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EVALUATION OF SERVICE QUALITY OF AIRWAY COMPANIES GIVING DOMESTIC SERVICES IN TURKEY WITH FUZZY SET APPROACH

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Abstract: *Today, service quality has become a major phenomenon with the requirement of meeting consumer demands in the best way brought along with the rising competition between companies. Airway transportation is preferred more and more during the recent years. Many qualitative and quantitative criteria are considered while evaluating service criteria in airway transportation. In this context, evaluation of service quality is a decision-making problem with many criteria. The purpose of this study is to evaluate service quality of domestic airway companies in Turkey. In this study; fuzzy TOPSIS method which is one of the most preferred fuzzy MCDM methods, extension of multi criteria decision making methods in fuzzy environments, considering qualitative and quantitative criteria together and giving opportunity to make group decisions in fuzzy environments. As a result, evaluation was made based on service quality criteria for the most preferred airways companies in Turkey and these companies were ranked according to their levels of service quality.*

Keywords: *Airways, service quality, fuzzy TOPSIS method, triangular fuzzy numbers.*

1. INTRODUCTION

One of the situations where fuzzy logic applies is the situations requiring human judgment. Use of human judgment in decision making models has increased notably in recent years. Chen also states that fuzzy multi criteria decision making method is required if different qualitative and quantitative criteria are to be evaluated together and if a ranking based on their gravity shall be made [1].

Multi criteria decision making (MCDM); can be defined as evaluation of the alternative for selection, ranking or elimination purposes by applying contradictory and different multiple qualitative and/or quantitative criteria using units of measure [2].

TOPSIS (The Technique For Order Preference By Similarity To An Ideal Solution) method used in this study is a MCDM method. Upon review of the literature, the reasons for preferring TOPSIS method in fuzzy environments frequently in the last years are as follows: the method is easy to calculate and understandable for decision makers; the method can be applied in fuzzy environments; and both qualitative and quantitative data can be used in the method. Besides, the method has the capability of relative performance measurement for each alternative; it is scientific and objective; it prevents conflicts among decision makers; it is flexible and it has a rational logic, which can be counted among the reasons for preference [3].

It is seen that there are many researches carried out with fuzzy TOPSIS (FTOPSIS) method in the literature. Application field of FTOPSIS is very wide. Recently, airway transportation is getting more and more important both in our country and in the world and the number of people who prefer this kind of transportation is increasing. Therefore, the number of the companies in this industry is increasing in the same rate. So, the competition among these companies brings along variability in service qualities. Two remarkable studies in the subject of evaluating service qualities of airways companies are the study by Tsaur and his friends in 2002 and Önüt and his friends in 2008. When the main and sub criteria were determined in the study by Önüt and his friends, some of the criteria used in the study by Tsaur and his friends which matched with the conditions in Turkey and Turkish airways companies were used or were partially changed and adapted. Besides, some of the other criteria were defined after consultations with experts working in airways industry and service quality of airways companies in Turkey was evaluated with AHP method, one of MCDM methods [4]. The purpose of this study is to evaluate service quality of airways companies in Turkey by using FTOPSIS method. While evaluating the service quality of four airways companies with domestic flights in Turkey with FTOPSIS method, the criteria in Önüt and his friends' study were used exactly [4].
At the following sections of the study, information on fuzzy set theory and FTOPSIS method was given and then an application was used; and the gathered results were stated.

2. FUZZY SET THEORY

Fuzzy set theory generally has a set of meanings such as misty, uncertain, indefinite etc [5]. Fuzzy theory was added to the literature by Zadeh in 1965. Certain set theory can be insufficient in cases of decision making with linguistic variables. However, fuzzy sets are based on feasibility not possibility. In such cases, making decisions by applying fuzzy set theory generates more successful results [6].
Variables formed by the values defined by expressions, linguistically are called "linguistic variables". Linguistic variables are very useful in definition of expressions which are complex or not clearly defined [7]. It is not certain what the expressions such as little, medium, a lot mean quantitatively. Capability of expressing such unclear cases is ensured with fuzzy sets easily [8].
The expressions like yes/no, good/bad, correct/wrong in certain sets are replaced with expressions such as partially correct and "partially wrong" in fuzzy sets [9]. Fuzzy set theory function as a bridge for transfer from verbal to numerical [5].

