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A three-level framework to evaluate airline service quality based on interval valued neutrosophic AHP considering the new dimensions

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ABSTRACT

Measuring customer satisfaction in service businesses is very important in terms of both increasing service quality and meeting customer expectations. Up-to-date and comprehensive quality of service measurement techniques provide important information to the companies about the way customers perceive the quality and their service quality expectations. It is critical to measure the service quality for airline transportation, which is becoming more popular compared to other types of transportation and therefore increasing competition. In order to compete in the market and improve their service quality, companies should know their customers well and make improvements by analysing their expectations correctly. In this context, the SERVQUAL method is one of the frequently preferred and effective tools in service quality measurement. However, it is not possible to deal with the effects of radical changes such as the development and transformations of technology, events and trends under the influence of the world with the conventional SERVQUAL method. For this purpose, the traditional method consisting of five dimensions has been extended to nine dimensions by adding four more dimensions, namely Environment, Pandemic, Digital Technology and Information Systems. While it is possible to perform a more detailed service quality measurement with the proposed method, companies are provided with an effective and up-to-date tool to determine which dimensions are more important. In this study after structuring main dimensions and its inner levels hierarchically, Modified Delphi method is applied to a group of experts and the main criteria are evaluated with Best Worst Method and sub-criteria are evaluated with Interval-Valued Neutrosophic AHP method. After subjecting the criteria, whose importance are determined, to sensitivity analysis, the results obtained are evaluated in terms of airline transportation and recommendations are presented. In addition to the extended approach it proposes, this study is the most detailed research on airline service quality as far as we know.

1. Introduction and related studies

Service-producing businesses have to analyze the demands and expectations of the customers correctly and make improvements in this direction in order to gain competitive advantage in the market. Especially in recent years, airline companies, where the demand has increased even more, should handle the demands, which are described as “the voice of the customer”, with the right techniques and update their quality characteristics in this direction (Pakdil and Aydin, 2007). However, it is not enough to just analyze and apply quality expectations. After providing the service, businesses have to monitor whether the customer expectations are met and how customers perceive the service with the right methods. At this point, SERVQUAL is one of the most suitable methods for these tasks (Parasuraman et al., 1988).

This method, which is used quite frequently, has applications in many different service areas, such as health services and healthcare management (Butt and de Run, 2010; Chakraborty and Majumdar, 2011; Lam, 1997; Pansiri and Mmereki, 2010; Ramsaran-Fowdar, 2005; Sinha et al., 2013), education (Arambewela and Hall, 2006; Cerri, 2012; Galeeva, 2016; José and Oliveira, 2009), tourism (Bhat, 2012; Gabbie and O’Neill, 1996; López Fernández and Serrano Bedia, 2005; Markovic and Raspor, 2010), banking and financial management (Aydemir and

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Gerni, 2011; Krishnamurthy et al., 2010; Ramanathan et al., 2018), public transportation (Barabino et al., 2012; Mikhaylov et al., 2015; Ojo et al., 2014; Randheer et al., 2011), and airline transportation (Basfirinci and Mitra, 2015; Büyüközkan et al., 2020b; Ganiyu, 2016; Kiatcharoenpol and Laosirihongthong, 2006; Pakdil and Aydin, 2007; Rezaei et al., 2018).

SERVQUAL is a method that measures service quality in five main dimensions as tangibles, reliability, responsiveness, assurance and empathy (Parasuraman et al., 1988). In the literature, there are studies dealing with all of these dimensions, as well as studies dealing with some of these dimensions. Aydin and Yildirim (2012) investigated whether there is a significant difference between passengers' service quality expectations and service perceptions in different airlines using five main SERVQUAL dimensions. As a result of the analysis of the survey conducted face to face with passengers, they revealed that the most important dimension is reliability in their research. Pakdil and Aydin (2007) conducted a service quality assessment for Turkish airlines by including flight patterns, accessibility and image dimensions in addition to the five main SERVQUAL dimensions. In this study based on weighted factor analysis, responsiveness is found as the most important and accessibility is found the least important dimensions. Chou et al. (2011) propose fuzzy weighted SERVQUAL model in order to evaluate airline service quality and the importance of the dimensions listed as follows: Reliability and assurance, responsiveness, empathy, tangibles and flight pattern. Security is the most important element in terms of service items, the second is the handling of customer complaints and the third is the courtesy of the crew. Airline service quality has been handled by different researchers with different parameters. Gourdin (1988) expressed the quality of airline service in three dimensions as price, safety and timeliness. Elliott and Roach (1993) presented research in terms of baggage handling, food and beverage quality, seat comfort, check-in process and in-flight service dimensions.

Although widely used, the traditional 5-dimensional SERVQUAL method is not suitable for measuring up-to-date dimensions such as technological development, digitalization on flight or environmental effects. In addition, the pandemic that has been ongoing since the first half of 2020 has led to serious changes and transformations in air transport, as in all sectors. It is very important to measure these changing situations in terms of customer service quality with a proper tool.

In order to meet these needs and adapt the SERVQUAL method to current needs, we propose to extend the method by adding four more main dimensions: Environment, Pandemic, Digital Technology and Information Systems. The proposed 9-dimensional new method has 89 sub-dimensions and is the most detailed assessment tool in the literature for airline service quality.

2. The extension of SERVQUAL for airline service quality

The traditional SERVQUAL method has five main dimensions, each of which consists of many different sub-dimensions. These sub-dimensions depend on the subject of the studies or researchers' preferences, but the five main dimensions are generally fixed. Table 1 shows the five SERVQUAL dimensions and brief explanations proposed by Parasuraman et al. (1988).

Table 1
Five main SERVQUAL dimensions.

Dimensions	Brief Explanations
Tangibles	Physical facilities and owned equipment, employees' appearance
Reliability	Skills of related to providing consistent and reliable services
Responsiveness	Fast, agile and customer-oriented approaches
Assurance	Employees' attitudes and ability to cope with difficult situations
Empathy	Individually valuing the customer and understanding his or her needs

These 5 main dimensions and sub-dimensions are examined to measure service quality. In order to make an accurate and up-to-date evaluation, the dimensions of the method should also be up-to-date and the quality expectations of the customer should be addressed in all aspects. For this reason, it is necessary to extend the dimensions of the SERVQUAL method in today's world, where especially the pandemic has affected many systems and the age of digitalization transforms quality expectations in every field. This study extended the 5 main dimensions of the method to 9 main dimensions, and added 2 more inner levels providing a broad assessment tool with 89 sub-dimensions in total. The method with the extended criteria is explained in detail in the next section.

2.1. *The novel SERVQUAL criteria*

Traditional SERVQUAL method has been extensively studied in the airline service quality literature. The main dimensions of the SERVQUAL model are needed to be updated with Environmental, Pandemic, Digital Technology and Information Systems perspective to measure customer satisfaction due to the changing demands and expectations of customers over time. The novel dimensions of the model are obtained through a detailed literature survey and expert opinions. Fig. 1 shows the proposed extended SERVQUAL model with criteria at all levels. The SERVQUAL model is considered as a source to develop the model.

Nowadays, not only in airline transportation but also in many other sectors, service quality is affected by environmental awareness and affects the quality perception of the customer. The rapid growth in the airline service sector and the negative effects of climate change on the world especially cause the concepts of environment and sustainability to come to the fore and it becomes necessary to provide them in order to compete in today's economy (Abdullah et al., 2016).

