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APPLICATION OF FUZZY AHP AND FUZZY MARCOS APPROACH FOR THE EVALUATION OF E-SERVICE QUALITY IN THE AIRLINE INDUSTRY

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Abstract: *Airlines today use e-services extensively for marketing activities and the distribution of services. Monitoring and evaluating e-service quality are essential for customers' satisfaction and thus the success of airlines. This study aims to evaluate e-service quality in the airline industry from the point of view of the consumers. To achieve this, an integrated Fuzzy Analytical Hierarchy Process (F-AHP) and Fuzzy Measurement Alternatives and Ranking according to Compromise Solution (F-MARCOS) approach was proposed to handle the uncertain and imprecise nature of e-service evaluation. In the first stage, e-service quality criteria were prioritized using the F-AHP method. Then, a real-world case study was carried out on scheduled airlines to demonstrate the applicability of the proposed approach using the F-MARCOS method, utilizing a total sample of 395 airline passengers in Turkey. As a result, the top three e-service criteria were found as reliability, understandability, and security. A three-stage sensitivity analysis was also conducted to examine the credibility and stability of the results. This study is the first study to integrate F-AHP and F-MARCOS methods for the first time in literature.*

Key words: *E-service quality; Airlines; Fuzzy AHP; Fuzzy MARCOS; Fuzzy sets theory.*

1. Introduction

The spread of Internet and information technologies (IT) has profoundly affected many industries. With the growth of the Internet, firms started to set up their websites and have offered their marketing and distribution activities through this channel (Cheng, 2011). One of the industries most affected by this development is the airline

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industry. Until the 1990s, airlines had distributed their services through travel agencies, call centers, and global distribution systems (GDS) while later adopting the Internet as an important outlet for the distribution of e-services. Airlines, especially low-cost carriers, have gained a significant presence and power owing to online channels and geographic barriers losing their importance (Díaz & Martín-Consuegra, 2016). Thus, airlines have bypassed intermediaries and have the chance to reach consumers directly and at lower prices. The elimination of intermediaries has also provided opportunities such as reducing costs, reducing uncertainty in the use of e-services, sharing detailed product information, and continuing marketing activities (Tsai et al., 2011).

Today, airlines offer many services to current and potential consumers over the Internet. An airline website is a pivotal channel where these e-services are offered, and it includes many functions such as providing flight routes, price information, an interactive communication channel, online booking, ticket purchase, and online check-in (Díaz & Martín-Consuegra, 2016). Moreover, in addition to providing core services, complementary services, such as hotel booking and car rental, are available on these websites (Harison & Boonstra, 2008). Therefore, it is necessary to create cost-effective, content-rich, and attractive websites to increase e-service use. By doing so, the online presence and effectiveness of airlines will increase, thus increasing business performance, customer satisfaction, and loyalty (Díaz & Martín-Consuegra, 2016; Shankar & Datta, 2020).

In the existing literature, many studies have addressed the evaluation of e-service quality in the airline industry (Elkhani et al., 2014; Güreş et al., 2015; Tarkang et al., 2020). Due to the multi-dimensional nature of e-services, this situation can also be considered as a Multiple Criteria Decision-Making (MCDM) problem (Büyüközkan et al., 2020; Tsai et al., 2011). MCDM methods are applied in complex problems involving conflicting criteria to assist decision-making processes. In this regard, service quality, measured by quantitative and qualitative criteria, can be handled with MCDM methods (Mardani et al., 2015). However, human judgments are often uncertain and imprecise in service quality evaluation (Hu & Liao, 2011). This study aims to evaluate e-service quality in the airline industry considering the uncertain and imprecise environment. In doing so, we propose an integrated Fuzzy Analytical Hierarchy Process (F-AHP) and Fuzzy Measurement Alternatives and Ranking according to Compromise Solution (F-MARCOS) approach. This proposed approach provides a systematic and well-defined solution for e-service quality evaluation in the airline industry. The contribution of this study to literature is twofold. First, this study employs an integrated F-AHP and F-MARCOS methods for the first time in literature. Second, the e-service performance of scheduled airlines in Turkey has been successfully evaluated utilizing a comprehensive framework.

The rest of this paper proceeds as follows: Section 2 reviews the concept of e-service quality and the existing literature within the airline industry context. Section 3 explains the detailed algorithms for the F-AHP and F-MARCOS methods. Section 4 presents the application of the real-world case study, followed by a three-stage sensitivity analysis. Next, Section 5 discusses the results. This study ends with a discussion of the managerial and theoretical implications, presenting research limitations and avenues for future research.

2. Literature review

Fassnacht and Koese (2006) defined e-services as "*services delivered via information and communication technology where the customer interacts solely with an appropriate user interface (e.g. automated teller machine or Web site) in order to retrieve desired benefits*". In literature, this concept is also discussed under different labels such as website quality and online service quality. However, it should be noted that the main focus is the needs of consumers in the virtual environment and what they expect from online services. Researchers have discussed that e-service quality has implications for many key marketing concepts such as customer satisfaction, loyalty, and purchase intention, and it consequently affects financial outcomes positively. Starting from this point of view, the exploration of e-service quality and the question of which critical factors e-services cover have attracted researchers. E-services provided in a virtual environment have distinctive characteristics, and since service quality scales are incapable of measuring e-services, e-service-specific scales have been proposed in literature (Shankar & Datta, 2020).

Considering the main scales, Yoo and Donthu (2001) developed the SiteQual scale to evaluate e-service quality of online shopping websites. Wolfinbarger and Gilly (2003) used the eTailQ scale, consisting of fulfillment/reliability, privacy/security, website design, and customer service dimensions for retail e-services. Parasuraman et al. (2005) applied the E-S-QUAL scale to evaluate e-commerce websites. Based on the multi-dimensional nature of e-services, different second-order measurement models with various sub-dimensions have also been proposed (Blut, 2016). Reviewing the related studies, e-service quality is generally discussed in different contexts such as e-services, e-retailing, e-banking, and website-based services (Shankar & Datta, 2020). In addition, it is observed that proposed models are predominantly based on the Technology Acceptance Model (TAM) or the Theory of Reasoned Action (TRA). Thus, the e-service quality scales are generally a combination of usefulness and ease of use concepts, as well as other related beliefs such as entertainment (Cheng, 2011; Loiacono et al., 2002).

In the context of the airline industry, many studies have addressed e-service quality. Generally speaking, the methodology used in these studies can be grouped as conventional statistical methods, usability testing, content analysis, and MCDM methods (Chong & Law, 2019). In the first group, Elkhani et al. (2014) examined the effect of e-service quality on e-satisfaction and e-loyalty through e-SERVQUAL, e-marketing, and Expectancy Disconfirmation Theory (EDT) frameworks. Llach et al. (2013) analyzed the impact of e-service quality on perceived value and loyalty in Spanish airline services. Lee and Wu (2011) added hedonics to the E-S-QUAL model and examined the relationships between website quality, perceived value, and satisfaction for 30 different airlines. Vuthisopon and Srinuan (2017) reported the positive impact of e-service quality on customer satisfaction in low-cost airlines in Thailand. Güreş et al. (2015) studied the relationship between e-service quality, passenger satisfaction, and passenger loyalty of domestic and international passengers in Turkey. In a recent study, Tarkang et al. (2020) examined the associations between airline website quality, electronic word of mouth, and purchase intention in Turkey.