2.1. Fuzzy Number

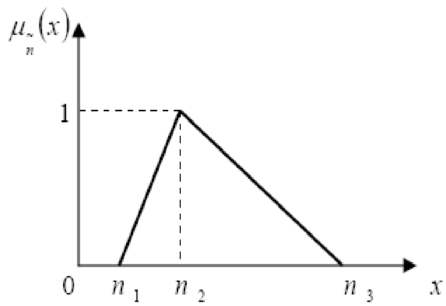
Normal and convex fuzzy set is called fuzzy number. Most frequently used fuzzy numbers are triangular and skewed fuzzy numbers [6] [10]. Fuzzy numbers are a special subset of fuzzy sets. Fuzzy sets are very useful in definition of uncertain or approximate numerical amounts such as around 5, approximately 9, roughly 15, etc. In this study, triangular fuzzy numbers are used [11].

2.2. Triangular Fuzzy Number

Most frequently used fuzzy number type is triangular fuzzy number because of its feature of providing operation convenience [12]. One triangular fuzzy number is indicated as $\tilde{n} = (n_1, n_2, n_3)$ as seen in Figure 1. $\mu_{\tilde{n}}(x)$ membership function is expressed as follows and indicated as in Figure 2 [7].

$$\mu_{\tilde{n}}(x) = \begin{cases} 0, & x < n_1, \\ \dfrac{x - n_1}{n_2 - n_1}, & n_1 \le x \le n_2, \\ \dfrac{x - n_3}{n_2 - n_3}, & n_2 \le x \le n_3, \\ 0, & x > n_3. \end{cases}$$

Figure 1 $\tilde{n}$ Triangular Fuzzy Number



Fighure 2 $\tilde{n}$ Triangular Fuzzy Number

Fuzzy number $\tilde{n}$ seen in Figure 2 is a triangular fuzzy number. Here $n_1 \leq n_2 \leq n_3$' indicates type and n_1 indicates the lowest possible value, n_2 indicates the net value, n_3 indicates the biggest possible number [13].

2.3. Vertex Method

Vertex method is a method applied for finding the distance between fuzzy numbers. The distance between two triangular fuzzy numbers like $\tilde{m} = (m_1, m_2, m_3)$ and $\tilde{n} = (n_1, n_2, n_3)$ can be calculated as below [7].

$$d(\tilde{m} - \tilde{n}) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \quad (1)$$

3. THE FUZZY TOPSIS METHOD

FTOPSIS method is a MCDM method developed for elimination of fuzziness stemming from human judgment in decision making process, in solution of problems requiring group decisions and in environments with linguistic fuzziness [7]. FTOPSIS method is based on the fact that the selected alternative is closest to fuzzy positive-ideal solution (FPIS) and most distant to the fuzzy negative-ideal solution (FNIS). Positive ideal solution is defined as a solution maximizing advantage criteria and minimizing disadvantage criteria; while negative ideal solution is defined as maximizing disadvantage criteria and minimizing advantage criteria [14].

The most explicit feature of FTOPSIS method is that it provides opportunity for decision criteria to have different importance weight. Decision makers use appropriate linguistic variables to evaluate importance weight of decision criteria and to evaluate alternatives according to these criteria. These linguistic variables can be expressed with triangular numbers as indicated in Table 1 and Table 2 [7].

In this study, TOPSIS method is applied based on the model developed by Chen [7]. As mathematical expression of Chen's model; in a group consisting of K number of decision makers where $\tilde{w}_j^K$' s Kth decision maker is evaluated, importance weight of decision criteria is indicated as $\tilde{x}_{ij}^K$' and i. is the criteria value of the alternative, the importance weight of the criteria and criteria value of alternatives are respectively;

$$\tilde{w}_j = \frac{1}{K}[\tilde{w}_j^1(+)\tilde{w}_j^2(+)\cdots\tilde{w}_j^K] \quad (2)$$

$$\tilde{x}_{ij} = \frac{1}{K}[\tilde{x}_{ij}^1(+)\tilde{x}_{ij}^2(+)\cdots\tilde{x}_{ij}^K] \quad (3)$$

calculated using these formulas.