In addition to the many advantages it provides, the air transport industry also brings along a number of environmental problems such as the greenhouse effect caused by various pollutants and increasing emission rates (Sun et al., 2021). Not only emission rates, but also noise in air transport, sustainable waste management and fuel consumption attract attention as issues that need to be addressed. It is inevitable that such serious environmental effects will also transform the customer's perception of quality. In order to handle the changing perception in terms of customer satisfaction, the "Environmental "dimension has been added to the conventional SERVQUAL scale. Environmental dimension has three sub-dimensions as General eco-efficiency, Operational eco-efficiency and Ground eco-efficiency. Thus, it is aimed to examine environmental impacts in a comprehensive and versatile way with the help of the new extended scale.

The (COVID-19) pandemic naturally affected the perceptions and expectations of customers regarding the services they received from the airways under pandemic conditions. The Pandemic criterion has been added to the traditional SERVQUAL method. Thus, the method will be able to measure current developments and the effects of these developments on customer service quality. Pandemic criterion has three sub-criteria as; Hygiene, In-flight and Operational precaution. The investigations show that the Coronavirus is spread to the airplane by infected passengers and taking precautions can effectively reduce the risk of infection (Pavlik et al., 2021), and some studies suggest that hygiene and safety will be paramount to passengers (Choi, 2021). Another critical measure is social distancing and hygiene kit. Social distance is very important and the companies have to revise their seat assignment rules (Moore et al., 2021). Precautions are necessary not only in-flight, but also in all operational steps. Therefore, we add the Operational precaution criterion and its sub-criteria as Contactless ticket process, Contactless baggage claim, Transport management and Regulations. Contactless ticket processes are applications that reduce contact in case the virus spreads. For ticketing and baggage claiming, it can be an advantage for the company profile and customer satisfaction (Merkert and Pearson, 2015; Milne et al., 2021).

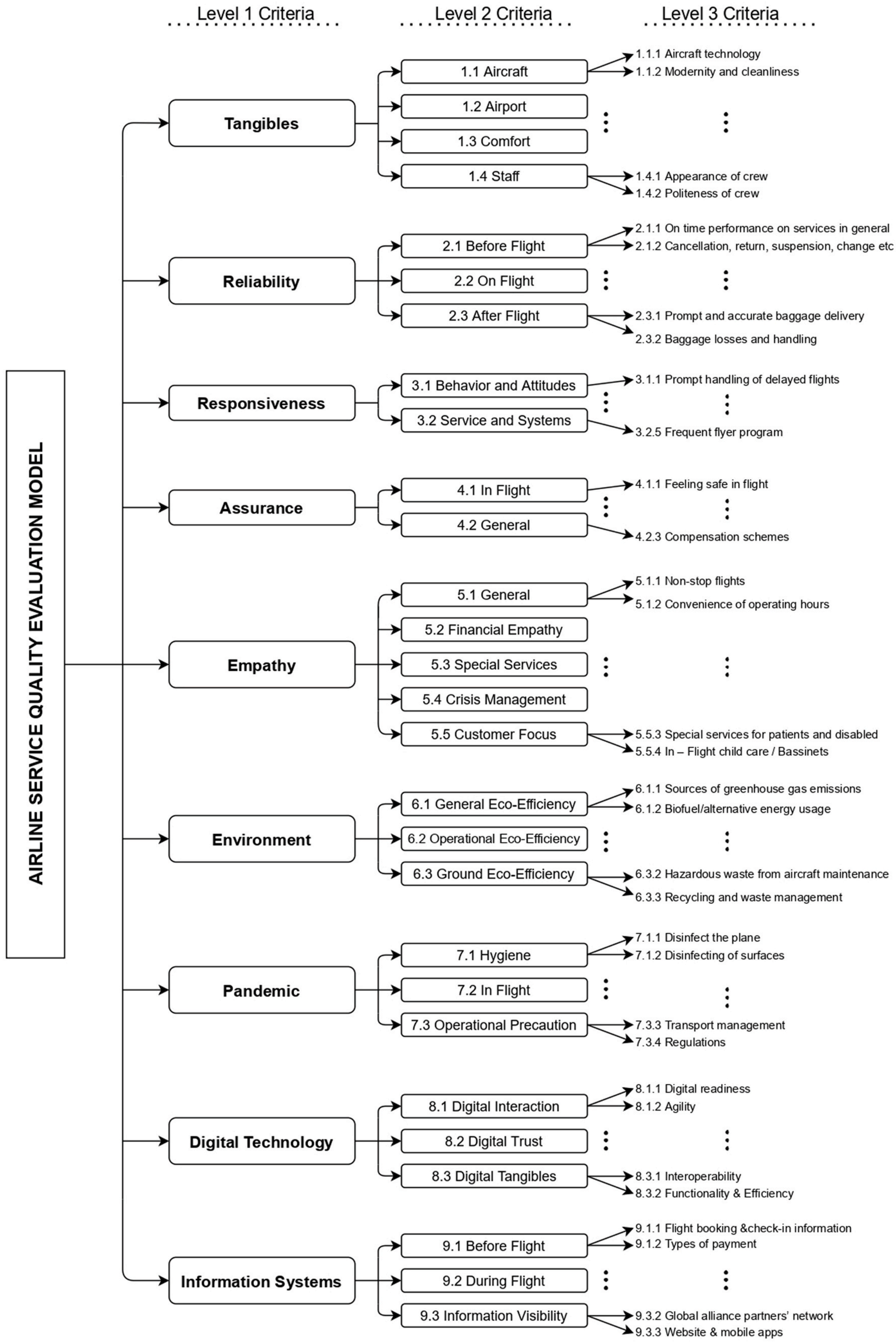

Fig. 1. The extended SERVQUAL model for airline services.

Nowadays, airline companies have to keep up with the developing age of digitalization to keep customer satisfaction at the highest level. Trust in companies lagging behind in digitalization is gradually decreasing. it aims to increase the service quality by including the comments and digital interactions of the passengers, by adding the Digital technology dimension into the traditional SERVQUAL method (Büyüközkan, Havle & Feyzioğlu, 2020b).

Information systems aim for passengers and airlines to collect, process and distribute data about each other. This system continues before, during and after the flight. If a passenger can easily find the flight information at the airport or provide enough information to feel comfortable during the flight. One of the most common situations encountered by pre-flight passengers is online ticket reservation and check-in (Elliott and Roach, 1993; Tsaura et al., 2002). Another important criterion for customer satisfaction is Information visibility that related to flight number, boarding announcements, gate number, etc. (Bulut et al., 2018; Elliott and Roach, 1993). Entertainment panels are the one of the most important factors used to ensure customer satisfaction, especially on long flights (Pakdil and Aydin, 2007). Cabin announcements should be clear and understandable, and an information tracking system like speed, status or pattern of the flight should be placed on the entertainment panel (Gilbezrt and Wong, 2003; Hussain et al., 2015; Pakdil and Aydin, 2007). The internet and mobile applications are the most popular places for passengers to access such visible information. With the help of the websites and mobile applications, airline companies can track the way the user searches for flights. With these available data, airlines can see from which sites passengers buy airline tickets and compare prices (Alauddin et al., 2019). All added Level-2 and Level-3 criteria to the conventional SERVQUAL scale are shown in Table 2.

3. The proposed hybrid decision making methodology

In this study, a three-levels criteria hierarchy is constructed based on SERVQUAL model to evaluate customer expectations for the airline industry in the globalizing world, taking into account the pandemic. Firstly, to determine weights of nine different Level 1 criteria, the Best Worst Method (BWM) is employed by experts' evaluation. Then, IVN-AHP is constructed to determine the weights of both Level 2 and 3 criteria. Also, the sensitivity analysis is performed to show the reliability and robustness of the methodology. The inner levels of the proposed hybrid decision making methodology are given in Fig. 2.