In the second group, Economides and Apostolou (2009) introduced a holistic airline site evaluation framework (ASEF) model and analyzed the websites of 30 major airlines using multiple quality criteria from the perspectives of the consumers. Díaz and Martín-Consuegra (2016) conducted a content analysis using 240 airline websites through six dimensions, including informativeness, usability, involvement, inspiration, credibility, and reciprocity. Ceballos Hernandez et al. (2020) evaluated the web-based e-service quality of 25 Chinese airlines with content analysis. There are also some studies examining airline e-services using usability testing. Ekşioğlu et al. (2013) analyzed the website quality of airlines in Turkey through usability testing and heuristic evaluation. Murillo et al. (2017) evaluated LATAM airlines' critical website functions through usability testing and heuristic evaluation. Although these studies provide powerful tools that incorporate qualitative and quantitative methods, they only aimed to identify usability problems on the websites (Chong & Law, 2019).

Finally, limited studies in the extant literature have evaluated e-service quality of airlines using MCDM methods. In fact, the MCDM approach is frequently preferred in the airline industry. Badi and Abdulshaded (2019) analyzed the overall performance of Libyan airlines using AHP and the Full Consistency Method (FUCOM). On the other hand, e-services are also very suitable to be evaluated using MCDM methods. It also enables the imprecise information that may arise in quality evaluations to be easily overcome using fuzzy logic (Pamucar & Ecer, 2020). For example, Pamucar et al. (2018) applied AHP and MABAC (Multi-Attributive Border Approximation area Comparison) methods using interval rough numbers (IRN) and evaluated faculty web pages. In the airline industry, Tsai et al. (2011) examined e-marketing and e-service performance of airlines in Taiwan using the Decision Making Trial and Evaluation Laboratory (DEMATEL), ANP, and VIKOR methods. Çelik and Gök Kısa (2017) presented an e-service quality evaluation in the Turkish civil aviation industry by employing AHP and Promethee methods in a fuzzy environment. Abbasi et al. (2018) evaluated website quality of 5 airlines in Iran using the methods of F-AHP and Fuzzy Technique for Order Preference by Similarity to Ideal Solutions (F-TOPSIS). Similarly, Bakır and Atalık (2019) prioritized the factors affecting website quality of airline firms. More recently, Büyüközkan et al. (2020) developed a digital service quality model for airlines using the interval-valued intuitionistic fuzzy AHP (IVIF-AHP) method. Apart from these, some other studies have analyzed the website performance of airlines using ordinary or fuzzy MCDM methods (Dominic & Khan, 2014; Vatansever & Akgül, 2018). However, it should be noted that these studies use many criteria such as website traffic and broken link based on web diagnostic tools. Therefore, these studies focusing on technical issues do not reflect the consumer perspective. Built on the consumer perspective, the present study contributes to the evaluation of e-service quality in airlines using a larger sample size.

3. Research methodology

This section covers the computation steps of the proposed F-AHP and F-MARCOS methods. The F-AHP method was used since it is the most frequently and successfully used methodology in service quality evaluation (Mardani et al., 2015). The F-MARCOS is also a recent and reasonable method that combines the rate and the reference point approaches, thus providing more robust results under uncertainty (Stanković et al., 2020).

3.1. Preliminaries for triangular fuzzy sets

In many real-world problems, human judgments and perceptions are not certain or precise. The Fuzzy sets theory was proposed by Zadeh (1965) to handle the uncertainty of judgments. Fuzzy sets are sets with membership degrees defined as real numbers in the interval [0;1] (Lin, 2010). A triangular fuzzy number (TFN) can be defined as $\tilde{A} = (l, m, u)$ and membership functions are found in Eq. (1) as follows:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-1}{m-l}, & l \leq x \leq m \\ \frac{u-x}{u-m}, & m \leq x \leq u \\ 0, & otherwise \end{cases} \tag{1}$$

Where l and u stand for the lower and upper bounds of the fuzzy number $\tilde{A}$, and m is the mid-value of $\tilde{A}$. If it is assumed that $\tilde{A}_1 = (l_1, m_1, u_1)$ and $\tilde{A}_2 = (l_2, m_2, u_2)$ are two TFNs, the basic arithmetic operations for these two sets can be shown in Eq. (2)-(6) (Lin, 2010; Stanković et al., 2020):

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1, m_1, u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \tag{2}$$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \tag{3}$$

$$\tilde{A}_1 - \tilde{A}_2 = (l_1, m_1, u_1) - (l_2, m_2, u_2) = (l_1 - u_2, m_1 - m_2, u_1 - l_2) \tag{4}$$

$$\frac{\tilde{A}_1}{\tilde{A}_2} = \frac{(l_1, m_1, u_1)}{(l_2, m_2, u_2)} = \left(\frac{l_1}{l_2}, \frac{m_1}{m_2}, \frac{u_1}{u_2} \right) \tag{5}$$

$$\tilde{A}_1^{-1} = (l_1, m_1, u_1)^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1} \right) \tag{6}$$

3.2. The F-AHP method

The AHP method is used to calculate criteria weights based on decision-maker (DM) judgments (Saaty, 1980). The AHP method uses pairwise comparisons and allows both qualitative and quantitative criteria to be evaluated. To handle uncertainty, the ordinary AHP method was extended to the fuzzy sets theory, and F-AHP was introduced. In literature, the F-AHP method has been successfully applied in many studies, including in-flight service quality evaluation (Li et al., 2017), the classification of container terminals (Adenso-Díaz et al., 2019), and the prioritization of traffic accessibility criteria (Stanković et al., 2019). In this study, we adopted Buckley's (1985) approach, which received the least criticism in the existing literature (Kahraman et al., 2018). The application steps can be summarized as follows (Havle & Kılıç, 2019; Singh & Prasher, 2019):

Step 1. Construct a fuzzy pairwise comparison matrix. In this step, DMs construct a pairwise comparison matrix of criteria using linguistic terms. In doing so, we adopted the nine-point conversion scale of Anagnostopoulos et al. (2007) to convert responses into fuzzy numbers (See Table 1). The resulting comparison matrix is given in Eq. (7).

$$\tilde{A} = \begin{pmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \cdots & \cdots & \ddots & \cdots \\ \tilde{a}_{m1} & \tilde{a}_{m2} & \cdots & 1 \end{pmatrix} \tag{7}$$

Table 1. The nine-point fuzzy conversion scale (Anagnostopoulos et al., 2007)

Linguistic Terms	Crisp Scale	TFS Scale	Reciprocal TFN Scale
Equally Preferred	1	(1,1,1)	(1/1,1/1,1/1)
Equally to moderately preferred	2	(1,2,3)	(1/3,1/2/,1/1)
Moderately preferred	3	(2,3,4)	(1/4,1/3,1/2)
Moderately to strongly preferred	4	(3,4,5)	(1/5,1/4,1/3)
Strongly preferred	5	(4,5,6)	(1/6,1/5,1/4)
Strongly to very strongly preferred	6	(5,6,7)	(1/7,1/6,1/5)
Very strongly preferred	7	(6,7,8)	(1/8,1/7,1/6)
Very strongly to extremely preferred	8	(7,8,9)	(1/9,1/8,1/7)
Extremely preferred	9	(8,9,9)	(1/9,1/9,1/8)

Step 2. Aggregate the fuzzy pairwise comparison matrix. In case of group decision-making, the judgments of the DMs are aggregated using Eq. (8).

$$l_{ij}=\left(\prod_{k=1}^{K} l_{ijk}\right)^{1/K},\ m_{ij}=\left(\prod_{k=1}^{K} m_{ijk}\right)^{1/K},\ u_{ij}=\left(\prod_{k=1}^{K} u_{ijk}\right)^{1/K} \tag{8}$$

Where $\tilde{A}=(l_{ij},m_{ij},u_{ij})$ and K denotes the number of DMs.

