Sigma J Eng & Nat Sci 35 (3), 2017, 523-534

Sigma Journal of Engineering and Natural Sciences
Sigma Mühendislik ve Fen Bilimleri Dergisi

Research Article

INTERNET SERVICES CAMPAIGN RANKING BASED ON AN INTEGRATED DECISION MAKING APPROACH

Zehra Nur LAFCI[1], Hüseyin Selçuk KILIÇ[2]*

[1]*Marmara University, Department of Industrial Engineering, ISTANBUL;* ORCID:0000-0002-6401-1572
[2]*Marmara University, Department of Industrial Engineering, ISTANBUL;* ORCID:0000-0003-3356-0162

Received: 18.03.2016 Revised: 26.07.2017 Accepted: 04.08.2017

ABSTRACT

Regarding the firms, the internet service sector in Turkey is quite small. There are few major brands competing strictly both to attract new customers and protect existing customers by providing advantageous and aggressive campaigns. In this study, a campaign selection model in the internet service sector is established by using multiple-criteria decision making 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 the alternatives. Afterwards, one listing has been established by integrating two separate listings.
Keywords: FAHP, TOPSIS, VIKOR, internet services.

1. INTRODUCTION

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. In this paper, an internet service sector campaign ranking model is proposed and a real case is handled using campaign information of the leader firm. The campaign having the best ranking is regarded as the most appropriate campaign to present customers. For this ranking, multi-criteria decision making techniques (MCDM) are used. Furthermore, fuzzy approach is combined with MCDM techniques for handling the judgments and uncertainties. Fuzzy AHP method is used to determine the importance weights of the criteria. Afterwards, TOPSIS and VIKOR methods are used to rank the alternative campaigns. As stated by Hodgett [1] and Zamani-Sabzi et al. [2], different results can be obtained when different MCDM techniques are

* Corresponding Author/Sorumlu Yazar: e-mail/e-ileti: huseyin.kilic@marmara.edu.tr, tel: (216) 348 02 92

applied to the sa me problem. Hence, the rankings are integrated and a unique ranking is established in this study. The motivation of combining the results of TOPSIS and VIKOR is the similarity of the approach they use. They both are distance based techniques and have no superiority over each other. Hence, their results are combined so as to find a single final result.

In the second part of this paper, there is the literature review. In the third part, methodology and techniques that are used in the study are detailed. The application is given in the fourth part and the results of this study are evaluated in the last part.

2. LITERATURE REVIEW

In this paper, integrated MCDM techniques are used to create the campaign ranking model for internet service sector. They are also known as hybrid MCDM techniques. This literature review consists of integrated MCDM techniques which are including FAHP – TOPSIS, FAHP – VIKOR and FAHP – TOPSIS – VIKOR. However, up to the knowledge of the authors, there isn't any study using these MCDM techniques for the selection of internet service campaign.

2.1. Studies Including FAHP-TOPSIS

There are 11 studies in which FAHP-TOPSIS methodologies are used in an integrated way. In these studies, FAHP method was used to calculate the criteria weights and TOPSIS method was used to rank the alternatives according to the criteria weights.

Ertuğrul and Karakaşoğlu [3] evaluated cement firms in Turkey by using these two methods. For decision making, financial ratio tables of alternative firms were used. Five main different financial ratios and 18 sub ratios were evaluated as criteria considering 15 Turkish cement firms in the İstanbul Stock Exchange. Gümüş [4] evaluated hazardous waste transportation firms. Hazardous waste management was detailed and eight main criteria were chosen to calculate the importance weight. These criteria were determined using modified Delphi method by 15 experts. Five alternative firms were handled for evaluation. Ballı and Korukoğlu [5] proposed a model for the selection of computer operating system. Selection of the right operating system is very important for companies to decrease cost, time efficiency and increase quality. There were seven main criteria and 21 sub criteria to create a model. Also, there were three alternatives. Seçme et al. [6] proposed a fuzzy MCDM model to evaluate the performance of Turkish banks. Largest five banks were chosen and examined to create the model. They were evaluated by using FAHP according to the 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. [7] 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. There were six main criteria. In this paper, alternatives weren't given, there was only proposed model for dismantling ranking of vehicles in the dismantling center. Mikaeil et al. [8] 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 seven alternatives. Also, this study was supported with a questionnaire. Jia et al. [9] 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 five main indicators and 10 sub indicators. Parsaei et al. [10] proposed a model to order acceptance. The model helps to decide which orders will be processed and which orders will be rejected. This model is useful for factories which have a limited production capacity. There were four main criteria and 18 alternatives. Amile et al. [11] proposed a fuzzy MCDM to evaluate the performance of State-owned Banks, Partially Private and Private Banks in Iran. Criteria were divided in two groups as financial and non-financial. At the end of the study, there were two different rankings according to the financial and non-financial criteria. Also there was a unique ranking which involved these