3.1. Best Worst Method

Decision making is a research field that has been studied extensively for many years. The results achieved by decision makers are of vital importance, especially for large companies. For such problems, we usually have to make a decision by considering more than one criterion. The main question we have to answer is which criteria are more important than others. Multi Criteria Decision Making (MCDM) is one of the popular methods used to solve these problems. The MCDM methods in the literature can be classified into three titles: scoring, outranking, and pairwise comparison. The applicability of each method strongly depends on the nature of the problem. However, pairwise comparison methods are preferred by researchers such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP) and The Decision Making Trial and Evaluation Laboratory (DEMATEL) (Ilbahar et al., 2019).

Rezaei (2015) proposed a novel MCDM method called as BWM. This method uses the pairwise comparison technique to weigh the criteria as AHP and ANP. But BWM reduces the number of pairwise comparisons and provide more consistent comparisons. BWM is a method based on selecting the best and worst criteria and comparing these criteria with other criteria (Mou et al., 2016). Many researchers (Kumar et al., 2020; Omrani et al., 2020; Yadav et al., 2020) have recently studied this method to compute weights in different areas. The steps of BWM are

Table 2
Level-2 and Level-3 criteria of novel dimensions.

Level 2 Criteria	Level 3 Criteria	References
6.1 General eco-efficiency	6.1.1 Sources of greenhouse gas emissions	Chou et al. (2011); Lynes and Dredge (2006); Sarkar (2012)
	6.1.2 Biofuel/alternative energy usage	Abdullah et al. (2016); Chang et al. (2015); Moharamnejad and Azarkamand (2007)
	6.1.3 Noise emissions	(Chang et al., 2015; Lynes and Dredge, 2006; Moharamnejad and Azarkamand, 2007)
6.2 Operational eco-efficiency	6.2.1 Flight planning to reduces fuel consumption	(Abdullah et al., 2016; Lynes and Dredge, 2006; Moharamnejad and Azarkamand, 2007; Sarkar, 2012)
	6.2.2 Aircraft weight reduction incentives	Moharamnejad and Azarkamand (2007)
	6.2.3 Onboard waste management and recycling	Abdullah et al. (2016); Moharamnejad and Azarkamand (2007); Sarkar (2012)
6.3 Ground eco-efficiency	6.3.1 Solid waste amount	Lynes and Dredge (2006); Moharamnejad and Azarkamand (2007)
	6.3.2 Hazardous waste from aircraft maintenance	Lynes and Dredge (2006); Moharamnejad and Azarkamand (2007)
	6.3.3 Recycling and waste management	Lynes and Dredge (2006); Moharamnejad and Azarkamand (2007)
7.1 Hygiene	7.1.1 Disinfection the plane	Choi (2021); Pavlik et al. (2021)
	7.1.2 Disinfection the airport	Choi (2021); Pavlik et al. (2021)
	7.1.3 Air filtration systems	Choi (2021); Pavlik et al. (2021)
7.2 In-flight	7.2.1 Social distancing	Milne et al. (2021); Moore et al., 2021.
	7.2.2 Hygiene kit	Forouzandeh et al. (2021); Huang et al. (2021)
7.3 Operational precaution	7.3.1 Contactless ticket process	Choi (2021)
	7.3.2 Contactless baggage claim	Milne et al. (2021).
	7.3.3 Transport management	De Vos (2020).
	7.3.4 Regulations	Taşdemir (2020)
8.1 Digital interaction	8.1.1 Digital readiness	Sukhorukov et al. (2020)
	8.1.2 Agility	Ayyildiz and Taskin Gumus (2021); Büyüközkan et al. (2020a)
	8.1.3 Gamification	(Büyüközkan et al., 2020a; Kalantzis, 2017)
	8.1.4 Human-machine dialogue	Khouzaimi et al. (2017)
	8.1.5 Mobile communication & social media	Rawat and Matter Expert (2016)
8.2 Digital trust	8.2.1 Cyber security	Mattila et al. (2016)
	8.2.2 Privacy, transparency & accountability	Büyüközkan et al. (2020a)
	8.2.3 Online integrity	Sá et al. (2016)
8.3 Digital tangibles	8.3.1 Interoperability	Sá et al. (2016)
	8.3.2 Functionality & efficiency	Hanna and Alawneh (2010)
9.1 Before flight	9.1.1 Flight booking &check-in information	Tsaura et al. (2002); Elliott and Roach (1993); Jiang and Zhang (2016); Park et al. (2004))
	9.1.2 Types of payment	Suparta (2012)
	9.1.3 Self-check-in facilities	Chang and Yang (2008)
	9.1.4 Boarding announcement & flight directions	Bulut et al. (2018); Elliott and Roach (1993); Liou et al. (2011)
9.2 During flight	9.2.1 In-flight entertainment	Chen and Chang (2005); Gilbert and Wong (2003); Pakdil and Aydin (2007); Park et al. (2004)

(continued on next page)

Table 2 (*continued*)

Level 2 Criteria	Level 3 Criteria	References
	9.2.2 Clear and precise cabin announcement	Chen and Chang (2005); Chou et al. (2011); Hussain et al. (2015); Li et al. (2017)
	9.2.3 Flight pattern and tracking	Gilbert and Wong (2003); Pakdil and Aydin (2007); Park et al. (2004)
9.3 Information visibility	9.3.1 Advertising and campaigns	Gursoy et al. (2005).; Yeh and Kuo (2003)
	9.3.2 Global alliance partners' network	Gilbert and Wong (2003); Pakdil and Aydin (2007)
	9.3.3 Website & mobile apps	Alauddin et al. (2019)

given below (Ayyildiz and Taskin Gumus, 2021; Kheybari et al., 2019):

Step 1 Determine the criteria $(C_1, C_2, \ldots, C_n)$.Let n be the number of criteria.

Step 2 Determine the best (most important) and the worst (least important) criteria.

Step 3 Construct the Best-to-Others vector. Determine the level of importance of the best criterion among all criteria. While 1 means there is equal importance between two criteria, 9 means that the best criteria is absolutely more important than the other criterion:

$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$ where a_{Bj} shows the level of importance of the best criterion B over criterion j.

Step 4 Construct the Others-to-Worst vector. Determine the level of importance of all criteria over the worst criterion between 1 and 9.:

$A_w = (a_{1W}, a_{2W}, \ldots, a_{nW})^T$ where a_{jW} shows the level of importance of the criterion j over the worst criterion W.

Step 5 Find the optimal weights of the criteria $(w_1^*, w_2^*, \ldots, w_n^*)$. For each pairwise comparison of $\frac{w_B}{w_j}$ and $\frac{w_j}{w_W}$, the value of $\frac{w_B}{w_j} = a_{Bj}$ and $\frac{w_j}{w_W} = a_{jW}$ are determined in Step 3 and Step 4. The main purpose is to determine the optimal weights to make compute maximum absolute value of $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ for all j is minimized. Nonnegativity constraints (3.2) and the constraint for the sum of all criteria weights (3.3) are added to solve the following problem:

$$\text{minmax}_j\left\{\left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_W} - a_{jW}\right|\right\} \tag{3.1}$$

subject to

$$w_j \geq 0, \text{ for all } j \tag{3.2}$$

$$\sum_{j=1}^{n} w_j = 1 \tag{3.3}$$

This mathematical model can be represented:

$$min\ \zeta \tag{3.4}$$

subject to:

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \zeta, \text{ for all } j \tag{3.5}$$

$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \zeta, \text{ for all } j \tag{3.6}$$

The optimal weights of criteria $(w_1^*, w_2^*, \ldots, w_n^*)$ and ζ are determined by the mathematical model. ζ is the consistency of the mathematical model. It is concluded that the comparisons are less reliable and their consistency is weak as the value increases.