Step 3. Calculate the fuzzy weights matrix. In this step, the fuzzy comparison values are first calculated using Eq. (9), as Buckley (1985) suggested.

$$\tilde{r}_i=\left(\prod_{j=1}^{n}\tilde{a}_{ij}\right)^{1/n},\quad i=1,2,\dots,n \tag{9}$$

Then, fuzzy weights $\tilde{w}_i$ of criteria are calculated using Eq. (10).

$$\tilde{w}_i=\tilde{r}_i\otimes(\tilde{r}_1\oplus\tilde{r}_2\oplus\dots\oplus\tilde{r}_n)^{-1} \tag{10}$$

Where $\tilde{r}_i$ represents the geometric mean of the fuzzy comparison values, while $\tilde{w}_i$ represents criteria weights.

Step 4. Defuzzy fuzzy weights $\tilde{w}_i$. Since $\tilde{w}_i$ is a fuzzy number, it is defuzzified with the center of area (COA) method using Eq. (11).

$$w_i=(lw_i+mw_i+uw_i)/3 \tag{11}$$

Step 5. Normalize the crisp weights. The calculated crisp values are normalized using Eq. (12) and crisp criteria weights are obtained.

$$w_r=\frac{w_i}{\sum_{i=1}^{n}w_i} \tag{12}$$

3.3. The F-MARCOS method

The MARCOS method has been proposed by Stević et el. (2020) more recently. The basic principle of the MARCOS method is to find a solution based on the relationship between alternatives and reference values. Accordingly, the utility functions of the alternatives are calculated based on the ideal and anti-ideal solutions indicating best and worst values according to the criteria. Similar to the TOPSIS method, the best alternative is located closest to the ideal solution and farthest from the anti-ideal solution (Puška et al., 2020). In literature, the MARCOS method has successfully been applied in sustainable supplier selection (Stević et al., 2020), the evaluation of human resource (Stević & Brković, 2020), and the selection of software (Puška et al., 2020). It also has been applied in fuzzy numbers (Stanković et al., 2020), D numbers (Chakraborty et al., 2020), and grey numbers (Badi & Pamucar, 2020). The steps of the F-MARCOS method can be summarized as follows (Stanković et al., 2020):

Step 1. Formulate a fuzzy aggregated initial matrix. First, a decision matrix, which includes *m* alternatives and *n* criteria, is established. In this step, the fuzzy anti-ideal $\tilde{A}(AI)$ and the fuzzy ideal $\tilde{A}(ID)$ solutions are also determined using Eq. (13).

$$\tilde{X} = \begin{pmatrix} \tilde{x}_{ai1} & \tilde{x}_{ai2} & \cdots & \tilde{x}_{ain} \\ \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \cdots & \cdots & \cdots & \cdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \\ \tilde{x}_{id1} & \tilde{x}_{id2} & \cdots & \tilde{x}_{idn} \end{pmatrix} \tag{13}$$

The fuzzy ideal $\tilde{A}(ID)$ solution marks the desirable alternative, while the fuzzy anti-ideal $\tilde{A}(AI)$ solution shows the undesirable alternative. Considering the criterion type, solutions $\tilde{A}(ID)$ and $\tilde{A}(AI)$ are defined using Eq. (14) and (15).

$$\tilde{A}(AI) = \min_i \tilde{x}_{ij} \text{ if } j \in B \text{ and } \max_i \tilde{x}_{ij} \text{ if } j \in C \tag{14}$$

$$\tilde{A}(ID) = \max_i \tilde{x}_{ij} \text{ if } j \in B \text{ and } \min_i \tilde{x}_{ij} \text{ if } j \in C \tag{15}$$

Where *B* denotes the benefit type criteria, and *C* denotes the cost type criteria.

Step 2. Create the fuzzy normalized decision matrix. In this step, the fuzzy decision matrix including $\tilde{A}(ID)$ and $\tilde{A}(AI)$ solutions is normalized using Eq. (16) and (17).

$$\tilde{n}_{ij} = (n_{ij}^l, n_{ij}^m, n_{ij}^u) = \left(\frac{x_{id}^l}{x_{ij}^u}, \frac{x_{id}^l}{x_{ij}^m}, \frac{x_{id}^l}{x_{ij}^l} \right) \text{ if } j \in C \tag{16}$$

$$\tilde{n}_{ij} = (n_{ij}^l, n_{ij}^m, n_{ij}^u) = \left(\frac{x_{ij}^l}{x_{id}^u}, \frac{x_{ij}^m}{x_{id}^u}, \frac{x_{ij}^u}{x_{id}^u} \right) \text{ if } j \in B \tag{17}$$

Where the elements $x_{ij}^l, x_{ij}^m, x_{ij}^u$ and x_{id}^l, x_{id}^u are subtracted from the fuzzy decision matrix $\tilde{X}$.

Step 3. Construct the fuzzy weighted-normalized decision matrix. The elements of the fuzzy normalized matrix are multiplied by weight coefficients using Eq. (18).

$$\tilde{v}_{ij} = (n_{ij}^l \times \tilde{w}_j^l, n_{ij}^m \times \tilde{w}_j^m, n_{ij}^u \times \tilde{w}_j^u) \tag{18}$$

Step 4. Calculate the fuzzy summation matrix $(\tilde{S}_i)$. In this step, the fuzzy weighted-normalized matrix elements are summed using Eq. (19).

$$\tilde{S}_i = \sum_{i=1}^{n} \tilde{v}_{ij} \tag{19}$$

For $n_{ij}^l, n_{ij}^m, n_{ij}^u$ elements, the calculation is repeated and the column values are summed.

Step 5. Determine the utility degree for each alternative. Two different matrices ($\tilde{K}_i^-$ and $\tilde{K}_i^+$) are constructed, taking into account the ideal and anti-ideal solutions. This procedure is performed using Eq. (20) and (21).

$$\tilde{K}_i^- = \frac{\tilde{S}_i}{\tilde{S}_{ai}} = \left(\frac{s_i^l}{s_{ai}^u}, \frac{s_i^m}{s_{ai}^m}, \frac{s_i^u}{s_{ai}^l} \right) \tag{20}$$

$$\tilde{K}_i^+ = \frac{\tilde{S}_i}{\tilde{S}_{id}} = \left(\frac{s_i^l}{s_{id}^u}, \frac{s_i^m}{s_{id}^m}, \frac{s_i^u}{s_{id}^l} \right) \tag{21}$$

Step 6. Construct the fuzzy combined matrix $\left(\tilde{T}_i\right)$. The utility degree scores of the alternatives are summed using Eq. (22).

$$\tilde{T}_i = \tilde{K}_i^- \oplus \tilde{K}_i^+ = (k_i^{-l} + k_i^{+l}, k_i^{-m} + k_i^{+m}, k_i^{-u} + k_i^{+u}) \tag{22}$$

In this step, $\tilde{T}_i$ elements also need to be converted to a new fuzzy number $\left(\tilde{D}\right)$ using Eq. (23). Note that in doing so, the maximum values of the columns are used.

$$\tilde{D} = (d^l, d^m, d^u) = \max_i \tilde{t}_{ij} \tag{23}$$

In this step, the fuzzy number $\tilde{D}$ is finally defuzzified by applying the formula $df_{crisp} = \frac{l+4m+u}{6}$. By doing so, a crisp number is obtained.