two criteria weights together. Pavani et al. [12] evaluated teachers by using FAHP and TOPSIS methodologies in an integrated way. While determining the criteria, experts' opinions were considered. There were five criteria and 10 teachers were ranked. Kilic et al. [13] developed a hybrid methodology for enterprise resour ce planning system (ERP) selection and there was a case study in Turkish Airlines. A focus group was composed to determine the criteria and alternatives. There were three main criteria and 12 sub criteria. Also there were four alternatives.

2.2. Studies Including FAHP-VIKOR

There are nine studies in which FAHP-VIKOR methodologies are used in an integrated way. In these studies, FAHP method was used to calculate the criteria weights and VIKOR method was used to rank the alternatives according to the criteria weights.

Mohaghar et al. [14] 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. There were six criteria and three alternatives. Kuo et al. [15] evaluated a mid-scale profitable Taiwan wireless solution firm and made a case study to select business strategy management for this firm. There were three criteria, nine sub-criteria and two alternatives. Fouladgar et al. [16] proposed a method including FAHP to select project portfolio. Six criteria and five alternatives were considered. Thipparat and Thaseepetch [17] presented an application of MCDM model for dwelling selection regarding 10 criteria and eight alternatives. Moreover, Thipparat and Thaseepetch [18] analyzed a case study to assess a sustainable project including four main criteria, 22 sub criteria and four alternatives. Rezaie et al. [19] 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 Tehran. There were four criteria and 13 sub criteria. Pourebrahim et al. [20] analyzed 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 six coastal areas as alternatives. This model was applied in Iran. Chaghooshi and Zarchi [21] presented an integrated approach for selecting the best green supply chain management strategy. In this paper, key performance indicators (KPI) were used for criteria. There were seven criteria and four alternatives. Finally, Ren and Lützen [22] described a methodology to select technology for emission reduction from shipping under uncertainty.

2.3. Studies Including FAHP-TOPSIS-VIKOR

There are few studies in which FAHP-VIKOR and FAHP-TOPSIS methodologies are used in an integrated way. In these studies, FAHP method was used to calculate the criteria weights and TOPSIS and VIKOR methods were used to rank the alternatives according to the criteria weights. Then, these two integrated methods are compared.

Yalçın et al. [23] proposed a new financial performance evaluation approach for Turkish manufacturing industries. The criteria which were accounting-based financial performance (AFP) and value-based financial performance (VFP) measures were used for evaluation. There were two main criteria and eight sub criteria. Sasirekha and Ilangkumaran [24] described a novel MCDM method to evaluate and select the suitable network for heterogeneous wireless network environment. There were five alternative heterogeneous wireless networks and 10 criteria to evaluate these alternatives. Results showed that TOPSIS and VIKOR methods provided the same ranking. Anojkumar et al. [25] used MCDM methods in an integrated way 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. There were seven criteria and five alternative pipe materials. When the results were viewed, ranking of TOPSIS and VIKOR method

were same. ELECTRE and PROMETHEE methods had different rankings according to the criteria weights which were obtained by FAHP method.

3. 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 ranking of the campaigns in the second part. After obtaining these two rankings, a unique ranking is created. In order to obtain this unique sequence, ranking values of these two methods are averaged. Based on the averaged ranking values, the packages with campaigns can be listed from the best to the worst. The methodology is illustrated in Figure 1.

