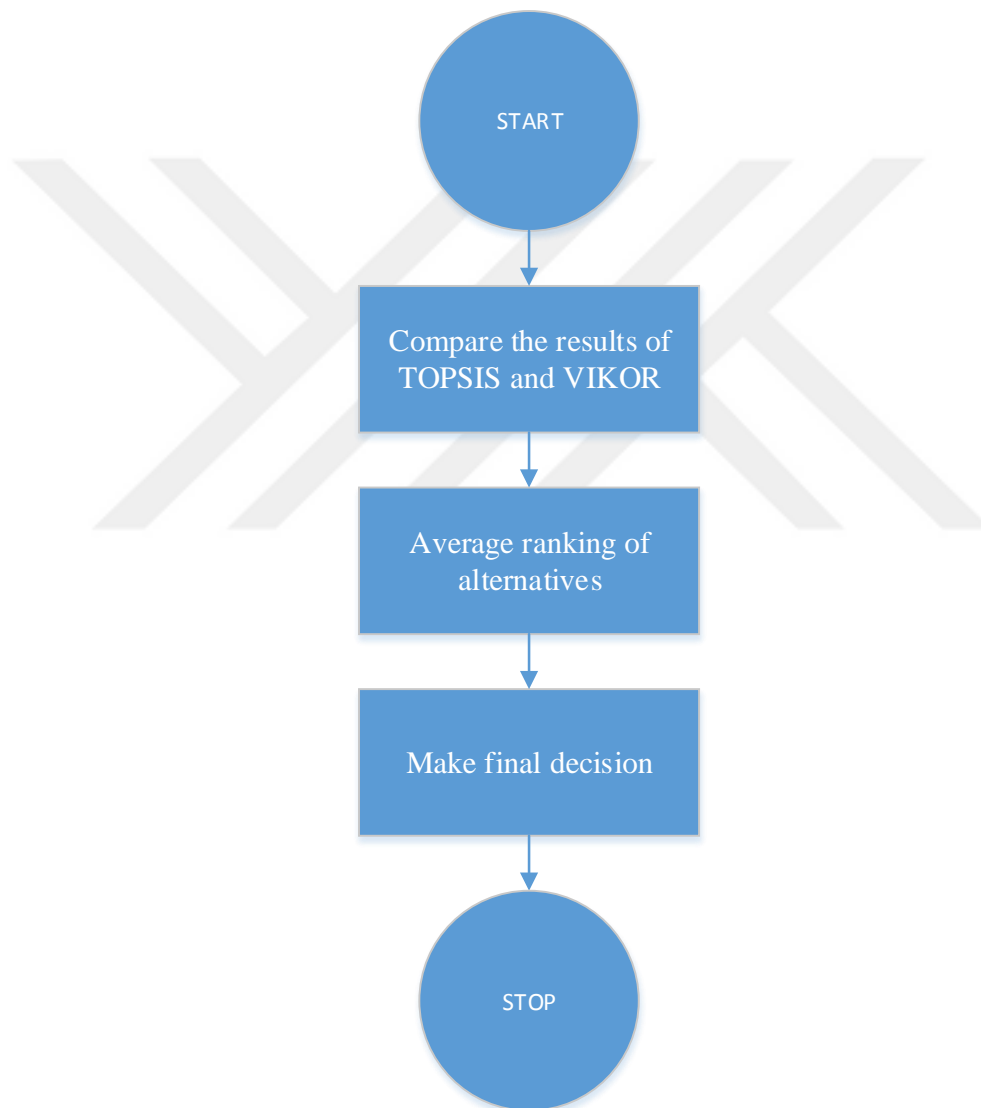
TOPSIS and VIKOR techniques provide the ranking of alternatives regarding “nearness to ideal”. The main principle behind of TOPSIS is that the best alternative should have the shortest distance from the positive ideal solution and the furthest distance from the negative ideal solution. VIKOR method use the multi-criteria ranking index based on closeness to the ideal solution. In order to obtain this index, it uses the positive and negative solutions. At the same time, it presents a compromise solution. In this stage, the ranking of alternatives are obtained separately using these two methods. The application steps of these two methods are given in Figure 4.4.



**Figure 4.4.** TOPSIS and VIKOR stages to rank alternatives

#### 4) Comparison of the results and making final decision

Finally, the ranking of alternatives that are obtained from TOPSIS and VIKOR methods are compared. In this thesis, obtaining a unique ranking is purposed. In order to obtain a ranking, the ranking of these two methods are combined. Both of these methods' structure have the approach that the chosen alternative should have the shortest geometric distance from the ideal solution. Depending on this similarity, this combination is provided by averaging the ranking values.



**Figure 4.5.** Comparison of the results and making final decision

## **5. APPLICATION STUDY**

### **5.1. Company Information**

The company was established in 2006. The aim of this establishment is to connect Turkey to the internet and also the world. This Company is the market leader in the sector and it has the most number of subscribers. It has important role in the sector today. At the same time, company provides mobile voice, fixed voice, mobile data, TV and digital services.

### **5.2. The Definition of Problem**

Campaigns are very important to preserve the existing customers and attract the new ones in most of the sectors in today's competitive business environment.

Detailed researches and grand ideas are essential for a successful campaign. Planning a marketing campaign should start with understanding the position in the marketplace. There are different marketing tools and methods that can be used for this aim. At this point, campaigns play a big role for increasing sales and revenue for especially shrunken and satisfied markets. One of such markets is the internet service sector where technology plays a big role and there is a hard competition. People use internet for lifelong and if they are satisfied with the campaigns, they can use the same internet service brand for lifelong. Within this study, the campaign selection process will be focused on in Turkey's internet service provider sector. In Turkey, internet has been used since 1993. In 2008, the number of internet subscribers was approximately 6 million. The number of internet subscribers has reached a significant number and this number was approximately 46,7 million (ICTA, 2015) in the 3th quarter of 2015. It means that the number of internet subscriber increases as 8 doubling for 6 years.