Step 7. Determine the utility functions of alternatives. Based on the formula df_{crisp}, the utility functions are calculated according to the ideal $f(\tilde{K}_i^+)$ and anti-ideal $f(\tilde{K}_i^-)$ solutions. In doing so, Eq. (24) and (25) are applied.

$$f(\tilde{K}_i^+) = \frac{\tilde{K}_i^-}{df_{crisp}} = \left(\frac{k_i^{-u}}{df_{crisp}}, \frac{k_i^{-m}}{df_{crisp}}, \frac{k_i^{-l}}{df_{crisp}} \right) \tag{24}$$

$$f(\tilde{K}_i^-) = \frac{\tilde{K}_i^+}{df_{crisp}} = \left(\frac{k_i^{-l}}{df_{crisp}}, \frac{k_i^{-m}}{df_{crisp}}, \frac{k_i^{-u}}{df_{crisp}} \right) \tag{25}$$

Step 7 is finalized with the defuzzification of $\tilde{K}_i^-$, $\tilde{K}_i^+$, $f(\tilde{K}_i^-)$ and $f(\tilde{K}_i^+)$ values through the same defuzzification formula.

Step 8. Calculate the defuzzified utility function $f(K_i)$. Using Eq. (26), the final utility function score for each alternative is calculated.

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1 - f(K_i^+)}{f(K_i^+)} + \frac{1 - f(K_i^-)}{f(K_i^-)}} \tag{26}$$

Step 9. Alternatives are ranked according to the decreasing values of utility function $f(K_i)$.

4. Empirical case study and findings

This section presents an empirical real-world case study in the Turkish airline industry employing the proposed approach. In this approach, we aimed to demonstrate the applicability of the integrated F-AHP and F-MARCOS methods in e-service quality evaluation. To achieve this, we focused on the web-based e-services provided by scheduled airlines in Turkey. A three-stage approach was adopted to address this problem, and the research framework of this study is given in Figure 1.

4.1. The proposed hierarchical model

The existing literature proposes many hierarchical models for measuring e-service quality from the perspective of the consumers. One of these models is DeLone and McLean's (2003) updated Information Systems (IS) success model. According to this model, information systems consist of three quality dimensions, namely: information quality, system quality, and service quality. In this study, this three-dimensional hierarchical model based on the IS success model was used, which has since been successfully applied in many studies (Chou & Cheng, 2012; Ecer, 2014; Nilashi et al., 2012; Tsai et al., 2011). The definitions of the hierarchical model elements are presented in Table 2.

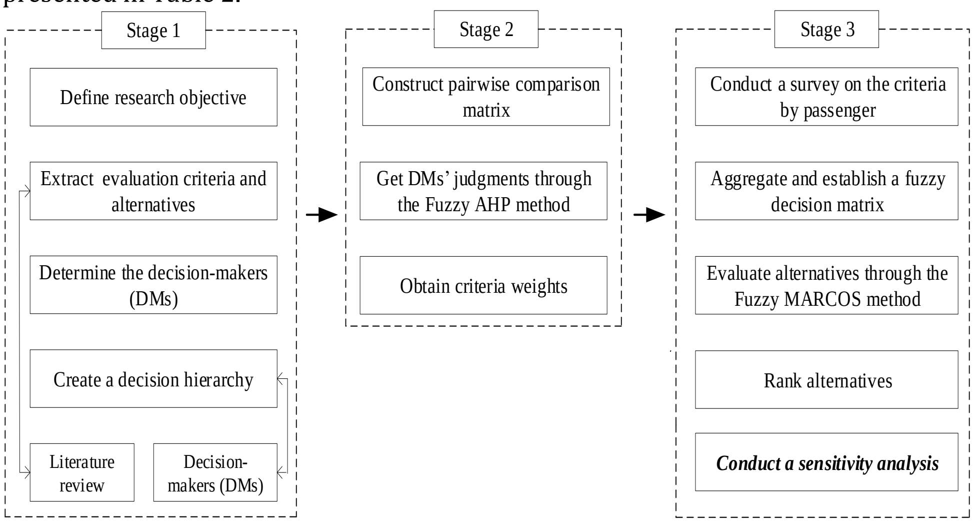

Figure 1. Framework for research methodology

Table 2. E-service quality criteria and definitions

Criteria	Definition	References
Information Quality (C1)	It refers to the appropriateness of the information provided by the website.	
Relevancy (C11)	It means that the information on the website complies with customer needs and expectations.	(Chou & Cheng, 2012; Tsai et al., 2011; Ustasüleyman, 2013)
Understandability (C12)	It expresses that the information on the website is clear and easy to understand.	(Blut, 2016; Ecer, 2014; Kim & Stoel, 2004; Y. Lee & Kozar, 2006)
Currency (C13)	It means that the information on the website is current and timely.	(Ecer, 2014; Lin, 2010; Nilashi et al., 2012; Tsai et al., 2011)
Richness (C14)	It means how detailed the information is about the service provided by the website.	(Chou & Cheng, 2012; Ecer, 2014; Ustasüleyman, 2013)
System Quality (C2)	It refers to the technological equipment and infrastructural competence of the website.	
Security (C21)	It means the level of confidentiality and protection of customer information on the website.	(Blut, 2016; Hu & Liao, 2011; Tsai et al., 2011)
Response time (C22)	It expresses how quickly the website loads.	(Alptekin et al., 2015; Lin, 2010; Nilashi et al., 2012)
Personalization (C23)	It refers to the level of the website's ability to be personalized for the users.	(Blut, 2016; Ecer, 2014; Hu & Liao, 2011)
Navigability (C24)	It means how easy it is to navigate around the website.	(Ecer, 2014; Lin, 2010; Tsai et al., 2011)
Accessibility (C25)	It refers to how easily the website can be accessed.	(Alptekin et al., 2015; Chou & Cheng, 2012; Lin, 2010)
Service Quality (C3)	It refers to the overall support to the users offered by the website.	
Empathy (C31)	It refers to how caring the information is and the attention paid to the users.	(Ecer, 2014; Nilashi et al., 2012; Tsai et al., 2011)
Responsiveness (C32)	It expresses the level of willingness to provide service promptly and helpfully to online customers.	(Chou & Cheng, 2012; Hu & Liao, 2011; Tsai et al., 2011)
Reliability (C33)	It expresses how accurate the services offered by the website are and the fulfillment of the promised service.	(Chou & Cheng, 2012; Fassnacht & Koese, 2006; Hu & Liao, 2011)
Trust (C34)	It means how well the reputation of the e-services is perceived and that using the website is reassuring and relaxing.	(Chou & Cheng, 2012; Ecer, 2014; Lin, 2010; Nilashi et al., 2012)

4.2. Data collection process

The questionnaire technique was employed as a primary data source in both the weighting and evaluation stages. In the first questionnaire, DMs made pairwise comparisons for dimensions and criteria, while in the second questionnaire, passengers evaluated airlines based on the same criteria. Questionnaires for the F-AHP application were collected from 11 DMs in the June-July period in 2017. The DMs encompassed airline managers, website designers, and aviation academics. In the second step, the questionnaire was distributed to passengers to evaluate their perceptions about airline e-services. The responses were collected in the Antalya Airport, Turkey during the period 6-10 November 2017. Since five domestic airlines operate at the airport, the weighted stratified sampling approach was adopted based on the number of passengers they carried. A total of 395 valid questionnaires were obtained. Demographic characteristics and the number of airline-based observations for the sample are given in Table 3.

Table 3. Characteristics of sample and strata

Variables	Alternatives	Percentage (%)
Gender	Male	65
	Female	35
Age	18-25	27
	26-35	41
	36-45	24
	46-55	6
	56+	2
Educational status	High School	22
	University	60
	Postgraduate	18
Travel purpose	Business	35
	Leisure	28
	Education	13
	VFR (Visiting friends and relatives)	18
	Other	6
Airline	Passengers Carried	Size of Strata (n)
X1	2,682,682	153
X2	1,915,506	110
X3	1,117,509	67
X4	564,745	32
X5	589,551	33
Total	6,869,993	395

4.3. Application of the F-AHP method

In this section, pairwise comparison matrices for dimensions and criteria are constructed using Eq. (7). Then, using Eq. (8), the responses from DMs are aggregated through Anagnostopoulos et al.'s (2007) scale into fuzzy numbers. The comparison results and local weights of e-service quality dimensions obtained using Eq. (9)-(12) are given in Table 4.