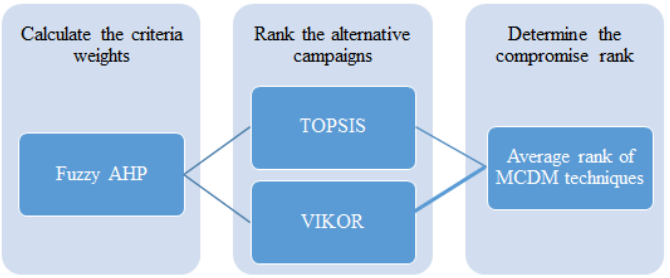

Figure 1. The brief methodology

The MCDM techniques that are used in this methodology are detailed as follows:

3.1. Fuzzy AHP

AHP is a beneficial and useful method for MCDM problems to determine the weights of each alternative and it has three main sections which are hierarchy structure, pairwise comparison matrix and determining of weights [26]. 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 [27]. The best advantage of FAHP is that it makes decision making easier for multi criteria problems [28].

The FAHP steps are not provided here but can be found in the study of [29]. Moreover, in the application part, the steps are clearly elaborated.

3.2. TOPSIS

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 [30]. In this method, alternatives are ranked based on the ideal solution similarity. Alternative has a higher grade when it is closer to the ideal solution. For measuring the similarity of a design to ideal level and non-ideal level, distance of that design from ideal and non-ideal solution is considered [31]. 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 [32]. Before solving the problem using TOPSIS method, TOPSIS decision matrix should be created. The TOPSIS matrix indicating the score ($X_{11},X_{12},\ldots,X_{mn}$) of each alternative ($A_1,A_2,\ldots,A_m$) with respect to each criterion ($C_1,C_2,\ldots,C_j$) is shown in the Eq. (1).

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

The traditional TOPSIS method steps are not provided but can be found in the study of [30].

3.3. VIKOR

The aim of VIKOR method is to obtain a compromise sorting and a compromise solution under the determined weights. It provides the selection of the most suitable alternative under conflicting criteria. Compromise solution is based on the closeness to the ideal solution [33]. 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. Reaching an agreement by making mutual concessions can be called as compromise [34]. Since compromise solution ensures maximum group utility for majority and provides minimum regret for opponent, decision maker can accept it [35].

The traditional VIKOR method steps are not provided but can be found in the studies of [30, 36].

4. APPLICATION

Companies spend a lot of time for 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. In this part of this study, the proposed model was applied in order to select the best campaign for the leader company in internet service sector.

Step 1: Determining the criteria and alternatives

Five main criteria are determined based on the experts' opinions in the sector. They are cost, link speed, quota, commitment and side benefits. Also, four most popular campaigns and their 15 packages are selected as alternatives. The hierarchical structure of this problem is given in Figure 2. Criteria values for each alternative are given in Table 1.