There are 3 strong brands in Turkey internet service provider sector, they are TTNET, Turkcell Superonline, and Digiturk Dsmartnet and they use the same internet service foundation (for ADSL not fiber) which is provided by Türk Telekom. As specified in the second part "Internet Service Sector and Campaigns", the leader of this sector is TTNET and it has 76,51% market share. Since there are few brands for this sector in Turkey and Türk Telekom is considered as a monopoly company, competition is very aggressive and highly flexible. All brands want to have new internet subscribers and they want to pull

existing internet subscribers to their brand. For this reason, these brands have to become more customer oriented. Therefore, internet services companies organize lots of campaigns. Campaigns are very important to attract the customers and they should be considered attentively before presenting to the customers.

At the same time, existing customer is more important for these firms. They don't want to lose their customers, also they want to attract the new customers to their brands. Generally, Internet service customers give commitment and when this commitment closes to the end, firms create new campaigns for this customer.

Preparing a new campaign is also a costly activity for firms. In general, from the beginning to end, creating a campaign has 8 basic steps and for these steps, different teams and equipment are required. These steps should be studied deservedly for a successful campaign and naturally these steps bring with highly expenditures. They are sorted below.

- 1) Making market research
- 2) Making a budget
- 3) Defining the aims
- 4) Advertising venue
- 5) Selecting the creatives
- 6) Making design and words
- 7) Placing the ad
- 8) Evaluation

A successful internet service campaign is more important than other sector campaigns. The major reason is that, when people buy an internet campaign, they give commitment minimum 12 months, maximum 24 months. If customers aren't grateful for internet service, they may not finish their subscription immediately because they have to pay a huge bill cause of finishing commitment before the commitment end date. However, customer can decide to never use the same internet service when their commitment will finish. Furthermore, these firms make some special and secret campaigns and they accept these higher bills for transfer out which mean that finishing the commitment and taking service from another firm. All of them are risks and it is clear that that determining the most suitable campaign is more crucial.

These 3 major brands can't attract people without more quota, more speed and less cost. In other sector, firms can present different features to customers such as different color product in order to attract them. These features can be required less cost but in this sector, more speed means that infrastructural change. Its cost is higher than a pink dye or pink fabric. Internet sector is nonphysical and small, so their marketing experts must create very attractive, aggressive and fastener campaigns.

Depending on the importance of determining the most suitable campaigns, an internet services campaign selection model was proposed for the leader firm of this sector. Also, this model can be used for other firms because criteria couldn't be different from brand to brand for internet service sector. The presented model is based on three strong multi-criteria decision making techniques including fuzzy AHP, TOPSIS and VIKOR which can be used under the changing market conditions, sector situations and people demands. Moreover, 5 main criteria are determined based on the experts' opinions in the sector. They are cost, link speed, quota, commitment and side benefits. With developing technology, these criteria weights can be changed for example, in next years, people can choose their quota needs like 7,5 GB quota. These improvements can be reflected in the proposed model by changing the weights.

### **5.3. Determining the Criteria and Alternatives**

In this thesis, 4 most popular campaigns and their 15 packages are selected as alternatives. These campaigns are approximately suitable for all potential customers. These campaigns have different new sale packages with different features according to the criteria. Their details are given in Table 5.1.

When internet service sector was evaluated, five main criteria appeared for selecting an internet service campaign. They are cost, link speed, quota, and commitment and side benefits such as free web-tv, free phone. Their details are explained below.

- Cost is referred how much customers pay monthly.
- Link speed is measured by Mbps. Mbps stands for megabits per second and is a measure of bandwidth (the total information flow over a given time) on a telecommunications medium. Also, link speed is known as download speed. It can change according to location but they are sold as 5 main types; 16, 24, 35, 50 and 100 Mbps.

- Quota is another critical criterion for customers. Limitless quota is the best alternative for customers. When speed is higher, quota must be higher. Higher speed means that higher bit flowing per second and quota reach the limit speed.
- Commitment is divided into two as 12 months and 24 months. Sometimes, customers don't want to give commitment but they must give commitment, if they want benefit from campaigns' discount.
- Side benefits provide customers gifts with campaigns. They are generally free web tv and free phone and free modem.

**Table 5.1.** Brief of alternatives-criteria table

	Campaign	Packages	Speed (Mbps)	Quota (GB)	CRITERIA		
					Total Cost (TL)	Commitment (Month)	Side Benefit
<b>ALTERNATIVES</b>	A	1	16	6	669,60	24	+
		2	16	50	1.197,60	24	+
		3	16	6	666,00	24	-
		4	16	50	1.242,00	24	-
		5	24	6	720,00	24	-
		6	24	12	864,00	24	-
	B	7	24	75	1.314,00	24	-
		8	35	100	1.494,00	24	-
		9	24	6	720,00	24	-
		19	24	12	864,00	24	-
		11	24	75	1.314,00	24	-
	C	12	24	35	1.214,04	24	-
		13	35	100	1.605,60	24	-
	D	14	16	6	382,80	12	+
		15	16	50	682,80	12	+

At the same time, campaigns have different price strategies and they are given in also Table 5.2. They are not segment campaigns and address suitable for all potential customers. The real names of campaigns are not given due to confidentiality. The campaigns which are used in this study are represented as below;

- Campaign “A
- Campaign “B”
- Campaign “C”
- Campaign “D”

At the end of the implementation, these packages and their campaigns are sorted from the best to worst.