Table 4. Fuzzy comparison matrix of dimensions

	C1	C2	C3	Weight
C1	(1.00,1.00,1.00)	(0.87,1.28,1.85)	(0.68,0.91,1.25)	0.348
C2	(0.54,0.78,1.15)	(1.00,1.00,1.00)	(0.51,0.72,1.08)	0.276
C3	(0.80,1.09,1.47)	(0.93,1.39,1.98)	(1.00,1.00,1.00)	0.386

Table 4 shows that the most important dimension is service quality $(w_{C3} = 0.386)$, followed by information quality $(w_{C1} = 0.348)$ and system quality $(w_{C2} = 0.276)$. After the analysis of the dimensions, the evaluation criteria were subjected to pairwise comparison. The aggregated comparison matrices expressing local criteria weights are given in Tables 5-7.

Table 5. Fuzzy comparison matrix for information quality criteria

	C11	C12	C13	C14	Weight
C11	(1.00,1.00,1.00)	(0.57,0.72,0.96)	(0.56,0.76,1.05)	(1.22,1.75,2.36)	0.234
C12	(1.04,1.38,1.76)	(1.00,1.00,1.00)	(1.13,1.38,1.75)	(1.86,2.66,3.59)	0.350
C13	(0.95,1.32,1.77)	(0.57,0.72,0.88)	(1.00,1.00,1.00)	(1.72,2.33,2.86)	0.281
C14	(0.42,0.57,0.70)	(0.28,0.38,0.52)	(0.36,0.44,0.78)	(1.00,1.00,1.00)	0.135

Table 6. Fuzzy comparison matrix for system quality criteria

	C21	C22	...	C25	Weight
C21	(1.00,1.00,1.00)	(3.50,4.39,5.22)	...	(1.18,1.63,2.09)	0.431
C22	(0.19,0.23,0.29)	(1.00,1.00,1.00)	...	(0.54,0.72,0.99)	0.147
C23	(0.16,0.20,0.25)	(0.31,0.37,0.45)	...	(0.26,0.36,0.55)	0.072
C24	(0.24,0.28,0.34)	(0.65,0.83,1.12)	...	(0.46,0.58,0.79)	0.130
C25	(0.48,0.61,0.85)	(1.01,1.40,1.86)	...	(1.00,1.00,1.00)	0.221

Table 7. Fuzzy comparison matrix for service quality criteria

	C31	C32	C33	C34	Weight
C31	(1.00,1.00,1.00)	(0.75,0.97,1.21)	(0.29,0.39,0.54)	(0.40,0.53,0.71)	0.155
C32	(0.83,1.03,1.34)	(1.00,1.00,1.00)	(0.31,0.38,0.53)	(0.46,0.70,1.11)	0.172
C33	(1.84,2.59,3.42)	(1.90,2.61,3.27)	(1.00,1.00,1.00)	(0.94,1.21,1.58)	0.388
C34	(1.41,1.88,2.49)	(0.90,1.42,2.18)	(0.63,0.83,1.07)	(1.00,1.00,1.00)	0.285

The judgments of the DMs are consistent since the consistency ratio of the comparison matrices presented above is below 0.10 (Ecer, 2014). Lastly, the synthesizing procedure is carried out to find the global weight of each criterion. The local and global weights of the criteria are given in Table 8. As can be seen in Table 8, the most important criterion is found to be reliability $(w_{C33} = 0.146)$. Following this criterion, understandability $(w_{C12} = 0.122)$ and security $(w_{C21} = 0.119)$ rank second and third, respectively.

Table 8. Global weights of the criteria

Dimension	Weight	Criteria	Local Weight	Global Weight
C1	0.348	C11	0.234	0.081
		C12	0.350	0.122
		C13	0.281	0.098
		C14	0.135	0.047
C2	0.276	C21	0.431	0.119
		C22	0.147	0.040
		C23	0.072	0.020
		C24	0.130	0.036
		C25	0.221	0.061
C3	0.386	C31	0.155	0.058
		C32	0.172	0.065
		C33	0.388	0.146
		C34	0.285	0.107

4.4. Application of the F-MARCOS method

In this subsection, a real-world case study on the Turkish airline industry is presented to evaluate e-service quality of airlines. Air traffic has steadily increased in Turkey and a total of 11 airlines are already based in the country (SHGM, 2020). These airlines are composed of different carriers, such as scheduled airlines, cargo carriers and charter airlines. As we focused on the consumer market, cargo carriers and charter airlines that usually do not sell directly and trade their seats with tour operators were excluded from this study (Williams, 2011). Therefore, the remaining five scheduled airlines (X1-X5) were the subject of the study.

Using a five-point scale (1="strongly disagree" to 5="strongly agree"), a total of 395 passengers were surveyed to evaluate the e-services offered by scheduled airlines. The triangular fuzzy numbers (TFNs) corresponding to these values are presented in Table 9 (Pandey & Shukla, 2019). After collecting the questionnaire forms, they were aggregated via the arithmetic mean and fuzzy aggregated decision matrix including the fuzzy anti-ideal $\tilde{A}(AI)$ and the fuzzy ideal $\tilde{A}(ID)$ solutions are given in Table 10.

Table 9. Five-point fuzzy rating scale

Range		Linguistic Terms	TFNs
1	SD	Strongly Disagree	(0.0,1.0,2.0)
2	D	Disagree	(1.0,2.0,3.0)
3	N	Neutral	(2.0,3.0,4.0)
4	A	Agree	(3.0,4.0,5.0)
5	SA	Strongly Agree	(4.5,5.0,5.0)

Table 10. Average performance ratings and reference values

	X1	...	X5	AI	ID
C11	(3.67,4.39,4.82)	...	(3.42,4.25,4.91)	(3.17,4.00,4.67	(3.67,4.39,4.91)
C12	(3.62,4.35,4.82)	...	(3.53,4.28,4.78)	(3.37,4.17,4.77)	(3.62,4.35,4.88)
C13	(3.83,4.51,4.87)	...	(3.50,4.28,4.84)	(3.50,4.28,4.76)	(3.83,4.51,4.88)
C14	(3.34,4.13,4.71)	...	(3.53,4.31,4.88)	(3.00,3.88,4.65)	(3.53,4.31,4.88
C21	(2.87,3.69,4.33)	...	(2.61,3.50,4.28)	(2.29,3.18,3.97)	(2.87,3.69,4.33)
C22	(3.25,4.05,4.65)	...	(3.11,3.97,4.69)	(2.85,3.73,4.48)	(3.25,4.05,4.70)
C23	(2.49,3.39,4.21)	...	(2.53,3.44,4.25)	(1.98,2.94,3.84)	(2.82,3.68,4.41)
C24	(3.40,4.16,4.67)	...	(3.81,4.53,4.97)	(3.17,4.00,4.67)	(3.81,4.53,4.97)
C25	(3.55,4.27,4.71)	...	(3.73,4.44,4.84)	(3.42,4.19,4.71)	(3.73,4.44,4.85)
C31	(3.00,3.84,4.53)	...	(2.66,3.63,4.56)	(2.66,3.63,4.48)	(3.18,4.01,4.66)
C32	(2.47,3.39,4.23)	...	(2.89,3.75,4.47)	(2.15,3.09,3.97)	(2.89,3.75,4.47)
C33	(3.32,4.12,4.72)	...	(3.61,4.38,4.91)	(2.84,3.72,4.47)	(3.61,4.38,4.91)
C34	(3.15,3.96,4.59)	...	(3.34,4.16,4.78)	(2.88,3.76,4.52)	(3.34,4.16,4.78)

The next step was the normalization process to eliminate the anomalies in the decision matrix. Since all criteria are of the benefit type, the normalization procedure of alternatives and reference values was completed using Eq. (17). The fuzzy normalized decision matrix is given in Table 11.