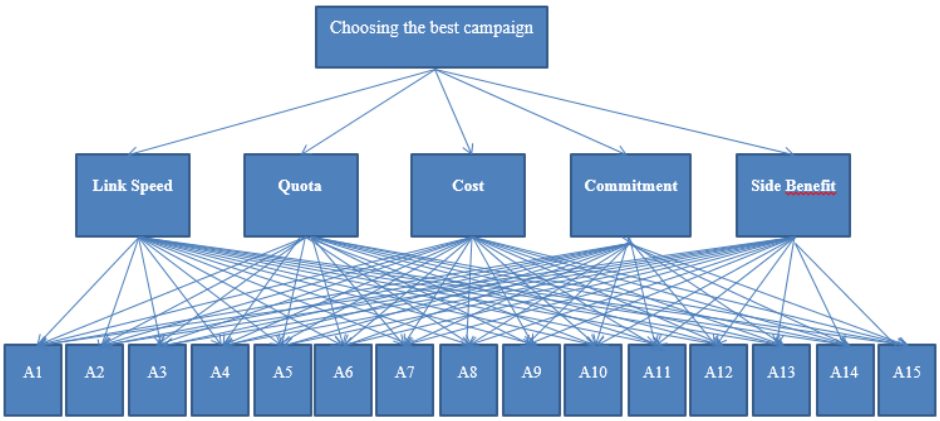

Figure 2. AHP tree of the problem

Table 1. Criteria and alternatives

			CRITERIA				
	Campaign	**Packages**	**Speed (Mbps)**	**Quota (GB)**	**Total Cost (TL)**	**Commitment (Month)**	**Side Benefit (TL)**
ALTERNATIVES	A	1	16	6	669.60	24	4.90
		2	16	50	1197.60	24	4.90
	B	3	16	6	666.00	24	0
		4	16	50	1242.00	24	0
		5	24	6	720.00	24	0
		6	24	12	864.00	24	0
		7	24	75	1314.00	24	0
		8	35	100	1494.00	24	0
		9	24	6	720.00	24	0
		19	24	12	864.00	24	0
		11	24	75	1314.00	24	0
	C	12	24	35	1214.04	24	0
		13	35	100	1605.60	24	0
	D	14	16	6	382.80	12	4.90
		15	16	50	682.80	12	4.90

Step 2: Determining the criteria importance weights using Fuzzy AHP

These criteria were evaluated by internet services marketing experts to determine the importance weights. A group of three experts were chosen from different departments in marketing; acquisition, retention and churn.

In this section, application steps were given as follows and all steps were summarized in Table 2.

- The pairwise comparison matrix was fulfilled according to marketing experts' common sides. When fulfilling this table, linguistic terms were used with fuzzy numbers.
- The geometric mean of fuzzy comparison values was calculated and they were represented by r.
- The fuzzy weights were calculated, these values were represented by W.
- The fuzzy weights were converted to be de-fuzzied. These values were represented by M.
- Weights were normalized and they were represented by N. All importance weights of internet campaign selection criteria were obtained with this last step.

Table 2. Determination of criteria importance weights using Fuzzy AHP

	Cost	**Link Speed**	**Quota**	**Commitment**	**Side Benefit**
Cost	(1,1,1)	(2,3,4)	(1,0.5,0.33)	(9,9,9)	(5,6,7)
Link Speed	(0.25,0.33,0.5)	(1,1,1)	(0.5,0.33,0.25)	(6,7,8)	(6,7,8)
Quota	(3,2,1)	(4,3,2)	(1,1,1)	(9,9,9)	(6,7,8)
Commitment	(0.11,0.11,0.11)	(0.13,0.14,0.17)	(0.11,0.11,0.11)	(1,1,1)	(0.5,0.33,0.25)
Side Benefit	(0.14,0.17,0.2)	(0.13,0.14,0.17)	(0.13,0.14,0.17)	(4,3,2)	(1,1,1)
$\mathbf{r_i}$	(2.46,2.408,2.426)	(1.351,1.403,1.516)	(3.65,3.277,2.702)	(0.238,0.226,0.22)	(0.389,0.4,0.407)
$\mathbf{W_i}$	(0.338,0.312,0.3)	(0.186,0.182,0.187)	(0.502,0.425,0.334)	(0.033,0.029,0.027)	(0.054,0.052,0.05)
$\mathbf{M_i}$	0.317	0.185	0.42	0.03	0.052
$\mathbf{N_i}$	**0.316**	**0.184**	**0.419**	**0.03**	**0.052**

Step 3: Rank the alternatives with TOPSIS

After determining the criteria importance weights, alternatives were evaluated by using TOPSIS method. In this section, application steps were given as follows:

- All values were normalized to evaluate each criterion in common unit. For this normalization Euclidean method was used. Normalized matrix was given in Table 3.

Table 3. 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
B	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
	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

- Using criteria importance weights, the weighted normalized decision matrix was created. The weighted normalized matrix was given in Table 4.

Table 4. 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
B	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
	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
	11	0.049	0.146	0.096	0.008	0.000
C	12	0.049	0.146	0.089	0.008	0.000
	13	0.072	0.146	0.118	0.008	0.000
D	14	0.033	0.018	0.056	0.004	0.026
	15	0.033	0.146	0.100	0.004	0.026

- The positive ideal solution set included the best values and they were; (0.072, 0.146, 0.049, 0.004, 0.026). The negative ideal solution set included the worst values and they were; (0.033, 0.018, 0.118, 0.008, 0.00).