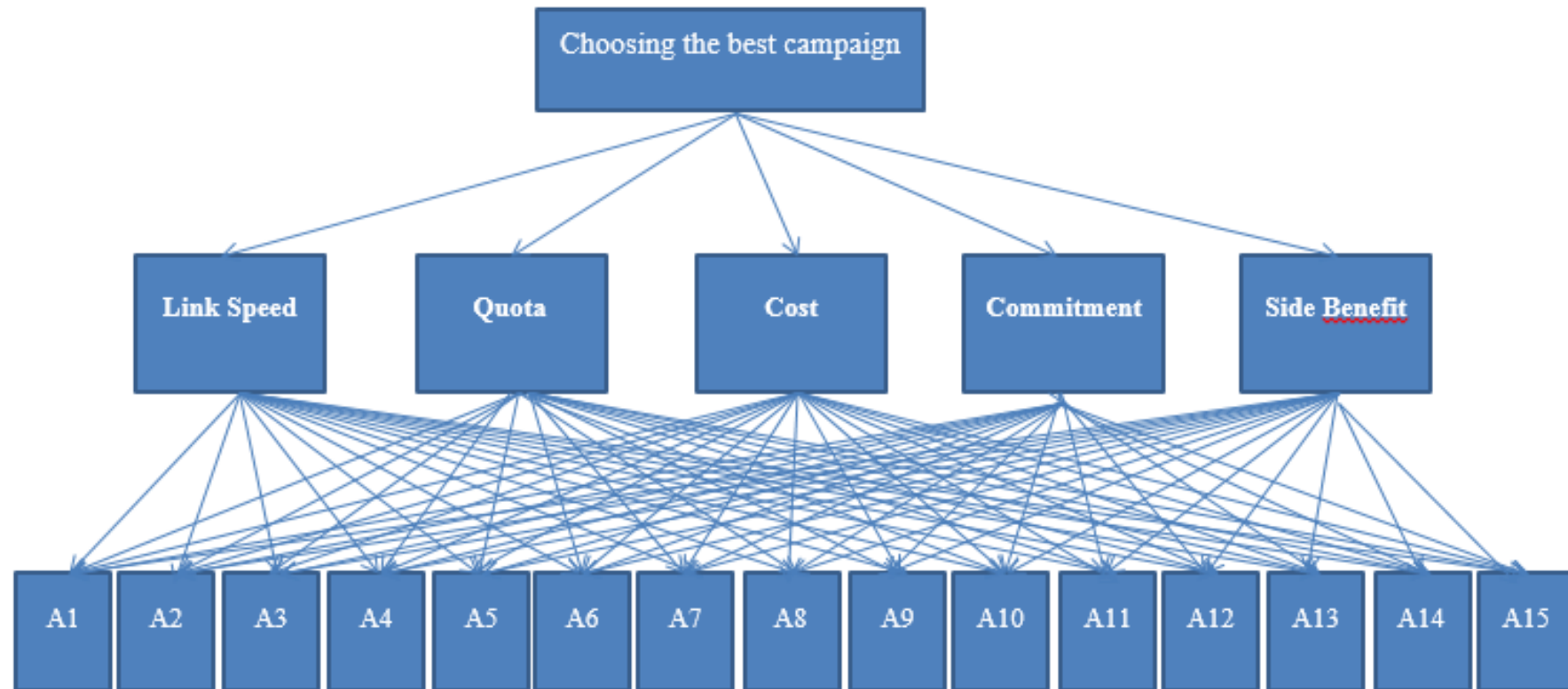


**Table 5.2.** Campaign details table

<b>Campaign</b>	<b>Package</b>	<b>Speed (Mbps)</b>	<b>Quota (GB)</b>	<b>Package Tariff (TL/month)</b>	<b>Campaign Total Cost (TL)</b>	<b>Total Cost without Discount (TL)</b>	<b>Discount(TL)</b>	<b>Commitment (Month)</b>	<b>Side Benefit</b>
A	1	16	6	37,00	669,60	888,00	218,40	24	+
A	2	16	50	69,00	1.197,60	1.656,00	458,40	24	+
B	3	16	6	37,00	666,00	888,00	222,00	24	-
B	4	16	50	69,00	1.242,00	1.656,00	414,00	24	-
B	5	24	6	40,00	720,00	960,00	240,00	24	-
B	6	24	12	48,00	864,00	1.152,00	288,00	24	-
B	7	24	75	73,00	1.314,00	1.752,00	438,00	24	-
B	8	35	100	83,00	1.494,00	1.992,00	498,00	24	-
B	9	24	6	40,00	720,00	960,00	240,00	24	-
B	10	24	12	48,00	864,00	1.152,00	288,00	24	-
B	11	24	75	73,00	1.314,00	1.752,00	438,00	24	-
C	12	24	35	82,00	1.214,04	1.968,00	754,00	24	-
C	13	35	100	98,00	1.605,60	2.352,00	746,40	24	-
D	14	16	6	37,00	382,80	444,00	61,20	12	+
D	15	16	50	69,00	682,80	828,00	145,20	12	+

According to the table 5.1, AHP tree is given in Figure 5.1. This tree provides to see the problem and it is known as decision tree.

**Figure 5.1.** AHP tree of the problem



### 5.3.1. Determining The Criteria Importance Weights Using Fuzzy AHP

These criteria were evaluated by internet services marketing experts to determine importance weights. Experts were chosen from different departments in marketing; acquisition, retention and churn. The goal of acquisition team is gaining new customers. Retention team is working for giving commitment to customers when customers' commitment approaches to the end. The aim of churn team is also gaining customers who want to repeal internet. All of them want to gain customers and make profit, its way is to sell campaign and give commitment to customers.

In this study, Fuzzy AHP was used to determine the importance weights of the criteria. AHP builds a hierarchy of decision items using comparisons between each pair of items. FAHP provides obtaining more accurate importance weights.