Table 11. Fuzzy normalized decision matrix

	X1	...	X5	AI	ID
C11	(0.75,0.89,0.98)	...	(0.70,0.87,1.00	(0.65,0.82,0.95)	(0.75,0.89,1.00)
C12	(0.74,0.89,0.99)	...	(0.72,0.88,0.98)	(0.69,0.86,0.98)	(0.74,0.89,1.00)
C13	(0.78,0.92,1.00)	...	(0.72,0.88,0.99)	(0.72,0.88,0.97)	(0.78,0.92,1.00)
C14	(0.69,0.85,0.97)	...	(0.72,0.88,1.00)	(0.62,0.80,0.95)	(0.72,0.88,1.00)
C21	(0.66,0.85,1.00)	...	(0.60,0.81,0.99)	(0.53,0.73,0.92)	(0.66,0.85,1.00)
C22	(0.69,0.86,0.99)	...	(0.66,0.84,1.00)	(0.61,0.79,0.95)	(0.69,0.86,1.00)
C23	(0.56,0.77,0.95)	...	(0.57,0.78,0.96)	(0.45,0.67,0.87)	(0.64,0.83,1.00)
C24	(0.68,0.84,0.94)	...	(0.77,0.91,1.00)	(0.64,0.81,0.94)	(0.77,0.91,1.00)
C25	(0.73,0.88,0.97)	...	(0.77,0.92,1.00)	(0.71,0.86,0.97)	(0.77,0.92,1.00)
C31	(0.64,0.82,0.97)	...	(0.57,0.78,0.98)	(0.57,0.78,0.96)	(0.68,0.86,1.00)
C32	(0.55,0.76,0.95)	...	(0.65,0.84,1.00)	(0.48,0.69,0.89)	(0.65,0.84,1.00)
C33	(0.68,0.84,0.96)	...	(0.74,0.89,1.00)	(0.58,0.76,0.91)	(0.74,0.89,1.00)
C34	(0.66,0.83,0.96)	...	(0.70,0.87,1.00)	(0.60,0.79,0.94)	(0.70,0.87,1.00)

After normalization, the fuzzy weighted-normalized matrix was constructed. In doing so, the fuzzy normalized matrix elements were multiplied by criteria weights using Eq. (18). The fuzzy weighted-normalized matrix is given in Table 12.

Table 12. Fuzzy weighted-normalized decision matrix

	X1	…	X5	AI	ID
C11	(0.06,0.07,0.08)	…	(0.06,0.07,0.08)	(0.05,0.07,0.08)	(0.06,0.07,0.08)
C12	(0.09,0.11,0.12)	…	(0.09,0.11,0.12)	(0.08,0.10,0.12)	(0.09,0.11,0.12)
C13	(0.08,0.09,0.10)	…	(0.07,0.09,0.10)	(0.07,0.09,0.10)	(0.08,0.09,0.10)
C14	(0.03,0.04,0.04)	…	(0.03,0.04,0.04)	(0.03,0.04,0.04)	(0.03,0.04,0.04)
C21	(0.08,0.10,0.12)	…	(0.07,0.10,0.12)	(0.06,0.09,0.11)	(0.08,0.10,0.12)
C22	(0.03,0.03,0.04)	…	(0.03,0.03,0.04)	(0.02,0.03,0.04)	(0.03,0.03,0.04)
C23	(0.01,0.01,0.02)	…	(0.01,0.01,0.02)	(0.01,0.01,0.02)	(0.01,0.02,0.02)
C24	(0.02,0.03,0.03)	…	(0.03,0.03,0.03)	(0.02,0.03,0.03)	(0.03,0.03,0.03)
C25	(0.04,0.05,0.06)	…	(0.05,0.05,0.06)	(0.04,0.05,0.06)	(0.05,0.05,0.06)
C31	(0.04,0.05,0.06)	…	(0.03,0.05,0.06)	(0.03,0.05,0.06)	(0.04,0.05,0.06)
C32	(0.04,0.05,0.06)	…	(0.04,0.05,0.06)	(0.03,0.04,0.06)	(0.04,0.05,0.06)
C33	(0.07,0.09,0.10)	…	(0.08,0.10,0.11)	(0.06,0.08,0.10)	(0.08,0.10,0.11)
C34	(0.10,0.12,0.14)	…	(0.10,0.13,0.15)	(0.09,0.12,0.14)	(0.10,0.13,0.15)

In the next step, the fuzzy summation matrix $(\tilde{S}_i)$ was calculated using Eq. (19). After this step, the utility degree of each alternative was determined based on the ideal and anti-ideal solutions. In doing so, fuzzy numbers $\tilde{K}_i^-$ and $\tilde{K}_i^+$ were calculated applying Eq. (20) and (21). Following this, the ideal and anti-ideal utility degrees of the alternatives were summed to construct the fuzzy combined matrix $(\tilde{T}_i)$ using Eq. (22). However, the $\tilde{T}_i$ elements needed to be converted to fuzzy number $(\tilde{D})$ using Eq. (23) and subsequently defuzzified. The results obtained by applying Eq. (19)-(23) are given in Table 13.

Table 13. Calculation of Steps 4-6 through the Fuzzy MARCOS Application

	$\tilde{S}_i$	$\tilde{K}_i^-$	$\tilde{K}_i^+$	$\tilde{T}_i$	$\tilde{D}$
AI	(0.61,0.79,0.94)				
X1	(0.69,0.85,0.97)	(0.73,1.08,1.59)	(0.69,0.97,1.35)	(1.42,2.05,2.95)	(1.42,2.06,3.01)
X2	(0.66,0.83,0.97)	(0.70,1.05,1.59)	(0.66,0.94,1.35)	(1.35,1.99,2.94)	
X3	(0.66,0.84,0.97)	(0.71,1.06,1.59)	(0.66,0.95,1.35)	(1.37,2.01,2.95)	
X4	(0.62,0.80,0.94)	(0.66,1.01,1.55)	(0.62,0.91,1.31)	(1.28,1.92,2.86)	2.11
X5	(0.69,0.86,0.99)	(0.73,1.09,1.62)	(0.69,0.98,1.38)	(1.42,2.06,3.01)	
ID	(0.72,0.88,1.00)				

As seen in Table 13, the defuzzification was carried out as the final step. The elements of the matrix $\tilde{T}_i$ were summed as follows using Eq. (22):

$$\tilde{t}_{X1} = (0.73+0.69, 1.08+0.97, 1.59+1.35) = (1.42,\ 2.05,\ 2.95)$$

Then, a new fuzzy number $\tilde{D}$ shows the maximum values of the column $\tilde{T}_i$. The maximum elements in this column were calculated as $\tilde{D} = \left(d^l, d^m, d^u\right) = (1.42,\ 2.06,\ 3.01)$. In the defuzzification of the number $\tilde{D}$, the formula $df_{crisp} = \frac{l+4m+u}{6}$ was used and $df_{crisp} = \frac{1.42+4\times 2.06+3.01}{6} = 2.11$. The remaining application steps were carried out based on the df_{crisp} values. Firstly, the utility functions of alternatives related to the ideal $f\left(\tilde{K}_i^+\right)$ and anti-ideal $f\left(\tilde{K}_i^-\right)$ solutions were calculated using Eq. (24) and (25). The calculated $\tilde{K}_i^-$, $\tilde{K}_i^+$, $f\left(\tilde{K}_i^-\right)$ and $f\left(\tilde{K}_i^+\right)$ values were also converted to crisp numbers with the defuzzification procedure above. In the last step, the utility functions $f\left(K_i\right)$ of the criteria were calculated using these crisp values applying Eq. (26). The results and ranking applied by Eq. (24)-(26) are depicted in Table 14.