Table 1: Linguistic variables used in evaluation of decision criteria and their equivalents as triangular fuzzy numbers

Very low (VL)	(0.0,0.0,0.1)
Low (L)	(0.0,0.1,0.3)
Medium low (ML)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
Medium high (MH)	(0.5,0.7,0.9)
High (H)	(0.7,0.9,1.0)
Very high (VH)	(0.9,1.0,1.0)

Table 2: Linguistic variables used in evaluation of alternatives and their equivalents as triangular fuzzy numbers

Very bad (VB)	(0,0,1)
Bad (B)	(0,1,3)
Medium bad (MB)	(1,3,5)
Medium (M)	(3,5,7)
Medium good (MG)	(5,7,9)
Good (G)	(7,9,10)
Very good (VG)	(9,10,10)

A fuzzy multicriteria group decision-making problem which can be concisely expressed in matrix format as

$$\tilde{D} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{11} & \cdots & \tilde{x}_{11} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix}$$

$$\tilde{W} = [\tilde{w}_1 \quad \tilde{w}_2 \quad \cdots \quad \tilde{w}_n]$$

where $\tilde{x}_{ij}$, $\forall$ i, j and $\tilde{w}_j$, j=1,2,…, n are linguistic variables. These linguistic variables can be described by triangular fuzzy numbers, $\tilde{x}_{ij}$ =(a_{ij}, b_{ij}, c_{ij}) and $\tilde{w}_j$ =(w_{j1}; w_{j2}; w_{j3}).

The next step is to normalize fuzzy decision matrix. Normalized fuzzy decision matrix is indicated with $\tilde{R}$ and expressed as below

$$\tilde{R} = [\tilde{r}_{ij}]_{m \times n}, \quad i = 1,2,\dots,m, \quad j = 1,2,\dots,n, \tag{4}$$

Decision criteria can be categorized in two: advantage and cost criteria. Here B indicates advantage and C indicates cost criteria;

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \quad j \in B, \quad c_j^* = \max_i c_{ij}, \tag{5}$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), \quad j \in C, \quad a_j^- = \min_i a_{ij} \tag{6}$$

is calculated using the above formulas.
Considering each decision criteria may have different importance weight, weighted normalized fuzzy decision matrix is indicated as:

$$\tilde{V} = [\tilde{v}_{ij}]_{m \times n}, \quad i = 1,2,\dots,m, \quad j = 1,2,\dots,n, \tag{7}$$

Elements of this matrix is calculated with the formula below:

$$\tilde{v}_{ij} = \tilde{r}_{ij} (\cdot) \tilde{w}_j \tag{8}$$

According to weighted normalized fuzzy decision matrix, for $\forall$ i, j; $\tilde{v}_{ij}$ elements are normalized positive triangular fuzzy numbers and are located between the intervals of [0,1].
Fuzzy positive ideal solution (A^*) and fuzzy negative ideal solution (A^-) is defined as below;

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*), \tag{9}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-), \tag{10}$$

In this definition according to Chen's FTOPSIS model; j =1, 2,…,n and $\tilde{v}_j^* = (1,1,1)$ $\tilde{v}_j^- = (0,0,0)$ [7].
Distances of each alternative from positive ideal solution (A^*) and negative ideal solution (A^-) are respectively calculated using the below formulas;

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i = 1,2,\dots,m, \tag{11}$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1,2,\dots,m, \tag{12}$$

Here d(…, ...) indicates the distance between two fuzzy numbers and is calculated using formula number (1) according to Vertex method [7].
To define the order of alternatives, closeness coefficient (CC_i) related to each alternative is calculated. Closeness coefficient of each alternative is calculated with the below formula:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \quad i = 1,2,\dots,m \tag{13}$$

As CC_i gets closer to 1, A_i alternative gets closer to FPIS and gets far from FNIS. Therefore, priority order of alternatives can be decided according to closeness coefficient [12] [15]. In line with the given information, algorithm of FTOPSIS method can be summed up as follows [7].
Step 1: Definition of the jury of decision makers, alternatives and decision criteria
Step 2: Evaluation of decision criteria and alternatives with linguistic variables according to decision criteria by decision makers
Step 3: Definition of importance weight of criteria
Step 4: Forming fuzzy decision matrix and normalized fuzzy decision matrix
Step 5: Forming weighted normalized fuzzy decision matrix
Step 6: Definition of fuzzy positive and negative ideal solutions
Step 7: Calculation of distances from fuzzy ideal solutions
Step 8: Calculation of closeness coefficient
Step 9: Order of alternatives

4. APPLICATION

In this study, FTOPSIS method is applied based on the algorithm developed by Chen in order to evaluate service quality of airways companies giving domestic flight services in Turkey [7]. The operations applied according to the algorithm of the method are indicated step by step as follows:
Step 1: In order to evaluate service quality of airways companies, the opinions of the three people who travelled at the flights by all companies in the survey at least once are referred. As a result of the negotiations with intermediary companies assigned for airways

travels and internet researches, four airways companies preferred the most in Turkey are included in the evaluation. It is not deemed appropriate to disclose the names of the companies included in the study. Thus, they will be named as A1, A2, A3, A4. In this study, the criteria prepared specially for Turkey are used by referring to the study of Tsaur in 2002 and study of Önüt and his friends in 2008. These criteria are kindness of the personnel, fulfillment of responsibilities by the personnel, giving effective service, professional competence of stewards and stewardesses, performance of timely take-off, security, luggage loss- damage rate, cabin cleanness and comfort, timeliness of take-off and landing monitor and announcements, food and beverage quality, appearance of personnel, ticket process, customer complaint evaluation, enlarged travel services [4].