The detailed explanation of FAHP steps were given in section 3.4.6. In this section, application steps were given in detail.

**Step 1:** Decision maker compares the criteria according to linguistic terms

The pairwise comparison matrix was fulfilled according to marketing experts' common sides. When fulfilling this Table 5.3, linguistic terms were used that is given in Table 3.3. "Linguistic Terms and The Corresponding Triangular Fuzzy Numbers".

**Table 5.3.** The pairwise comparison matrix with fuzzy numbers

	Cost			Link Speed			Quota			Commitment			Side Benefit		
<b>Cost</b>	1,00	1,00	1,00	2,00	3,00	4,00	1,00	0,50	0,33	9,00	9,00	9,000	5,00	6,00	7,00
<b>Link Speed</b>	0,25	0,33	0,50	1,00	1,00	1,00	0,50	0,33	0,25	6,00	7,00	8,000	6,00	7,00	8,00
<b>Quota</b>	3,00	2,00	1,00	4,00	3,00	2,00	1,00	1,00	1,00	9,00	9,00	9,000	6,00	7,00	8,00
<b>Commitment</b>	0,11	0,11	0,11	0,13	0,14	0,170	0,11	0,11	0,11	1,00	1,00	1,000	0,50	0,33	0,25
<b>Side Benefit</b>	0,14	0,17	0,20	0,13	0,14	0,17	0,13	0,14	0,17	4,00	3,00	2,00	1,00	1,00	1,00

**Step 2:** Aggregate the Group Decisions

This step was skipped because marketing experts gave compromise approach for the comparison matrix.

**Step 3:** Calculation of the geometric mean of fuzzy comparison values of each criterion

The geometric mean of fuzzy comparison values was represented by  $\tilde{r}$  and they were given in the Table 5.4.

**Table 5.4.** Geometric mean of fuzzy comparison values

	Cost			Link Speed			Quota			Commitment			Side Benefit		
<b>Cost</b>	1,00	1,00	1,00	2,00	3,00	4,00	1,00	0,50	0,33	9,00	9,00	9,00	5,00	6,00	7,00
<b>Link Speed</b>	0,25	0,33	0,50	1,00	1,00	1,00	0,50	0,33	0,25	6,00	7,00	8,00	6,00	7,00	8,00
<b>Quota</b>	3,00	2,00	1,00	4,00	3,00	2,00	1,00	1,00	1,00	9,00	9,00	9,00	6,00	7,00	8,00
<b>Commitment</b>	0,11	0,11	0,11	0,13	0,14	0,17	0,11	0,11	0,11	1,00	1,00	1,00	0,50	0,33	0,25
<b>Side Benefit</b>	0,14	0,17	0,20	0,13	0,14	0,17	0,13	0,14	0,17	4,00	3,00	2,00	1,00	1,00	1,00
<b>ri</b>	2,460	2,408	2,426	1,351	1,403	1,516	3,650	3,277	2,702	0,238	0,226	0,220	0,389	0,400	0,407

**Step 4:** Determination of fuzzy weights of each criterion

The fuzzy weights were calculated in this step, these values were represented by  $\tilde{w}_i$  and they were given in the Table 5.5.

**Table 5.5.** The fuzzy weights of criteria

	Cost			Link Speed			Quota			Commitment			Side Benefit		
<b>Cost</b>	1,00	1,00	1,00	2,00	3,00	4,00	1,00	0,50	0,33	9,00	9,00	9,00	5,00	6,00	7,00
<b>Link Speed</b>	0,25	0,33	0,50	1,00	1,00	1,00	0,50	0,33	0,25	6,00	7,00	8,00	6,00	7,00	8,00
<b>Quota</b>	3,0	2,0	1,00	4,0	3,0	2,0	1,00	1,00	1,00	9,00	9,00	9,00	6,00	7,00	8,00
<b>Commitment</b>	0,11	0,10	0,11	0,13	0,14	0,17	0,11	0,11	0,11	1,00	1,00	1,00	0,50	0,33	0,25
<b>Side Benefit</b>	0,14	0,17	0,20	0,13	0,14	0,17	0,13	0,14	0,17	4,00	3,00	2,00	1,00	1,00	1,00
<b>ri</b>	2,460	2,408	2,426	1,351	1,403	1,516	3,650	3,277	2,702	0,238	0,226	0,220	0,389	0,400	0,407
<b>Wi</b>	0,338	0,312	0,300	0,186	0,182	0,187	0,502	0,425	0,334	0,033	0,029	0,027	0,054	0,052	0,05

**Step 5:** Conversion of the fuzzy weights to de-fuzzy

The fuzzy weights were converted to be de-fuzzied. These values were represented by  $M_i$  and they were given in the Table 5.6.

**Table 5.6.** The weights of criteria

	Cost			Link Speed			Quota			Commitment			Side Benefit		
<b>Cost</b>	1,00	1,00	1,00	2,00	3,00	4,00	1,00	0,50	0,33	9,00	9,00	9,00	5,00	6,00	7,00
<b>Link Speed</b>	0,25	0,33	0,50	1,00	1,00	1,00	0,50	0,33	0,25	6,00	7,00	8,00	6,00	7,00	8,00
<b>Quota</b>	3,00	2,00	1,00	4,00	3,00	2,00	1,00	1,00	1,00	9,000	9,00	9,00	6,00	7,00	8,00
<b>Commitment</b>	0,11	0,11	0,11	0,13	0,14	0,17	0,11	0,11	0,11	1,00	1,00	1,00	0,50	0,33	0,25
<b>Side Benefit</b>	0,14	0,17	0,20	0,13	0,14	0,17	0,13	0,14	0,17	4,00	3,00	2,00	1,00	1,00	1,00
<b>ri</b>	2,460	2,408	$\frac{2,42}{6}$	1,351	1,403	1,516	3,650	3,277	2,702	0,238	0,226	0,220	0,389	0,400	0,407
<b>Wi</b>	0,338	0,312	0,300	0,186	0,182	0,187	0,502	0,425	0,334	0,033	0,029	0,027	0,054	0,052	0,050
<b>Mi</b>	0,317			0,185			0,420			0,030			0,052		

**Step 6:** Normalization of the weight

In the last step, weights were normalized and they were represented by  $N_i$ . All importance weights of internet campaign selection criteria were obtained with this last step and they were given in the Table 5.7.