Table 14. Ranking of alternatives via utility functions

	$f\left(\tilde{K}_i^-\right)$	$f\left(\tilde{K}_i^+\right)$	K_i^-	K_i^+	$f\left(K_i^-\right)$	$f\left(K_i^+\right)$	$f\left(K_i\right)$	Rank
X1	(0.33,0.46,0.64)	(0.35,0.51,0.75)	1.107	0.987	0.467	0.524	0.686	2
X2	(0.31,0.45,0.64)	(0.33,0.50,0.75)	1.081	0.964	0.456	0.511	0.649	4
X3	(0.31,0.45,0.64)	(0.33,0.50,0.75)	1.088	0.969	0.459	0.514	0.658	3
X4	(0.29,0.43,0.62)	(0.31,0.48,0.73)	1.040	0.927	0.438	0.492	0.593	5
X5	(0.33,0.46,0.65)	(0.35,0.51,0.77)	1.118	0.996	0.471	0.529	0.702	1

Table 14 provides the ranking of airline alternatives. Based on the table, the best alternative is X5. On the other hand, X4 is the worst alternative.

4.5. Sensitivity analysis

In this section, a sensitivity analysis was conducted to ensure the robustness of the application and validate the calculation. In doing so, our sensitivity analysis consisted of three parts to perform a rigorous analysis. In the first part, we tested the effect of the change in criteria weights on the calculation. Considering Keshavarz Ghorabaee et al.'s (2018) guidelines, 13 simulated scenarios (Set1-Set13) were employed to generate different criteria weights (See Figure 2). The ranking of the alternatives resulting from the scenarios is given in Figure 3. As Figure 3 shows, the ranking is largely stable except for a slight change in X2 and X3.

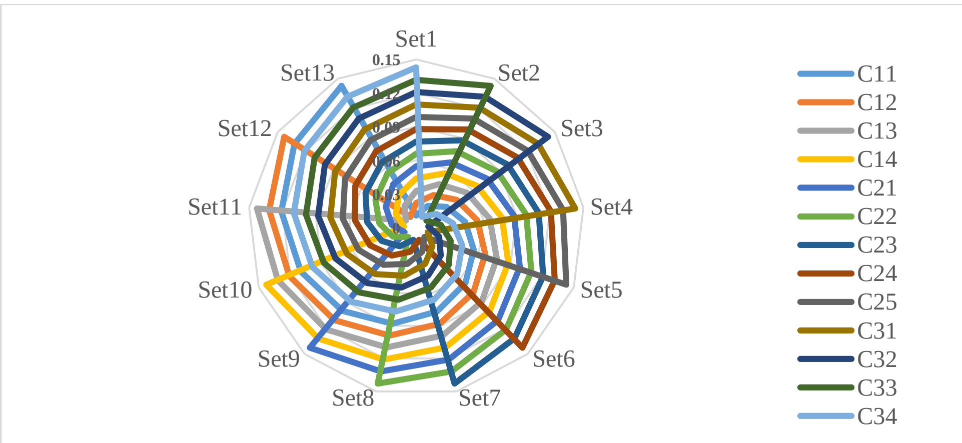

Figure 2. Simulated weights for scenarios

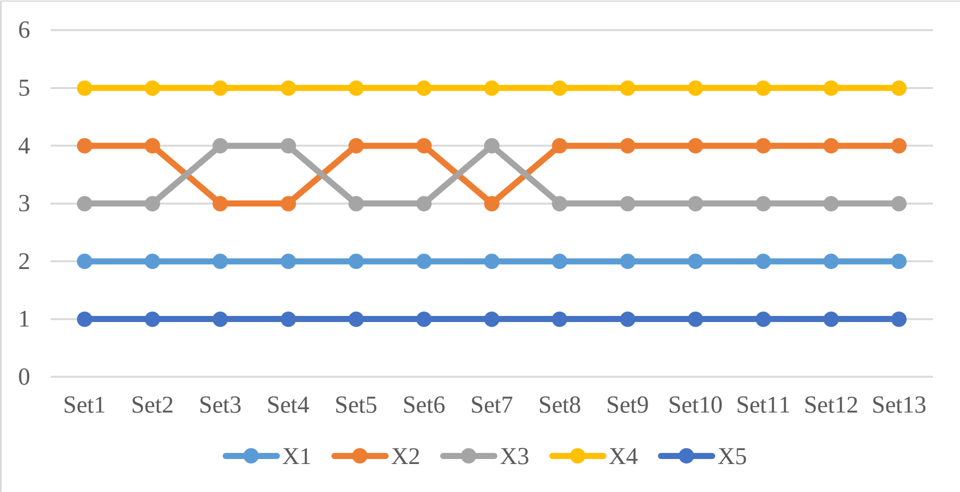

Figure 3. Ranking of airlines under different scenarios

The rank reversal effect is considered to be one of the major shortcomings of MCDM methods. It means that adding or removing an alternative in the decision matrix affects the ranking (Stanković et al., 2020; Yazdani et al., 2019). A scenario-based solution on dynamic decision matrices is presented in the second part. As mentioned above, the ranking of airlines was obtained as X5>X1>X3>X2>X4. Accordingly, X4 is clearly the worst alternative. Therefore, if this alternative is eliminated, in a robust calculation, the ranking of the remaining alternatives is expected to remain the same. To ensure this, we created dynamic decision matrices based on eliminating the worst alternative in each round and progressing until the last alternative remained. The scenario-based rankings in this study are presented in Table 15. As shown in Table 15, the worst alternative (X4) was deleted first, and then the remaining four alternatives are ranked in Scenario 1. The alternative X2, which was the worst in the new ranking, was then deleted, and the application was finalized in Scenario 3. It is clear that the ranking remained unchanged.

Table 15. Rank reversal effect in the application

Alternative	Initial Rank	Scenario 1	Scenario 2	Scenario 3
X1	2	2	2	2
X2	4	4	●	●
X3	3	3	3	●
X4	5	●	●	●
X5	1	1	1	1

In the last part of the sensitivity analysis, the stability of the results was compared with the results of other alternative fuzzy MCDM techniques. In this context, some effective methods such as TOPSIS, MABAC, MOORA, WASPAS, and MAIRCA were employed under a fuzzy environment. Spearman's rank-order correlation coefficients (r_s) were also employed for rankings in the analysis. As shown in the correlation heatmap in Figure 4, the proposed airline ranking is highly credible.