3.2. Interval-valued neutrosophic analytical hierarchy process (IVN-AHP)

Zadeh introduces the fuzzy theory to handle uncertainty and fuzziness to the literature (Zadeh, 1965). Firstly, fuzzy sets consist only membership function. After that, many different fuzzy sets are developed to better handle uncertainty and fuzziness. One of these fuzzy sets is intuitionistic fuzzy sets (IFSs) presented by Atanassov (1986). IFSs are a generalization of fuzzy sets defined by both the membership and non-membership functions. Smarandache (1998) develops the neutrosophic logic as a more advanced version of IFSs to deal with ambiguity more comprehensively by extending fuzzy logic with a new function called "uncertainty" (Kahraman et al., 2020).

A neutrosophic set $\widetilde{A}$ is defined in universe E and represented by three functions as $T_A(x)$, $I_A(x)$ and $F_A(x)$. They characterize truth-membership function, indeterminacy-membership function and falsity membership function, respectively (Bolturk and Kahraman, 2018a).

Definition 1. A single-valued neutrosophic number (SVNN) $\widetilde{A}$ can be represented as (Biswas et al., 2014; Bolturk and Kahraman, 2018a):

$$\widetilde{A} = \{x, (T_A(x), I_A(x), F_A(x)) > : x\,\varepsilon\,E, (T_A(x), I_A(x), F_A(x)\,\varepsilon\,]^{-}0, 1\,[+)\} \tag{3.7}$$

While experts are evaluating the criteria in decision making process, instead of giving crisp numbers, they can use interval numbers to better reflect the uncertainty. In this paper, interval valued neutrosophic sets (IVNSs) are applied to better deal with vagueness.

Definition 2. Interval valued neutrosophic number (IVNN) $\widetilde{A}$ defined in E is given as;

$$\widetilde{A} = \{x, [T_A^L(x), T_A^U(x)], [I_A^L(x), I_A^U(x)], [F_A^L(x), F_A^U(x)]\ ; x\,\varepsilon\,E\} \tag{3.8}$$

Similar to SVNNs degrees of functions must be between 0 and 1.

Definition 3. Deneutrosophication of an IVNN $\widetilde{A}$ can be performed as (Bolturk and Kahraman, 2018a);

$$\mathfrak{D}(x) = \left(\frac{(T_A^L + T_A^U)}{2} + \left(1 - \frac{(I_A^L + I_A^U)}{2}\right)(I_A^U) - \left(\frac{F_A^L + F_A^U}{2}\right)(1 - F_A^U)\right) \tag{3.9}$$

Definition 4. Let $\widetilde{\alpha} = [T_a^L, T_a^U], [I_a^L, I_a^U], [F_a^L, F_a^U]$ and $\widetilde{\beta} = \left[T_\beta^L, T_\beta^U\right], \left[I_\beta^L, I_\beta^U\right], \left[F_\beta^L, F_\beta^U\right]$ be two IVNNs. Some basic mathematical operations on $\widetilde{\alpha}$ and $\widetilde{\beta}$ are as follows (Kahraman et al., 2020; Karaşan et al., 2020):

$$\widetilde{\alpha} \oplus \widetilde{\beta} = \langle \left[T_a^L + T_\beta^L - T_a^L T_\beta^L,\ T_a^U + T_\beta^U - T_a^U T_\beta^U\right], \left[I_a^L I_\beta^L, I_a^U I_\beta^U\right], \left[F_a^L F_\beta^L, F_a^U F_\beta^U\right] \rangle \tag{3.10}$$

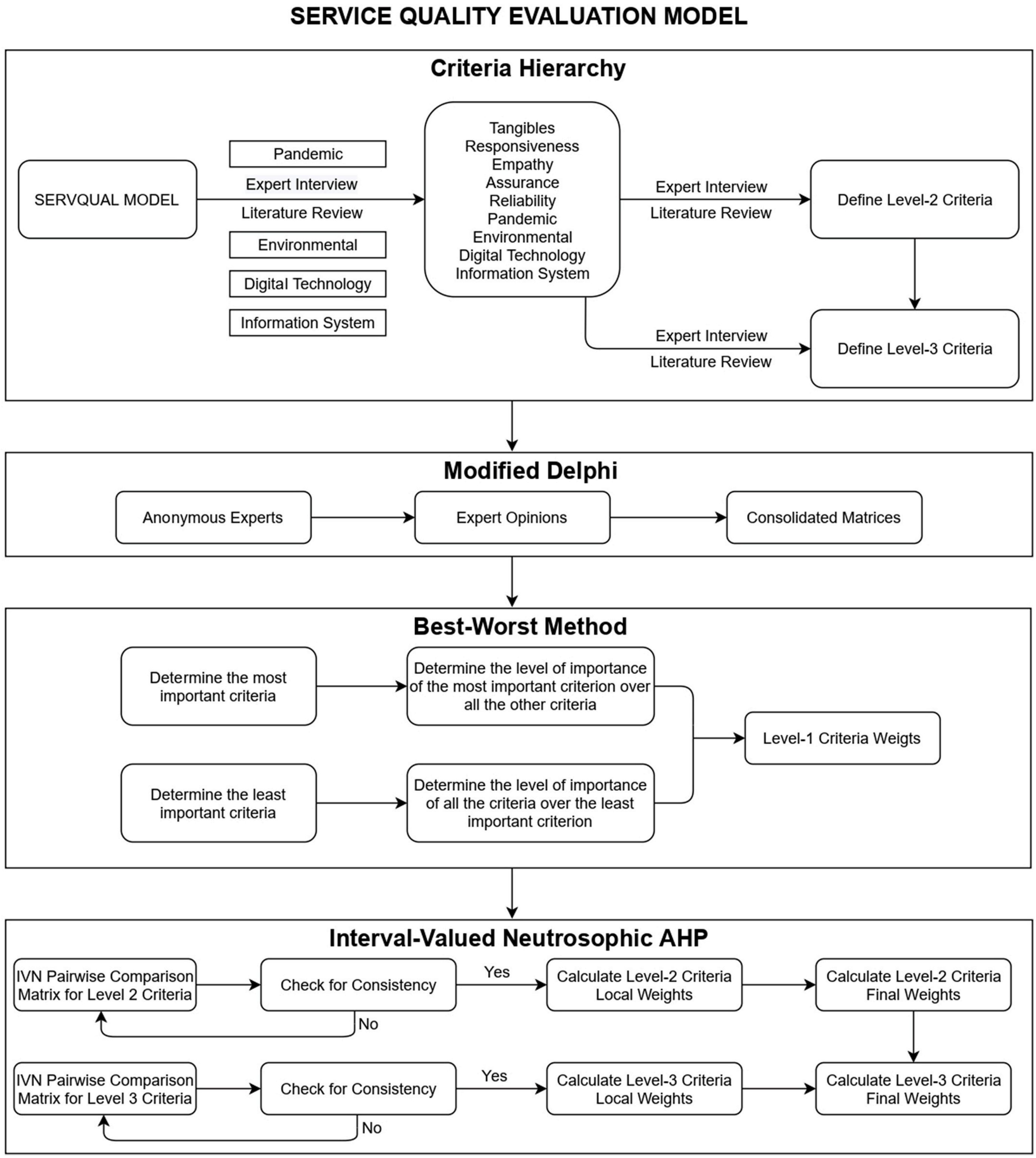

Fig. 2. The proposed methodology.