**Table 5.7.** The normalized weights of criteria

	Cost			Link Speed			Quota			Commitment			Side Benefit		
<b>Cost</b>	1,00	1,00	1,00	2,00	3,00	4,00	1,00	0,50	0,33	9,00	9,00	9,00	5,00	6,00	7,00
<b>Link Speed</b>	0,25	0,33	0,50	1,00	1,00	1,00	0,50	0,33	0,25	6,00	7,00	8,00	6,00	7,00	8,00
<b>Quota</b>	3,00	2,00	1,00	4,00	3,00	2,00	1,00	1,00	1,00	9,000	9,00	9,00	6,00	7,00	8,00
<b>Commitment</b>	0,11	0,11	0,11	0,13	0,14	0,17	0,11	0,11	0,11	1,00	1,00	1,00	0,50	0,33	0,25
<b>Side Benefit</b>	0,14	0,17	0,20	0,13	0,14	0,17	0,13	0,14	0,17	4,00	3,00	2,00	1,00	1,00	1,00
<b>ri</b>	$\frac{2,46}{0}$	$\frac{2,40}{8}$	$\frac{2,42}{6}$	$\frac{1,35}{1}$	$\frac{1,40}{3}$	$\frac{1,51}{6}$	$\frac{3,65}{0}$	$\frac{3,27}{7}$	$\frac{2,70}{2}$	0,238	$\frac{0,22}{6}$	$\frac{0,22}{0}$	$\frac{0,38}{9}$	$\frac{0,40}{0}$	$\frac{0,40}{7}$
<b>Wi</b>	$\frac{0,33}{8}$	$\frac{0,31}{2}$	$\frac{0,30}{0}$	$\frac{0,18}{6}$	$\frac{0,18}{2}$	$\frac{0,18}{7}$	$\frac{0,50}{2}$	$\frac{0,42}{5}$	$\frac{0,33}{4}$	0,033	$\frac{0,02}{9}$	$\frac{0,02}{7}$	$\frac{0,05}{4}$	$\frac{0,05}{2}$	$\frac{0,05}{0}$
<b>Mi</b>	$\frac{0,31}{7}$			$\frac{0,18}{5}$			$\frac{0,42}{0}$			$\frac{0,03}{0}$			$\frac{0,05}{2}$		
<b>Ni</b>	$\frac{0,31}{6}$			$\frac{0,18}{4}$			$\frac{0,41}{9}$			$\frac{0,03}{0}$			$\frac{0,05}{2}$		

**5.3.2 Evaluation of Alternatives with TOPSIS**

After determining the criteria importance weights, alternatives were evaluated by using TOPSIS method. It is a multi-criteria decision analysis method. Its main goal is to find the best alternative based on the closeness to the ideal solution approach.

The detailed explanation of TOPSIS steps were given in section 3.4.3. In this section, application steps were given for this problem.

Before starting the TOPSIS solution, alternatives' values according to each criterion were written in Table 5.8. It is known as TOPSIS decision matrix.

**Table 5.8.** Alternatives' values for each criterion

Campaign	Package	Speed (Mbps)	Quota (GB)	Monthly Cost (TL)	Commitment (Month)	Side Benefit (TL)
A	1	16	6	27,90	24	4,9
	2	16	50	49,90	24	4,9
	3	16	6	27,75	24	0
	4	16	50	51,75	24	0
	5	24	6	30,00	24	0
	6	24	12	36,00	24	0
B	7	24	50	54,75	24	0
	8	35	50	62,25	24	0
	9	24	6	30,00	24	0
	10	24	12	36,00	24	0
	11	24	50	54,75	24	0
C	12	24	50	50,58	24	0
	13	35	50	66,90	24	0
D	14	16	6	31,90	12	4,9
	15	16	50	56,90	12	4,9

**Step 1:** Normalization of the values

All values were normalized to evaluate each criterion in common unit. For this normalization Euclidean method was used. Normalized matrix was given in Table 5.9.

**Table 5.9.** Normalized TOPSIS matrix

Campaign	Package	Speed (Mbps)	Quota (GB)	Monthly Cost (TL)	Commitment (Month)	Side Benefit (TL)
A	1	0,179	0,042	0,155	0,272	0,500
	2	0,179	0,349	0,278	0,272	0,500
	3	0,179	0,042	0,154	0,272	0,000
	4	0,179	0,349	0,288	0,272	0,000
	5	0,268	0,042	0,167	0,272	0,000
	6	0,268	0,084	0,200	0,272	0,000
B	7	0,268	0,349	0,305	0,272	0,000
	8	0,391	0,349	0,347	0,272	0,000
	9	0,268	0,042	0,167	0,272	0,000
	10	0,268	0,084	0,200	0,272	0,000
	11	0,268	0,349	0,305	0,272	0,000
C	12	0,268	0,349	0,282	0,272	0,000
	13	0,391	0,349	0,372	0,272	0,000
D	14	0,179	0,042	0,178	0,136	0,500
	15	0,179	0,349	0,317	0,136	0,500

**Step 2:** Calculation of the weighted normalized values

The importance weight of each criterion was calculated with FAHP method in the previous section. Using these weights, the weighted normalized decision matrix was created. The weighted normalized matrix was given in Table 5.10.