- The separation distances from the positive ideal and negative ideal solutions for each alternative were calculated using Euclidean method for each alternative. Positive ideal values were represented as S* and negative ideal values were represented as S^-. Then the relative proximity of each alternative was calculated. The relative proximity value for each alternative was represented by C*. According to the relative proximity values, the alternatives were sorted from the best to the worst. These calculations are summarized in Table 5.

Table 5. Separation distances from the positive ideal and negative ideal values

Campaign	Package	S*	S^-	C*	Packages sorting from best to worst
A	1	0.135	0.073	0.352	**12**
	2	0.055	0.135	0.709	**2**
B	3	0.137	0.069	0.334	**7**
	4	0.063	0.132	0.675	**11**
	5	0.133	0.067	0.334	**4**
	6	0.117	0.059	0.336	**15**
	7	0.059	0.132	0.691	**8**
	8	0.066	0.135	0.671	**13**
	9	0.133	0.067	0.334	**1**
	10	0.117	0.059	0.336	**6**
	11	0.059	0.132	0.691	**10**
C	12	0.053	0.133	0.715	**3**
	13	0.074	0.135	0.647	**5**
D	14	0.135	0.067	0.331	**9**
	15	0.064	0.133	0.673	**14**

Step 4: Rank the alternatives with VIKOR

After determining the criteria importance weights, the alternatives were evaluated by using VIKOR method. In this section, application steps were given as follows:

- The best and the worst values of each criterion were determined. The best values composed of the ideal solution set and the worst values composed of the negative ideal solution set. These values were given in Table 6.

Table 6. 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

- The utility measure was found for each alternative according to each criterion separately. The utility measure was represented by S. Regret measure which is represented by R, was found according to the maximum S value. VIKOR index values which are represented by Q were calculated. Their values and rankings were given in Table 7.

Table 7. Ranking packages according to S, R and Q values

Campaign	Package	S_j	R_j	Q_j	Ranking Package (S_i)	Ranking Package (R_i)	Ranking Package (Q_i)
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

- According to condition 1; "$Q(P2) - Q(P1) \geq D(Q)$" equation is not provided. Since the first condition is not satisfied, the alternatives P1, P2,…,Pm are regarded where Pm is determined by $Q(Pm) - Q(P1) < D(Q)$. According to this equation number 12 and number 2 packages are members of the compromise solution set.

Step 5: Determine the compromise rank

As a result of VIKOR method, number 12 and number 2 packages constituted the compromise solution set. Their ranking values should be same because they are the elements of the 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 were obtained. After determination of rank values for both methods, their averages were calculated. According to these average ranking values, all packages are sorted from the best to the worst. These calculations are summarized in Table 8.

5. CONCLUSION

Depending on the increasing use of internet, the internet service providers present various campaigns to attract customers. At this point, determining the best campaigns becomes crucial and a systematic methodology is required. 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, the robust multi-criteria decision making techniques FAHP, TOPSIS and VIKOR are used. The reasons of choosing these techniques are the suitability and the strength of them. Although these techniques are used in various studies, this study can be regarded as the first study using these techniques in an integrated way 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 Kilic and Ayhan in a different area [37]. Since the methodology of the multi-criteria decision making techniques are different, it is not expected to obtain the same ranking from them. However, reaching a final ranking is important to make the decision. Therefore, two similar, distance based decision making techniques' final rankings are consolidated so as to overcome the probable conflict.

Table 8. Rank of alternatives

Packages	VIKOR Results	TOPSIS Results	Average Rank Value	Packages sorting from best to worst
	Rank Values	Rank Values		
1	13	9	11	**12**
2	1.5	2	1.75	**2**
3	15	12	13.5	**7**
4	5	5	5	**11**
5	11	13	12	**4**
6	9	10	9.5	**8**
7	3	3	3	**15**
8	6	7	6.5	**13**
9	12	14	13	**6**
10	10	11	10.5	**10**
11	4	4	4	**1**
12	1.5	1	1.25	**5**
13	8	8	8	**9**
14	14	15	14.5	**3**
15	7	6	6.5	**14**

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 different techniques such as ANP or FANP. Alternatives can also be ranked with various techniques such as ELECTRE or PROMETHEE. At the same time, the proposed methodology can be applied in different fields other than internet service sector.