$$\widetilde{\alpha}\Theta\widetilde{\beta} = \langle \left[T_a^L - F_\beta^U, T_a^U - F_\beta^L\right], \left[\mathrm{Max}\left(I_a^L, I_\beta^L\right), \mathrm{Max}\left(I_a^U, I_\beta^U\right)\right], \left[F_a^L - T_\beta^U, F_a^U - T_\beta^L\right] \rangle \quad (3.11)$$

$$\widetilde{\alpha}\otimes\widetilde{\beta}=\langle\left[T_a^L T_\beta^L,\ T_a^U T_\beta^U\right],\ \left[I_a^L+I_\beta^L-I_a^L I_\beta^L,\ I_a^U+I_\beta^U-I_a^U I_\beta^U\right],\left[F_a^L+F_\beta^L-F_a^L F_\beta^L, F_a^U+F_\beta^U-F_a^U F_\beta^U\right]\rangle \tag{3.12}$$

$$(\widetilde{\alpha})^\lambda=\langle\left[\left(T_a^L\right)^\lambda,\left(T_a^U\right)^\lambda\right],\ \left[\left(I_a^L\right)^\lambda,\left(I_a^U\right)^\lambda\right],\left[1-\left(1-F_a^L\right)^\lambda, 1-\left(1-F_a^U\right)^\lambda\right]\rangle;\lambda\geq 0 \tag{3.13}$$

$$\lambda\widetilde{\alpha}=\langle\left[1-\left(1-T_a^L\right)^\lambda, 1-\left(1-T_a^U\right)^\lambda\right],\ \left[\left(I_a^L\right)^\lambda,\left(I_a^U\right)^\lambda\right],\left[\left(F_a^L\right)^\lambda,\left(F_a^U\right)^\lambda\right]\rangle;\lambda\geq 0 \tag{3.14}$$

AHP method, whose foundations were laid by Myers and Alpert (Myers, James H. &Alpert, 1968), developed and systematized by Thomas Saaty in the 1970s and brought to the literature by systematization, is based on the logic of structuring a problem in hierarchies and then evaluating the components in the hierarchy through pairwise comparisons (Thor et al., 2013). Although AHP is a frequently used method in MCDM problems, it sometimes fails to reflect human thought. Unlike classical AHP, IVN-AHP can strongly express uncertainty with three variables and integrate human thought into the decision-making process effectively. Neutrosophic AHP and IVN-AHP methodologies ae used in different studies such as: Renewable energy source selection (Bolturk and Kahraman, 2018a), search engine evaluation (Abdel-Basset et al., 2018a), evaluation of the challenges of sustainable cities (Karaşan et al., 2020), law firms' performance analysis (Kahraman et al., 2020), physician selection (Sarucan et al., 2021), non-pharmacological treatment selection (Tello et al., 2020), hotel ranking (Sharma et al., 2020), strategic planning (Abdel-Basset et al., 2018b), personnel selection (Nabeeh et al., 2019), supply chain risk assessment (Junaid et al., 2020). In this study, the weights of the criteria are determined by using IVN-AHP methodology. The steps of IVN-AHP are given below (Bolturk and Kahraman, 2018b):

Step 1 Construct the pairwise comparison matrices $(\widetilde{\dddot{P}})$ by using interval-valued neutrosophic sets. To check the consistency, the pairwise comparison matrix is deneutrosophicated with the help of Equation (3.9). If the deneutrosophicated pairwise comparison matrix is determined as consistent, it can be said that the neutrosophic pairwise matrix is also consistent. The pairwise comparison matrices of the criteria are given in Equation (3.15).

$$\widetilde{P}_C=\begin{bmatrix}\langle[T_{11}^L,T_{11}^U],[I_{11}^L,I_{11}^U],[F_{11}^L,F_{11}^U]\rangle & \cdots\ \langle[T_{1m}^L,T_{1m}^U],[I_{1m}^L,I_{1m}^U],[F_{1m}^L,F_{1m}^U]\rangle\\ \vdots & \ddots\ \vdots\\ \langle[T_{m1}^L,T_{m1}^U],[I_{m1}^L,I_{m1}^U],[F_{m1}^L,F_{m1}^U]\rangle & \cdots\ \langle[T_{mm}^L,T_{mm}^U],[I_{mm}^L,I_{mm}^U],[F_{mm}^L,F_{mm}^U]\rangle\end{bmatrix} \tag{3.15}$$

where m represents the number of criteria.

Step 2 Sum the values in each column as in Equation (3.16):

$$\widetilde{S}_{ij}=\langle\left[\sum_{k=1}^m T_{kj}^L,\sum_{k=1}^m T_{kj}^U\right],\left[\sum_{k=1}^m I_{kj}^L,\sum_{k=1}^m I_{kj}^U\right],\left[\sum_{k=1}^m F_{kj}^L,\sum_{k=1}^m F_{kj}^U\right]\rangle \tag{3.16}$$

Step 3 The upper limit value is determined for each parameter and divided each term by its corresponding element to obtain $\widetilde{N}_{ij}$ values by Equation (3.17):

$$\widetilde{N}_{ij}=\langle\left[\frac{T_{kj}^L}{\sum_{k=1}^m T_{kj}^U},\frac{T_{kj}^U}{\sum_{k=1}^m T_{kj}^U}\right],\left[\frac{I_{kj}^L}{\sum_{k=1}^m I_{kj}^U},\frac{I_{kj}^U}{\sum_{k=1}^m I_{kj}^U}\right],\left[\frac{F_{kj}^L}{\sum_{k=1}^m F_{kj}^U},\frac{F_{kj}^U}{\sum_{k=1}^m F_{kj}^U}\right]\rangle \tag{3.17}$$

Then, the matrix is constructed as follows:

$$\widetilde{P}=\begin{bmatrix}\left[\frac{T_{11}^L}{\sum_{k=1}^m T_{kj}^U},\frac{T_{11}^U}{\sum_{k=1}^m T_{kj}^U}\right], & & \left[\frac{T_{1m}^L}{\sum_{k=1}^m T_{kj}^U},\frac{T_{1m}^U}{\sum_{k=1}^m T_{kj}^U}\right],\\ \langle\left[\frac{I_{11}^L}{\sum_{k=1}^m I_{kj}^U},\frac{I_{11}^U}{\sum_{k=1}^m I_{kj}^U}\right],\rangle & \cdots & \langle\left[\frac{I_{1m}^L}{\sum_{k=1}^m I_{kj}^U},\frac{I_{1m}^U}{\sum_{k=1}^m I_{kj}^U}\right],\rangle\\ \left[\frac{F_{11}^L}{\sum_{k=1}^m F_{kj}^U},\frac{F_{11}^U}{\sum_{k=1}^m F_{kj}^U}\right] & & \left[\frac{F_{1m}^L}{\sum_{k=1}^m F_{kj}^U},\frac{F_{1m}^U}{\sum_{k=1}^m F_{kj}^U}\right]\\ \vdots & \ddots & \vdots\\ \left[\frac{T_{m1}^L}{\sum_{k=1}^m T_{kj}^U},\frac{T_{m1}^U}{\sum_{k=1}^m T_{kj}^U}\right], & & \left[\frac{T_{m1}^L}{\sum_{k=1}^m T_{kj}^U},\frac{T_{m1}^U}{\sum_{k=1}^m T_{kj}^U}\right],\\ \langle\left[\frac{I_{m1}^L}{\sum_{k=1}^m I_{kj}^U},\frac{I_{m1}^U}{\sum_{k=1}^m I_{kj}^U}\right],\rangle & \cdots & \langle\left[\frac{I_{m1}^L}{\sum_{k=1}^m I_{kj}^U},\frac{I_{m1}^U}{\sum_{k=1}^m I_{kj}^U}\right],\rangle\\ \left[\frac{F_{m1}^L}{\sum_{k=1}^m F_{kj}^U},\frac{F_{m1}^U}{\sum_{k=1}^m F_{kj}^U}\right] & & \left[\frac{F_{m1}^L}{\sum_{k=1}^m F_{kj}^U},\frac{F_{m1}^U}{\sum_{k=1}^m F_{kj}^U}\right]\end{bmatrix} \tag{3.18}$$