**Table 5.10.** The weighted normalized decision matrix

Campaign	Package	Speed (Mbps)	Quota (GB)	Monthly Cost (TL)	Commitment (Month)	Side Benefit (TL)
A	1	0,033	0,018	0,049	0,008	0,026
	2	0,033	0,146	0,088	0,008	0,026
	3	0,033	0,018	0,049	0,008	0,000
	4	0,033	0,146	0,091	0,008	0,000
	5	0,049	0,018	0,053	0,008	0,000
B	6	0,049	0,035	0,063	0,008	0,000
	7	0,049	0,146	0,096	0,008	0,000
	8	0,072	0,146	0,109	0,008	0,000
	9	0,049	0,018	0,053	0,008	0,000
	10	0,049	0,035	0,063	0,008	0,000
C	11	0,049	0,146	0,096	0,008	0,000
	12	0,049	0,146	0,089	0,008	0,000
D	13	0,072	0,146	0,118	0,008	0,000
	14	0,033	0,018	0,056	0,004	0,026
	15	0,033	0,146	0,100	0,004	0,026

**Step 3:** Determination of positive ideal and negative ideal

In this step, positive ideal solution set and negative ideal solution set were created. When creating the positive ideal solution set, if a criterion is inversely proportional, its minimum value was chosen. When creating the positive solution set, if a criterion is inversely proportional, its minimum value was chosen. When creating the negative solution set, if a criterion is inversely proportional, its maximum value was chosen. Both of these sets were given in Table 5.11.:

**Table 5.11.** Positive ideal solution set and negative ideal solution set

	Speed (Mbps)	Quota (GB)	Cost (TL)	Commitment (Month)	Side Benefit (TL)
<b>Best</b>	0,072	0,146	0,049	0,004	0,026
<b>Worst</b>	0,033	0,018	0,118	0,008	0,000

**Step 4:** Calculation of the separation distances

The separation distances from the positive ideal and negative ideal for each alternative was calculated using Euclidean method for each alternative. Positive ideal values were

represented  $S^*$  and negative ideal values were represented by  $S^-$ . They will be used for calculation of relative closeness. Table 5.12. showed these ideal values.

**Table 5.12.** Separation distances from the positive ideal and negative ideal values

Campaign	Package	$S^*$	$S^-$
A	1	0,135	0,073
	2	0,055	0,135
	3	0,137	0,069
	4	0,063	0,132
	5	0,133	0,067
	6	0,117	0,059
B	7	0,059	0,132
	8	0,066	0,135
	9	0,133	0,067
	10	0,117	0,059
	11	0,059	0,132
C	12	0,053	0,133
	13	0,074	0,135
D	14	0,135	0,067
	15	0,064	0,133

**Step 5:** Calculation of the relative proximity

In order to rank the alternatives, the relative proximity of each alternative was calculated. The relative proximity value for each alternative was represented by  $C^*$ . The corresponding values were given in Table 5.13.

**Table 5.13.** Relative proximity values

Campaign	Package	$C^*$
A	1	0,352
A	2	0,709
B	3	0,334
B	4	0,675
B	5	0,334
B	6	0,336
B	7	0,691
B	8	0,671
B	9	0,334
B	10	0,336
B	11	0,691
C	12	0,715
C	13	0,647
D	14	0,331
D	15	0,673

**Step 6:** Ranking the alternatives

According to relative proximity values, alternatives were sorted from the best to worst.

As it is shown that number 12 package which is the package of “C” campaign has the biggest value of relative proximity values. Table 5.14. provided the decreasing order of alternatives based on C\* values. C campaign with 12 package is the best alternative to launch.

**Table 5.14.** Decreasing order for alternatives in TOPSIS method

Campaign	Package	C*
C	12	0,715
A	2	0,709
B	7	0,691
B	11	0,691
B	4	0,675
D	15	0,673
B	8	0,671
C	13	0,647
A	1	0,352
B	6	0,336
B	10	0,336
B	3	0,334
B	5	0,334
B	9	0,334
D	14	0,331

### 5.3.3. Evaluation of Alternatives with VIKOR

After determining the ranking with TOPSIS method, furthermore alternatives are evaluated by using VIKOR method. It is a multi-criteria decision analysis method. Its main goal is to find the best alternative based on creating compromise solution regarding the nearness to the ideal solution.

The detailed explanation of VIKOR steps was given in section 3.4.4. In this section, application steps were given in detail.

#### **Step 1:** Determination of positive ideal and negative ideal solutions

In the first step, the best and the worst values of each criterion were determined. Best values composed the ideal solution set and worst values composed the negative ideal solution set. When creating the positive ideal solution set, if a criterion is inversely proportional, its minimum value was chosen. When creating the positive negative solution set, if a criterion is inversely proportional, its maximum value was chosen. Both of these sets were given in Table 5.15.

**Table 5.15.** Ideal and negative ideal solution set

Criteria	$f^*i$	$f-i$	$f^*i - f-i$
Link Speed	35	16	19
Quota	50	6	44
Cost	27,75	66,90	-39,15
Commitment	12	24	-12
Side Benefit	4,9	0	4,9

**Step 2:** Calculation of the utility measure and the regret measure

Firstly, the utility measure was found for each alternative according to each criterion separately. The utility measure was represented by S. The S values for each alternative were given in Table 5.16.