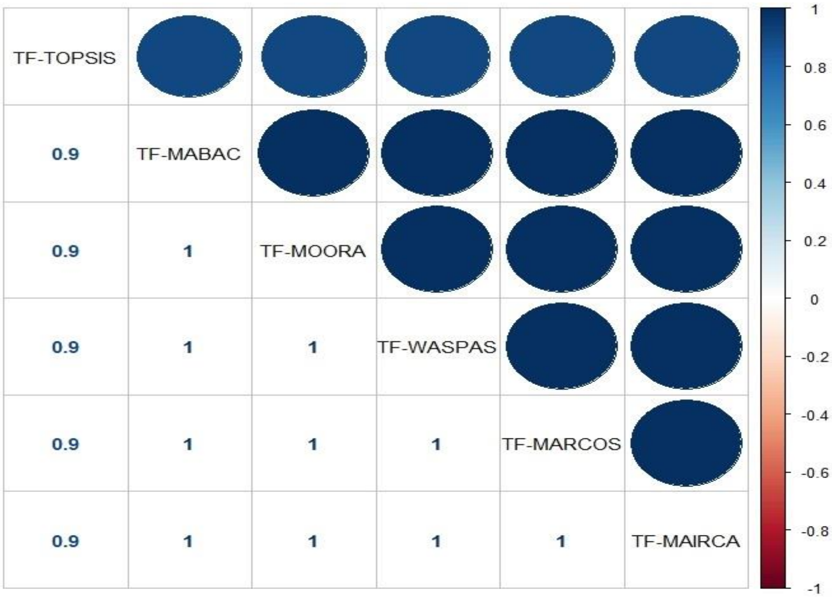

Figure 4. Correlation heatmap for results of alternative methods

5. Results and discussion

In the application, the dimensions and criteria in the hierarchical model were first subjected to pairwise comparison. Fuzzy pairwise comparison matrices are presented in Tables 4-7. The results are consistent since the consistency ratios of the comparison matrices are below 0.10 (CR <0.10) (Ecer, 2014). From the fuzzy pairwise comparison matrix the most important dimension was service quality (C3), which expresses the overall support offered by the airline website. Service quality was followed by the information quality (C1) and system quality (C2) dimensions, respectively (See Table 8). Considering the existing literature, service quality comes to the fore in many studies (Alptekin et al., 2015; Ustasüleyman, 2013). With regards to information quality, Lionella et al. (2020) reported that this is the most determining factor on overall e-service quality from the meta-analytical perspective. Moreover, they argued that information quality is the factor most associated with perceived trust. In addition, similar to the findings of Chou and Cheng (2012), system quality was found to be the least important criteria. In light of these findings, considering the characteristics of the airline industry, it can be concluded that passengers prioritize;

a) the delivery of services without any problems,

b) smooth interactions,

c) the acquisition of high-quality information about the service to be purchased.

In terms of the global weight of the criteria, the most important criterion was reliability (C33), followed by the understandability (C12) and security (C21) criteria. The importance of these criteria has also been identified in previous studies (Chou & Cheng, 2012; Lee & Kozar, 2006). Additionally, it is seen that the reliability criterion, which considers the degree to which the delivered services were as promised (i.e., flight delay due to increased air traffic, flight cancellation, and overbooking), was the most important criterion for airline passengers. In fact, reliability was also found to be the most important criterion in previous studies (Lee & Lin, 2005; Shankar & Datta, 2020; Tsai et al., 2011). Following the deregulation of the US airline industry in 1978, both flight frequencies and air traffic have increased considerably, which has caused some confusion for passengers. Thus, in this context, the understandability criterion may represent the expectations of passengers that the information provided will be understandable and satisfactory. In addition, as seen in previous studies (Çelik & Gök Kısa, 2017; Hsu et al., 2012), in the airline industry where services are mainly distributed online, consumers are concerned about the confidentiality of their personal and financial data and, therefore, they pay particular attention to the security criterion. This issue has also been found in past studies as one of the main concerns of passengers during online booking (Bigné et al., 2010; Lee et al., 2019).

In light of the above-mentioned findings, consumer expectations can also be associated with Hofstede's Cultural Dimensions Theory (Hofstede & Bond, 1984). As has previously been established (Blut et al., 2015), cultural dimensions exert a moderating effect on people's perceptions of the quality of e-services. Thus, it can be deduced that passengers care about receiving adequate general support and satisfactory information so as to minimize their risks in Turkey, a country in which the population is generally considered to be characterized by high levels of uncertainty avoidance.

After weighting, the web-based e-service quality of airlines was evaluated using F-MARCOS under uncertainty. As a result, the best and worst alternatives were X5 and X4, respectively. Finally, a three-stage sensitivity analysis was conducted to check the robustness of the calculation. With regards to the rank reversal effect, it was seen that there is no rank reversal effect. In addition, Figures 3 and 4 indicate that the weight changes do not affect ranking, thus indicating that the application presented is credible.

5. Conclusions

Being aware of consumer expectations helps to ensure firms' survival. Yet, it is evident that firms cannot fully understand consumer expectations (Kurtulmuşoğlu et al., 2016). From a different view, it is also not always possible to meet all consumer expectations in practice. Therefore, the most sensible approach is to recognize those criteria which have been prioritized. As the importance of providing satisfactory e-services has been established in literature, the importance levels of the constituent criteria should be ascertained in order to satisfy consumers. In this study, the criteria affecting e-service quality in airlines have been prioritized, and a real-world case study based on passenger evaluations of scheduled airlines is presented. It should be noted, however, that service quality evaluations often suffer from imprecise judgments. Therefore, we employed the proposed approach in a fuzzy environment in order to handle the subjective and imprecise judgments of people.

Theoretically, the key contributions of this study are twofold. This study is the first to integrate F-AHP and F-MARCOS methods in a case study. This approach, which was applied successfully in the area of airline e-service quality, can be used in different domains. Additionally, e-service quality of scheduled airlines in Turkey has been analyzed for the first time in literature. In this regard, the proposed approach is expected to contribute to the existing literature. The present study also has numerous implications for Turkish airline managers. From a managerial perspective, the findings will assist airlines in providing more satisfactory online services by becoming more aware of the priorities of customers in terms of the e-service quality elements. Moreover, since a hierarchical model with 13 criteria has been developed in this study, airlines can use these criteria to monitor their e-service processes. The success of airlines depends on their compatibility with the voice of the customer. Therefore, this study, in which passengers evaluated the e-service quality of scheduled airlines, provides vital understanding for airline managers. In terms of the findings, reliability, understandability, and security criteria were the most important criteria. Therefore, airlines should consider these in their web-based marketing strategies and strengthen the perception of reliability in the minds of the consumers.

Several recommendations for further research can be made based on the findings of this study. First, since a comprehensive e-service quality evaluation model is still required for the airline industry (Chong & Law, 2019), we suggest that the hierarchical model could be enriched by using focus groups, in-depth interviews, etc. Prior studies concerning e-service quality have considered matters such as website quality and e-service quality, and they have predominantly focused on services delivered through a personal computer (PC). However, it has been shown that the use of mobile devices in relation to the airline industry is increasing dramatically. According to SITA (2019), mobile applications for passenger services are one of the investment priorities of airlines. Mobile devices are frequently used in many services such as booking, bag tracking, self-boarding, etc. In addition, due to the ubiquity and localization characteristics of mobile devices, consumer expectations can be shaped accordingly (Lionello et al., 2020). Therefore, future studies should address airline e-service quality from the perspective of mobile devices. Second, when the literature regarding airline e-service quality is considered, it quickly becomes apparent that the issue of business model segmentation has previously been ignored. Thus, future studies can provide deeper insights by focusing on different airlines such as full-service carriers (FSCs) and low-cost carriers (LCCs).

It is important to recognize that this study has a few limitations. First, the survey data were only collected from a limited number of passengers using scheduled airlines in Turkey. Therefore, it is assumed that the sample represents the population. Is it also worth mentioning that demographics (age/culture etc) of passengers could also affect which criteria are more important. In addition, the ratings reflect the period in which the data were collected. As airline websites are very dynamic, there is a possibility that different results would be obtained in future studies. Second, the research data were collected at only a single airport due to procedural difficulties and time limitations. Third, the proposed hierarchical model may have excluded some factors that affect e-service quality. Therefore, the evaluation performed in this study reflects the investigated airlines' performances according to only certain criteria. Finally, the results should not be generalized because they were derived from data concerning just five scheduled airlines.

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