Step 4 The mean of each row is calculated to obtain the neutrosophic importance weight vector of the criteria by Equation (3.19).

$$\widetilde{\dddot{W}_C}=\begin{pmatrix}\frac{\left[\sum_{k=1}^m\frac{T_{1j}^L}{\sum_{k=1}^m T_{kj}^U},\sum_{k=1}^m\frac{T_{1j}^U}{\sum_{k=1}^m T_{kj}^U}\right]}{m},\\ \frac{\left[\sum_{k=1}^m\frac{I_{1j}^L}{\sum_{k=1}^m I_{kj}^U},\sum_{k=1}^m\frac{I_{1j}^U}{\sum_{k=1}^m I_{kj}^U}\right]}{m},\\ \frac{\left[\sum_{k=1}^m\frac{F_{1j}^L}{\sum_{k=1}^m F_{kj}^U},\sum_{k=1}^m\frac{F_{1j}^U}{\sum_{k=1}^m F_{kj}^U}\right]}{m}\end{pmatrix}\quad j=1,2,\ldots,m \tag{3.19}$$

Step 5 In order to obtain the crisp weights of the criteria, the deneutrosophication formula given in Eq (3.9) is employed.

4. A numerical application

In the highly competitive airline industry, it is very important for passengers to be satisfied with the service they receive. In this way, a long-term relationship is formed between a passenger who is satisfied with the services and the airline company, and passenger loyalty to the airline company increases (Hussain et al., 2015). In recent years, technological and environmental developments have created new dimensions that need to be investigated in order to measure customer satisfaction.

In this study, the most used customer satisfaction scale, SERVQUAL, has been adapted to today's conditions by adding different dimensions. Due to the pandemic that has entered our lives since 2020, airlines have to give importance to issues such as hygiene criteria and social distance for customer safety. Since these criteria play an important role in the selection of the airline company by the passengers, the "Pandemic" dimension has been added to the study as a priority. Due to environmental problems encountered in recent years, fuel consumption and global warming, passengers take care to choose companies that pay attention to environmental problems. "Environment" dimension has been added due to these factors. In addition, the "Digital technology" dimension has been added to measure the effect of the technological developments. Thus, it can be seen whether the companies catch up with the customer request and cutting-edge technologies. Finally, the "Information systems" dimension has been added to make customers feel more secure in the information era.

With the assistance of an expert group to calculate the weights, the BWM method for Level-1 was applied. Then, the internal level weights were determined with IVN-AHP. Therefore, importance levels are determined for each level metric in the proposed model.

4.1. Determination of the weights of level 1 metrics by BWM

First of all, an expert group is formed to get opinions about the criteria weights for each level for airline services during the pandemic and on evolving technological conditions and environmental issues. The expert group includes both academicians from different departments of universities and managers from airline companies. While choosing the decision makers, meticulous attention was paid to make an impartial and objective evaluation, and a group of 5 people was formed considering the different dimensions of the problem. At this point, experts who are competent to evaluate the main dimensions of the environment, pandemic and others, who have studies in the sector or related field and who have a good command of current developments, were preferred. Detailed information about the decision makers is given in Table 3.

Table 3
Information on the decision makers.

Decision Makers	Profession	Title	Experience (years)	Fields
DM1	Academician	Professor	20+	airline transportation, customer satisfaction researches, decision making methods, productivity
DM2	Academician	Professor	10+	service systems management, customer portfolio research and environment related researches
DM3	Engineer	Airline Quality Manager	15+	industry expertise in air transport quality practices and projects
DM4	Manager	Customer Relationship Specialist	10+	industry experience in customer relationship management
DM5	Engineer	IT Specialist	8+	digital transformation in airline transportation processes, information technologies expertise

Face to face interviews conducted with above mentioned five experts to get their opinions. Firstly, experts are asked to evaluate Level-1 criteria. For this purpose, a small questionnaire which has two main parts according to the BWM methodology is prepared (Rezaei, 2015). After that, it is asked to participants using a number between 1 and 9 to referring their MOST IMPORTANT criteria over the 9 main criteria. Similarly for the LEAST IMPORTANT one, they followed the same process. Table 4 and Table 5 illustrates the BWM questionnaires for two purposes, respectively.

These questionnaires are applied to each expert and experts are asked to choose the best (the most important) and the worst (the least important) Level 1 criteria from given forms. Modified Delphi method is used to consolidate experts' opinions. Subsequently, pairwise comparisons are performed between the best criterion and the other criteria. Then, pairwise comparisons are performed between the other criteria and the worst criterion. At the end of the all-evaluation process steps, Pandemic found as a best criterion and Digital technology specified as a worst one. Table 6 presents the pairwise comparisons of the best and the worst criteria and also their related vectors.

Then, the criteria weights are determined via mathematical model given before. The value of ζ is determined as 0.058. Then the consistency ratio is calculated via Eq. (4.1) (Moslem et al., 2020).

$$Consistency\ ratio = \frac{\zeta}{Consistency\ index} \tag{4.1}$$

The consistency index values for different criteria numbers are presented in Table 7 (Omrani et al., 2020; Rezaei, 2015):

According to the consistency ratio formula which is presented in Eq. (4.1), we should divide ζ value by the relevant consistency index. There are 9 main criteria so we have to take into consideration value of 5.23 here. As a result of division consistency ratio calculated as 0.0011. The consistency ratio is acceptable if its value is lower than 1 (Moslem et al., 2020). Thus, the results of the BWM application are determined as consistent. Table 8 gives the weights of Level 1 criteria.

Pandemic has the highest weight among 9 main criteria by 0.216. It is normal that the disease, which affects all areas of life and changes many situations, has an impact on airway service quality, too. In order to increase the perceived service quality, airline companies should attach importance to the pandemic criterion and make revisions to meet the expectations of the passengers. Tangibles, which includes physical features such as the comfort of the aircraft or the appearance of the cabin crew, comes after the pandemic with a final weight of 0.176. This situation shows that the Tangibles is important in terms of customer expectations for the expanded SERVQUAL and the company should properly manage the factors under this criterion. Reliability, Responsiveness and Empathy have the same final weight, 0.118 and these are the third important dimensions. The least important is Digital technology, which includes digital transformations and digitalization of processes. It is concluded that it is less important than other dimensions and has a lower share in service quality.

4.2. Determination of the weights of inner levels by IVN-AHP

The same experts are consulted to evaluate both Level 2 and Level 3 criteria. Experts use the linguistic terms given in Table 12 to evaluate criteria. When it comes to decision making problems, neutrosophic sets are more advantageous and flexible than other fuzzy sets in terms of handling uncertainty and indeterminacy. Since they are represented by three different parameters: truth membership, indeterminacy-membership, and falsity-membership, they are quite convenient for decision makers to represent their ideas (Tian et al., 2020; Basset et al., 2018; Karabasevic et al., 2020; Gulum et al., 2021). In order to make a

Table 4
Questionnaire for the most important criterion.