**Table 5.16.** S values of alternatives

Campaign	Package		Link Speed	Quota	Cost	Commitment	Side Benefit
A	1	<b>S1</b>	0,184349	0,418729	0,001209	0,029645	0,000000
A	2	<b>S2</b>	0,184349	0,000000	0,178559	0,029645	0,000000
B	3	<b>S3</b>	0,184349	0,418729	0,000000	0,029645	0,051676
B	4	<b>S4</b>	0,184349	0,000000	0,193472	0,029645	0,051676
B	5	<b>S5</b>	0,106728	0,418729	0,018138	0,029645	0,051676
B	6	<b>S6</b>	0,106728	0,361629	0,066506	0,029645	0,051676
B	7	<b>S7</b>	0,106728	0,000000	0,217656	0,029645	0,051676
B	8	<b>S8</b>	0,000000	0,000000	0,278116	0,029645	0,051676
B	9	<b>S9</b>	0,106728	0,418729	0,018138	0,029645	0,051676
B	10	<b>S10</b>	0,106728	0,361629	0,066506	0,029645	0,051676
B	11	<b>S11</b>	0,106728	0,000000	0,217656	0,029645	0,051676
C	12	<b>S12</b>	0,106728	0,000000	0,184067	0,029645	0,051676
C	13	<b>S13</b>	0,000000	0,000000	0,315601	0,029645	0,051676
D	14	<b>S14</b>	0,184349	0,418729	0,033455	0,000000	0,000000
D	15	<b>S15</b>	0,184349	0,000000	0,234988	0,000000	0,000000

Regret measure which is represented by R, was found according to maximum S value for each alternative. Then, the Table 5.17 was created according to S and R values.

**Table 5.17.** The utility measure and regret measure

Campaign	Package	S <sub>j</sub>	R <sub>j</sub>
A	1	0,633932	0,418729
A	2	0,392553	0,184349
B	3	0,684399	0,418729
B	4	0,459142	0,193472
B	5	0,624916	0,418729
B	6	0,616185	0,361629
B	7	0,405706	0,217656
B	8	0,359437	0,278116
B	9	0,624916	0,418729
B	10	0,616185	0,361629
B	11	0,405706	0,217656
C	12	0,372117	0,184067
C	13	0,396922	0,315601
D	14	0,636532	0,418729
D	15	0,419337	0,234988

**Step 3:** Calculation of VIKOR index

In this step, VIKOR index values which are represented by Q were calculated using S and R values. These values were given in Table 5.18.

**Table 5.18.** VIKOR index values

Campaign	Package	S <sub>j</sub>	R <sub>j</sub>	Q <sub>j</sub>
A	1	0,633932	0,418729	0,922350
A	2	0,392553	0,184349	0,051554
B	3	0,684399	0,418729	1,000000
B	4	0,459142	0,193472	0,173450
B	5	0,624916	0,418729	0,908477
B	6	0,616185	0,361629	0,773380
B	7	0,405706	0,217656	0,142759
B	8	0,359437	0,278116	0,200393
B	9	0,624916	0,418729	0,908477
B	10	0,616185	0,361629	0,773380
B	11	0,405706	0,217656	0,142759
C	12	0,372117	0,184067	0,019509
C	13	0,396922	0,315601	0,337940
D	14	0,636532	0,418729	0,926350
D	15	0,419337	0,234988	0,200662

**Step 4:** Ranking the order of preference according to Q<sub>j</sub>, S<sub>j</sub> and R<sub>j</sub>

Packages were sorted from lowest to highest one based on  $Q_j$ ,  $S_j$  and  $R_j$  values separately. According to VIKOR index values, “C” campaign with 12 package is the best package for creating a campaign. The related values were given in Table 5.19.

**Table 5.19.** Ranking packages according to S, R and Q values

Campaign	Package	$S_j$	$R_j$	$Q_j$	Ranking Package ( $S_j$ )	Ranking Package ( $R_j$ )	Ranking Package ( $Q_j$ )
A	1	0,633932	0,418729	0,922350	13	11	13
A	2	0,392553	0,184349	0,051554	3	2	2
B	3	0,684399	0,418729	1,000000	15	12	15
B	4	0,459142	0,193472	0,173450	8	3	5
B	5	0,624916	0,418729	0,908477	11	13	11
B	6	0,616185	0,361629	0,773380	9	9	9
B	7	0,405706	0,217656	0,142759	5	4	3
B	8	0,359437	0,278116	0,200393	1	7	6
B	9	0,624916	0,418729	0,908477	12	14	12
B	10	0,616185	0,361629	0,773380	10	10	10
B	11	0,405706	0,217656	0,142759	6	5	4
C	12	0,372117	0,184067	0,019509	2	1	1
C	13	0,396922	0,315601	0,337940	4	8	8
D	14	0,636532	0,418729	0,926350	14	15	14
D	15	0,419337	0,234988	0,200662	7	6	7

**Step 5: Validation and evaluation**

The VIKOR method required the validation at the end of the application. There are two conditions and their calculations were given below:

*Condition 1: Acceptable advantage*

Under this condition, it was expected to provide this equation;  $Q(P2) - Q(P1) \geq D(Q)$ .

Based on Table 5.19.;

The value of  $Q(P2)$  is 0,051554

The value of  $Q(P1)$  is 0,019509

$$Q(P2) - Q(P1) = 0,032044$$

$$D(Q) = 0,071428$$

As it is shown that, the first condition wasn't provided.

*Condition 2: Acceptable stability in decision making*

According to this condition, the best Q value, must be in the first rank at least in one of the rankings with respect to S and R.

As it shown in Table 5.19, number 12 package was the best package for both of Q and R values. This condition which is acceptable stability in decision making was provided.

If the first condition was not satisfied, the alternatives  $P_1, P_2, \dots, P_m$  were regarded where  $P_m$  was determined by  $Q(P_m) - Q(P_1) < D(Q)$ . According to this equation number 12 and number 2 packages were member of compromise solution set.