Acknowledgments

The authors would like to sincerely thank the anonymous referees and the editor for their valuable comments. This study is a part of the master thesis of the first author.

REFERENCES

[1] Hodgett, R. E., "Comparison of multi-criteria decision-making methods for equipment selection", The International Journal of Advanced Manufacturing Technology, 85(5-8), 1145-1157, 2016.

[2] Zamani-Sabzi, H., King, J. P., Gard, C. C., & Abudu, S., "Statistical and analytical comparison of multi-criteria decision-making techniques under fuzzy environment", Operations Research Perspectives, 3, 92-117, 2016.

[3] Ertuğrul, İ., Karakaşoğlu, N., "Banka şube performanslarının VIKOR yöntemi ile değerlendirilmesi", Endüstri Mühendisliği Dergisi, 20(1), 19-28, 2009.

[4] Gumus, A. T., "Evaluation of hazardous waste transportation firms by using a two step fuzzy-AHP and TOPSIS methodology", Expert Systems with Applications, 36(2), 4067-4074, 2009.

[5] Ballı, S., Korukoğlu, S., "Operating system selection using fuzzy AHP and TOPSIS methods", Mathematical and Computational Applications, 14(2), 119-130, 2009.

[6] Seçme, N. Y., Bayrakdaroğlu, A., Kahraman, C., "Fuzzy performance evaluation in Turkish banking sector using analytic hierarchy process and TOPSIS", Expert Systems with Applications, 36(9), 11699-11709, 2009.

[7] Tadić, D., Arsovski, S., Stefanovic, M., Aleksic, A., "A fuzzy AHP and TOPSIS for ELV dismantling selection", International Journal for Quality Research, 4(2), 377-384, 2010

[8] Mikaeil, R., Yousefi, R., Ataei, M., "Sawability ranking of carbonate rock using fuzzy analytical hierarchy process and TOPSIS approaches", Scientia Iranica, 18(5), 1106-1115, 2011.

[9] Jia, J., Fan, Y., Guo, X., "The low carbon development (LCD) levels' evaluation of the world's 47 countries (areas) by combining the FAHP with the TOPSIS method", Expert Systems with Applications, 39(7), 6628-6640, 2012.

[10] Parsaei S., Keramati, M. A., Zorriassatine, F., RezaFeylizadeh, M., "An order acceptance using FAHP and TOPSIS methods: A case study of Iranian vehicle belt production industry", International Journal of Industrial Engineering Computations, 3(2), 211-224, 2012.

[11] Amile, M., Sedaghat, M., Poorhossein, M., "Performance Evaluation of Banks using Fuzzy AHP and TOPSIS, Case study: State-owned Banks, Partially Private and Private Banks in Iran", Caspian Journal of Applied Sciences Research, 2(3), 128-138, 2013.

[12] Pavani, S., Sharma, L. K., Hota, H. S., "A group expert evaluation for teachers by integrating fuzzy AHP and TOPSIS models", IEEE International Conference in MOOC Innovation and Technology in Education (MITE), India, December, 2013, 85-90.

[13] Kilic, H. S., Zaim, S., Delen, D., "Development of a hybrid methodology for ERP system selection: The case of Turkish Airlines", Decision Support Systems, 66, 82-92, 2014.

[14] Mohaghar, A., Fathi, M. R., Zarchi, M. K., Omidian, A., "A combined VIKOR–fuzzy AHP approach to marketing strategy selection, Business Management and Strategy", 3(1), 13-27, 2012.

[15] Kuo, C. W., Chang, S. C., Tsai, P. H., "An evaluation of alternative business strategies: A Hybrid fuzzy model approach", International Conference on Fuzzy Theory and it's Applications (iFUZZY), China, November, 2012, 305-309.

[16] Fouladgar, M. M., Yazdani-Chamzini, A., Zavadskas, E. K., Yakhchali, S. H., Ghasempourabadi, M. H., "Project portfolio selection using Fuzzy AHP and VIKOR techniques", Transformation in Business & Economics, 11(1), 213-231, 2012.

[17] Thipparat, T., Thaseepetch, T., "Dwelling Selection by Applying VIKOR and Fuzzy AHP Method", International Proceedings of Economics Development and Research, 63(6), 26-32, 2013.