The MOST IMPORTANT criterion	Tangibles	Responsiveness	Empathy	Assurance	Reliability	Pandemic	Environmental	Digital Technology	Information System

Table 5
Questionnaire for the least important criterion.

The LEAST IMPORTANT criterion	
Tangibles	
Responsiveness	
Empathy	
Assurance	
Reliability	
Pandemic	
Environmental	
Digital Technology	
Information Technologies	

Table 6
Pairwise comparisons for Level 1 criteria.

Best	Worst	A_B	A_w^T
Pandemic	Digital technology	(1,2,2,3,2,4,1,4,3)	(3,3,4,2,2,3,4,1,2)

sensitive assessment, it is important that the consecutive linguistic expressions are not too close to each other and that they fully reflect the different ideas of the decision maker. Because of these reasons, scale which is presents in Table 9 restructured and preferred in this study in order to reflect decision makers' linguistic expressions and deal with ambiguity via indeterminacy and falsity memberships functions in addition to the conventional scales. Thus, pairwise comparison matrices are constructed.

The pairwise comparison matrix for the sub-criteria of Tangibles Level 1 criterion is given in Table 10, as an example. Similar pairwise comparison matrices are constructed for each Level 1 criteria.

Firstly, the pairwise comparison matrices are tested for consistency. If the matrices are not consistent, the experts' opinions are re-evaluated.

Table 7
The consistency index values.

a_{Bw}	1	2	3	4	5	6	7	8	9
Consistency index	0.00	0.44	1.00	1.63	2.3	3.00	3.73	4.47	5.23

Table 8
The weights of Level 1 criteria.

Level 1 Criteria	Final Weight
Tangibles	0.176
Reliability	0.118
Responsiveness	0.118
Assurance	0.078
Empathy	0.118
Environment	0.059
Pandemic	0.216
Digital technology	0.039
Information systems	0.078

Table 9
Linguistic terms and scale for IVN-AHP evaluations.

Linguistic Term		Interval-valued neutrosophic numbers					
		T^L	T^U	I^L	I^U	F^L	F^U
Absolutely More Important	AMI	0.9	0.95	0	0.05	0.05	0.15
Strongly More Important	SMI	0.8	0.9	0.05	0.1	0.1	0.2
More Important	MI	0.7	0.8	0.15	0.25	0.2	0.3
Weakly More Important	WMI	0.6	0.7	0.25	0.35	0.3	0.4
Equal Importance	EI	0.5	0.5	0.5	0.5	0.5	0.5
Weakly Less Important	WLI	0.4	0.5	0.55	0.65	0.5	0.6
Less Important	LI	0.3	0.4	0.65	0.75	0.6	0.7
Strongly Less Important	SLI	0.2	0.3	0.75	0.85	0.7	0.8
Absolutely Less Important	ALI	0.1	0.2	0.9	0.95	0.8	0.9

Table 10
Pairwise comparison of Level 2 criteria of Tangibles Level 1 criterion.

Tangibles	Aircraft	Airport	Comfort	Staff
Aircraft	EI	SMI	AMI	AMI
Airport	SLI	EI	WMI	MI
Comfort	ALI	WLI	EI	WMI
Staff	ALI	LI	WLI	EI

Table 11
The weights of the Level 2 criteria.

Level 2 Criterion	Local Weight	Final Weight	Rank
1.1 Aircraft	0.351	0.062	4
1.2 Airport	0.254	0.045	9
1.3 Comfort	0.210	0.037	10
1.4 Staff	0.185	0.033	13
2.1 Before flight	0.235	0.028	16
2.2 In-flight	0.457	0.054	5
2.3 After flight	0.307	0.036	11
3.1 Behavior and attitudes	0.404	0.048	7
3.2 Service and systems	0.596	0.070	3
4.1 In-flight	0.596	0.047	8
4.2 General	0.404	0.032	14
5.1 General	0.195	0.023	17
5.2 Financial empathy	0.261	0.031	15
5.3 Special services	0.154	0.018	25
5.4 Crisis management	0.195	0.023	17
5.5 Customer focus	0.195	0.023	17
6.1 General eco-efficiency	0.344	0.020	22
6.2 Operational eco-efficiency	0.344	0.020	22
6.3 Ground eco-efficiency	0.313	0.018	24
7.1 Hygiene	0.398	0.086	1
7.2 In-flight	0.364	0.079	2
7.3 Operational precaution	0.238	0.051	6
8.1 Digital interaction	0.388	0.015	26
8.2 Digital trust	0.388	0.015	26
8.3 Digital tangibles	0.223	0.009	28
9.1 Before flight	0.422	0.033	12
9.2 During flight	0.289	0.023	20
9.3 Information visibility	0.289	0.023	20

Once all matrices are determined to be consistent, IVN-AHP methodology is employed to calculate the local weights of the Level 2 criteria. The local weight of each Level 2 criterion is multiplied by the corresponding Level 1 criterion weight found by the BWM to find the final weight of the Level 2 criterion. Thus, final weights of Level 2 criteria are determined as given in Table 11.

Among all Level 2 criteria, the most important criterion is found as Hygiene. Considering that the most important main criterion is Pandemic, this situation is quite normal. At the same time, the In-flight criterion comes just after hygiene with a final weight of 0.079. This ranking shows us that the Pandemic and the parameters below are extremely important in terms of customer service quality, and companies should consider this situation in their decisions. The third important criterion is found as Service and systems, which is subcriterion of Responsiveness. The company needs to improve its service and system efficiency in terms of time and quality for customer satisfaction. After that, Aircraft comes in fourth, which shows that the subcriteria of Tangibles are important for good service quality. The least important criteria are all sub-criteria related to Digital technology. It shows that these criteria are not very important for the service quality of customers and it would make more sense to focus on areas that are of higher importance for improvement.

After matrices are constructed for each Level 1 criterion and its inner, the pairwise comparison matrices for Level 3 criteria of the related Level 2 criteria are constructed. Table 12 represents the Level-3 pairwise comparison matrix constructed for 1.1 Aircraft Level 2 criterion.

All matrices are consistent for Level-3 criteria. IVN-AHP methodology is employed again to determine the local weights of Level 3 criteria. The local weight of each Level 3 criterion is multiplied by the corresponding Level 2 criterion weight to find the final weight of the Level 3 criterion. Hence, the final weights of Level 3 criteria are determined, and presented in Table 13.

5. Discussion

Considering all the third level criteria, the social distancing is determined to be the most important one. Efforts to maintain a safe social distance for passengers during the pandemic period are important. However, the Hygiene kit, Disinfection the plane and Air filtration Systems come out as the most important ones. To make a general comment from these results, the improvements to be made in order to ensure the health and safety of the passengers against the spread of the virus, will increase the quality of the company in the eyes of the customer. It will be beneficial to increase disinfection frequency of aircraft in order to create seating plans based on social distance rule, distribute pre-flight hygiene kits to passengers and increase service quality.

In addition to these, customers attach importance to the fact that the aircraft is technological, modern and clean. The companies must ensure that the fleet consists of state-of-the-art aircraft and complies with safety specifications, both to ensure customer confidence and meet physical appearance expectations. However, keeping the planes modern and clean are also very important to the customer. At this point, it may be beneficial to review and improve on-board maintenance and cleaning policies. In addition, it is thought that sharing the frequency and quality

Table 12
Pairwise comparison of Level 3 criteria of Aircraft Level 2 criterion.

Aircraft	Aircraft technology	Modernity and cleanliness	Cleanliness of washroom facility
Aircraft technology	EI	WMI	SMI
Modernity and cleanliness	WLI	EI	MI
Cleanliness of washroom facility	SLI	LI	EI

Table 13
The final weights for all Level-3 criteria.