Decision makers could accept the obtained compromise solution because this set provides a maximum utility (S) and a minimum individual regret of the opponent (R). The measures S and R were used to integrate into Q for compromise solution. It was base for an agreement established by mutual concessions. The details of compromise solution set is given in Table 5.20.

**Table 5.20.** Compromise solution set

Campaign	Package	Speed (Mbps)	Quota (GB)	Monthly Cost (TL)	Commitment (Month)	Side Benefit (TL)
C	12	24	50	50,58	24	0
A	2	16	50	49,90	24	4,9

#### 5.3.4. Comparison and Evaluation of The TOPSIS and VIKOR Method Results

In this study, it was proposed to obtain a compromise solution using the average of ranking values which are obtained from TOPSIS and VIKOR methods. At the end of the TOPSIS method, the ranking was obtained for this problem but VIKOR method gave a compromise solution instead of ranking.

As a result of VIKOR method, number 12 and number 2 packages constitute the compromise solution set. Their ranking value should be same because they are elements of compromise solution set and they are equal. Number 12 package and number 2 package have 1,5 ranking value instead of 1 and 2. Also for TOPSIS method, ranking for all alternatives are obtained. They were given in Table 5.21.

**Table 5.21.** Rank values of VIKOR and TOPSIS methods

VIKOR RESULTS		TOPSIS RESULTS	
Rank Values	Packages	Rank Values	Packages
1,5	12	1	12
1,5	2	2	2
3	7	3	7
4	11	4	11
5	4	5	4
6	8	6	15
7	15	7	8
8	13	8	13
9	6	9	1
10	10	10	6
11	5	11	10
12	9	12	3
13	1	13	5
14	14	14	9
15	3	15	14

After determination of rank values for both methods, their averages were calculated. This calculation was given in Table 5.22.

**Table 5.22.** Average rank values

Packages	VIKOR Results	TOPSIS Results	Average Rank Value
	Rank Values	Rank Values	
1	13	9	11
2	1,5	2	1,75
3	15	12	13,5
4	5	5	5
5	11	13	12
6	9	10	9,5
7	3	3	3
8	6	7	6,5
9	12	14	13
10	10	11	10,5
11	4	4	4
12	1,5	1	1,25
13	8	8	8
14	14	15	14,5
15	7	6	6,5

Packages were sorted from best to worst regarding the methodology that was given in this study. It was given in Table 5.23. This table shows the result of this problem. It is obvious that the best campaign is “C” campaign with package 12. Company should make advertisements with this campaign to achieve success. Also, the average rank values of C and A campaigns are very close. According to environment, experts can choose the “A” campaign with package 2 for launch.

**Table 5.23.** Rank of alternatives

Campaigns	Packages	Average Rank Value
C	12	1,25
A	2	1,75
B	7	3
B	11	4
B	4	5
B	8	6,5
D	15	6,5
C	13	8
B	6	9,5
B	10	10,5
A	1	11
B	5	12
B	9	13
B	3	13,5
D	14	14,5

## 6. CONCLUSION

Campaigns are the best ways for companies in order to reach new customers and keep existing customers. Nowadays, many firms achieve success with a good campaign. Campaigns provide increase in the memorability of product. Also, although a customer doesn't need the product, he can prefer to buy the product because of campaign advantages. Generally, people think that campaign is the unmissable chance; they believe that they can't find the product with campaign advantages when campaign ends.

Before presenting the campaign to customers, companies spend a lot of money and time. If a campaign is created without effort, it can't be expected to achieve success. A better campaign can move a company from second to first. In this century, almost all sectors have strong competitors and all markets are contentious. Internet service sector is the one of these sectors, its market is very small but number of subscribers is very high. Because of this reason, creating an effective campaign is very important for this sector.

In internet service sector, companies make campaigns with many market research and create many different campaigns. In this study, a campaign selection model was created for internet service providers to present the right campaign to customers. In order to create this model, the campaign information of leader firm in this market was used. Multi-criteria decision making techniques were used to compose the model. Firstly, criteria and alternatives were determined with experts. Then the importance weights of criteria were determined by Fuzzy AHP technique. Using fuzzy numbers provided to decrease human vagueness. These importance weights were then used to rank the alternatives in TOPSIS and VIKOR methods. At the final, both of these ranking were combined and a unique ranking was obtained.

This study provides contribution to the literature by presenting an integrated model for the campaign selection process in internet service sector. Within the proposed methodology, FAHP, TOPSIS and VIKOR methods were used. Although these techniques are used in various studies, this thesis can be regarded as the first study using these techniques integrately in internet service sector campaign selection process.

Moreover, another distinctive part of the methodology is to provide the compromise

ranking of VIKOR and TOPSIS methods which were also proposed by Kılıç and Ayhan in a different area (Kılıç & Ayhan, 2014).

At the same time, the study provides the best campaign for the company to be presented in internet service sector. It is clear that this campaign and the package will be more preferred by customers than other campaigns. By this means, expectations of customers will be provided exactly with this campaign and customers will not be in search of new internet campaigns. The company can gain more new customers thanks to this selected campaign. In order to attract the potential customers, the firm should make advertisement and promotion studies for this campaign and package in the light of campaign creation detailed in section 2.2.1. For example, before schools start, the amount of potential customers increases, especially parents want to buy internet service for their children. In this term, marketing experts study for new campaigns. The firm can use this model and determine the best campaign and package for advertisement and promotion studies.

The model which was developed via FAHP, TOPSIS and VIKOR methods can be extended with other MCDM techniques. Importance of criteria weights can be calculated by ANP or FANP. Alternatives can be ranked with ELECTRE and PROMETHEE. Also, the proposed methodology can be applied in different fields other than internet service sector.

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