Step 2: İmportance weight table of the criteria is formed and evaluation results are formed into triangular fuzzy numbers. Evaluation table of alternatives according to the criteria is formed. Evaluation results are turned into triangular fuzzy numbers.

Step 3: İmportance weight tables of decision criteria are formed.

Step 4: Using the evaluation results of alternatives, according to the methodology explained in the second section of the study, normalized fuzzy decision matrix is formed according to the linear normalization method explained in the first section.

Step 5: Weighted normalized fuzzy decision matrix is formed.

Step 6: According to Chen's model applied in this study, as fuzzy positive ideal solution (A^*) and fuzzy negative ideal solution (A^-), n = 14 for a decision problem with 14 criteria; it is accepted as follows [7].

A^*=[(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1)]

A^-=[(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0), (0,0,0),(0,0,0)]

Step 7: Distances from FPIS and FNIS are calculated for each alternative using distances of alternatives from FPIS and FNIS for each criterion (Table 4).

Table 3: The fuzzy importance weight of the decision criteria

Criteria	Weight
Responsiveness of crew	(0.7,0.9,1.0)
Courtesy of crew	(0.7,0.9,1.0)
Actively providing service	(0.6,0.8,0.9)
Professional skill of crew	(0.6,0.8,0.9)
Timely take-off performance	(0.5,0.7,0.8)
Security	(0.8,0.9,1.0)
Luggage safety	(0.8,0.9,1.0)
Cabin cleanness and comfort	(0.5,0.7,0.8)
Appearance of crew	(0.6,0.8,0.9)
Timeliness of take-off and landing monitor and announcements	(0.6,0.8,0.9)
Food and beverage quality	(0.5,0.7,0.8)
Convenient ticketing process	(0.5,0.7,0.9)
Customer complaints handling	(0.5,0.7,0.8)
Extended travel services	(0.3,0.5,0.7)

Table 4: d_i* ve d_i^- values of alternatives

Alternatives	d_i*	d_i^-
A1	4,9264	10,0854
A2	6,7818	8,1496
A3	7,8792	7,0462
A4	6,0971	8,9440

Note: A_i: i. Alternative, d_i*: Distance of i. alternative from FPIS, d_i^-: Distance of i. alternative from FNIS

Step 8: Closeness coefficient of each alternative is calculated.
Step 9: By sorting closeness coefficients descending, priority order for alternatives is formed (Table 5)

Table 5: The closeness coefficient of alternatives and ordering table

Alternatives	CC_i	Order
A1	0,6718	1
A2	0,5458	3
A3	0,4721	4
A4	0,5946	2

Note: A_i: i. Alternative, CC_i: Closeness coefficient of i. alternative

5. RESULTS

As seen in Table 5 obtained as a result of calculations according to fuzzy TOPSIS method, as closeness coefficients of alternatives are defined in descending order $CC_1 > CC_4 > CC_2 > CC_3$, it is seen that the order is A_1, A_4, A_2, A_3 when service quality of alternatives are evaluated.

6. CONCLUSION

The fact that airways transportation which has a significant place in service industry is becoming widespread day by day draws attention to the significance of service quality at the customer satisfaction level. In this study, service quality of domestic airways companies in Turkey is evaluated with fuzzy TOPSIS method.
Many qualitative and quantitative criteria are taken into consideration while evaluating service quality. Therefore, service quality evaluation study can be considered as a multi criteria decision making problem. In the study, it is found out that the top two of importance weight of the criteria are security and luggage safety and the last one is enlarged travel service criteria.
With fuzzy TOPSIS method, linguistic variables forming verbal expressions of the people can be used and this method considers that each decision criteria can have a different importance weight. It is concluded that such features allow evaluation results be more realistic.
It was applied on four airways companies preferred the most in Turkey and as seen in Table 5, the first alternative is defined as the company with the best service quality level with the highest closeness coefficient. This company is ensued by fourth, second and third companies.
In conclusion, it can be said that FTOPSIS method can be evaluated with linguistic variables, alternatives are evaluated with multiple decision criteria and it can be easily applied to the situations which requires group decision.

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