[18] Thipparat, T., Thaseepetch, T., "An Integrated VIKOR and Fuzzy AHP Method for Assessing a Sustainable Research Project", World Applied Sciences Journal, 22(12), 1729-1738, 2013.

[19] Rezaie, K., Ramiyani, S. S., Nazari-Shirkouhi, S., Badizadeh, A., "Evaluating performance of Iranian cement firms using an integrated fuzzy AHP–VIKOR method", Applied Mathematical Modelling, 38(21), 5033-5046, 2014.

[20] Pourebrahim, S., Hadipour, M., Mokhtar, M. B., Taghavi, S., "Application of VIKOR and fuzzy AHP for conservation priority assessment in coastal areas: Case of Khuzestan district", Iran, Ocean & Coastal Management, 98, 20-26, 2014.

[21] Chaghooshi, A. J., Zarchi, M. K., "Using Integration of Fuzzy AHP–VIKOR for Selecting the Best Strategy in Green Supply Chain Management", Global Journal of Management Studies and Researches, 1(1), 46-53, 2014.

[22] Ren, J., Lützen, M., "Fuzzy multi-criteria decision-making method for technology selection for emissions reduction from shipping under uncertainties", Transportation Research Part D: Transport and Environment, 40, 43-60,2015.

[23] Yalcin, N., Bayrakdaroglu, A., Kahraman, C., "Application of fuzzy multi-criteria decision making methods for financial performance evaluation of Turkish manufacturing industries", Expert Systems with Applications, 39(1), 350-364, 2012.

[24] Sasirekha, V., Ilanzkumaran, M., "Heterogeneous wireless network selection using FAHP integrated with TOPSIS and VIKOR", International Conference on Informatics and Mobile Engineering (PRIME), India, February, 2013, 399-407.
[25] Anojkumar, L., Ilangkumaran, M., Sasirekha, V., "Comparative analysis of MCDM methods for pipe material selection in sugar industry", Expert Systems with Applications, 41(6), 2964-2980, 2014.
[26] Xia, W., Wu, Z., "Supplier selection with multiple criteria in volume discount environments", Omega, 35(5), 494-504, 2007.
[27] Terceno, A., De Andrés, J., Barberà, G., Lorenzana, T., "Using fuzzy set theory to analyse investments and select portfolios of tangible investments in uncertain environments", International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 11(3), 263-281, 2003.
[28] Kilic, H. S., "A fuzzy AHP based performance assessment system for the strategic plan of Turkish Municipalities", International Journal of Business and Management Studies, 3(2), 77-86, 2011.
[29] Buckley, J. J., "Fuzzy Hierarchical Analysis", Fuzzy Sets Systems, 17(1), 233–247, 1985.
[30] Opricovic, S., Tzeng, G. H. "Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS", European Journal of Operational Research, 156(2), 445-455, 2004.
[31] Bhutia, P. W., Phipon, R., "Application of AHP and TOPSIS method for supplier selection problem", IOSR Journal of Engineering (IOSRJEN), 2(10), 43-50, 2012.
[32] Ghosh, D. N., "Analytic Hierarchy Process & TOPSIS Method to Evaluate Faculty Performance in Engineering Education", Universal Journal of Computer Science and Technology, 1(2), 63-70, 2011.
[33] Yu, P. L., "A class of solutions for group decision problems", Management Science, 19(8), 936-946, 1973.
[34] Hung, Y. H., Tzeng, G. H., "Using ANP, VIKOR, and dematel for holistic knowledge management of SMEs", IEEE International Conference on Management of Innovation and Technology (ICMIT), Singapore, June, 2010, 898-903.
[35] Opricovic, S., Tzeng, G. H., "Extended VIKOR method in comparison with outranking methods", European Journal of Operational Research, 178(2), 514-529, 2007.
[36] Kilic, H. S., "The performance evaluation of municipalities with VIKOR: an application among municipalities in Istanbul", International Journal of Business and Management Studies, 4(2), 45-51, 2012.
[37] Kilic, H. S., Ayhan, M. B., "The comparison of municipality recyclable waste collection performances with fuzzy based integrated approaches", Joint Symposium on IMSS'14 and CIE'44, 2014.