Level-3 Criterion	Weight	Level-3 Criterion	Weight
1.1.1 Aircraft technology	0.0247	1.3.1 Comfortable seats in the cabins	0.0093
1.1.2 Modernity and cleanliness	0.0226	1.3.2 Books, newspapers and entertainment program	0.0052
1.1.3 Cleanliness of washroom facility	0.0147	1.3.3 Quality of meal service	0.0076
1.2.1 Visually appealing of facilities	0.0098	1.3.4 Seat space and legroom	0.0085
1.2.2 Convenience of check in and check-out	0.0133	1.3.5 Pillows and blankets/covers	0.0065
1.2.3 Availability of waiting lounges	0.0092	1.4.1 Appearance of crew	0.0132
1.2.4 Location of reservation office	0.0124	1.4.2 Politeness of crew	0.0194
2.1.1 On time performance on services in general	0.0138	2.2.3 Proper on board safety equipment	0.0156
2.1.2 Cancellation, return, suspension, change etc.	0.0138	2.2.4 Emergency management	0.0113
2.2.1 Safety in flying	0.0156	2.3.1 Prompt and accurate baggage delivery	0.0215
2.2.2 Professional training of flight attendants	0.0113	2.3.2 Baggage losses and handling	0.0146
3.1.1 Prompt handling of delayed flights	0.0219	3.2.2 Quality of the reservation services	0.0123
3.1.2 Responsiveness of crew	0.0155	3.2.3 Fast delivery of luggage to the belt	0.0138
3.1.3 Crew's speed handling request	0.0102	3.2.4 Check in and waiting time	0.0138
3.2.1 Service punctuality	0.0138	3.2.5 Frequent flyer program	0.0165
4.1.1 Feeling safe in-flight	0.0152	4.2.1 Reputation and image	0.0092
4.1.2 Language skill of crew	0.0100	4.2.2 Convenience of flight schedule	0.0092
4.1.3 Safety record	0.0215	4.2.3 Compensation schemes	0.0134
5.1.1 Non-stop flights	0.0092	5.3.2 Extended travel service	0.0091
5.1.2 Convenience of operating hours	0.0072	5.4.1 Customer complaints handing	0.0125
5.1.3 Chance to seat selection	0.0066	5.4.2 Crew's approach against unexpected situations	0.0104
5.2.1 Rational ticket prices	0.0141	5.5.1 Crew's behavior towards customers	0.0056
5.2.2 Price of overweight baggage	0.0100	5.5.2 Understanding of passenger's specific needs	0.0050
5.2.3 Handling of the fare problems	0.0066	5.5.3 Special services for patients and disabled	0.0067
5.3.1 Transportation between city and airport	0.0091	5.5.4 In-flight child care/bassinets	0.0056
6.1.1 Sources of greenhouse gas emissions	0.0080	6.2.3 Onboard waste management and recycling	0.0058
6.1.2 Biofuel/alternative energy usage	0.0074	6.3.1 Solid waste amount	0.0057
6.1.3 Noise emissions	0.0048	6.3.2 Hazardous waste from aircraft maintenance	0.0070
6.2.1 Flight planning to reduce fuel consumption	0.0085	6.3.3 Recycling and waste management	0.0057
6.2.2 Aircraft weight reduction incentives	0.0058		
7.1.1 Disinfection the plane	0.0295	7.3.1 Contactless ticket process	0.0130
7.1.2 Disinfection the airport	0.0269	7.3.2 Contactless baggage claim	0.0119
7.1.3 Air filtration systems	0.0295	7.3.3 Transport management	0.0112
7.2.1 Social distancing	0.0429	7.3.4 Regulations	0.0152
7.2.3 Hygiene kit	0.0357		
8.1.1 Digital readiness	0.0040	8.2.1 Cyber security	0.0062
8.1.2 Agility	0.0031	8.2.2 Privacy, transparency & accountability	0.0061
8.1.3 Gamification	0.0021	8.2.3 Online integrity	0.0029
8.1.4 Human-machine dialogue	0.0021	8.3.1 Interoperability	0.0044
8.1.5 Mobile communication & social media	0.0040	8.3.2 Functionality & efficiency	0.0044
9.1.1 Flight booking &check-in information	0.0069	9.2.2 Clear and precise cabin announcement	0.0074
9.1.2 Types of payment	0.0096		0.0048

Table 13 (*continued*)

Level-3 Criterion	Weight	Level-3 Criterion	Weight
		9.2.3 Flight pattern and tracking	
9.1.3 Self-check-in facilities	0.0096	9.3.1 Advertising and campaigns	0.0071
9.1.4 Boarding announcement & flight directions	0.0069	9.3.2 Global alliance partners' network	0.0065
9.2.1 In-flight entertainment	0.0105	9.3.3 Website & mobile apps	0.0091

of in-flight cleaning and disinfection processes with customers can increase the trust in the company.

The next criterion that customers care about relates to delayed flights. It is extremely critical for companies to have flexible flight schedules and to take measures to prevent passengers from being victimized in case of delays and it will affect the trust in the company. In addition, frequent flights are another criterion that customers attach importance. Customers will be delighted to find flight options to frequently preferred locations on different days and times. This criterion is directly related to the company's proper and real-time flight planning capability. Flight plans should be open to changes and can be updated.

Fast and accurate baggage delivery is among the important sub-criteria for customers. Companies should manage this process accurately and securely in order to reduce the time spent in crowded areas while waiting for luggage under pandemic conditions and to manage lost and damaged luggage situations correctly.

The attitude and behaviour of the cabin crew has been placed in the category of high importance to customers. A polite and understanding approach towards customers, which is a very important quality indicator especially in service businesses, draws attention here.

When we look at the criteria that can be defined as relatively moderately important, it is obvious that these are generally sub-criteria of Tangibles, Responsiveness and Reliability. These criteria are the average expectations that must be met and are generally related to the ease of access and speed of services. Proper on-board safety equipment, responsiveness of crew, service punctuality and the quality of reservation services are some examples of this group. The company should not only manage these basic expectations well, but also develop them and make improvements that exceed customer expectations. There are also some sub-criteria of the Security main criteria in this group. The company should inform the customers about the processes or disruptions and manage the processes safely. Informative text messages, descriptive announcements, although not very often, may be useful at this point. In addition, the websites should be informative and accessible for passengers.

In terms of environmental criteria, it can be said that even if it is not in the most important group, customers care about the criteria of gas emissions and environmental pollution. Since environmentally friendly sustainable processes are at the forefront today, if the company develops its policies in this context or gives more importance to environmental awareness, it will affect the service quality perception of the customers. Reducing in-flight waste, recycling of physical ticket prints or environmentally friendly fuel consumption policies can be beneficial in this respect.

When we look at the least important sub-criteria group, it can be said that technology-related sub-criteria are in the majority. It seems normal considering that Digital technology also has the least share in the main criteria weights. Here, it is important for companies to follow up-to-date technological developments and to integrate business processes into them. Although it is less important than other sub-criteria, complying with the requirements of the digitalization age will provide companies an advantage.

If developed similarly, there are sub-criteria such as Understanding of passenger's specific needs, Mobile communication & social media and Special services for patients and disabled that will distinguish the company from its competitors. The company can gain serious advantages by offering customized services to the passengers. Although it may seem less important at this point, the criteria in this group can be inspiring.

A further practical implications and theoretical contributions of the development of service quality area is expected in accordance with the proposed conceptual framework in this study. It can be concluded that this study made a theoretical and practical contribution to the further development of airline service quality. Service quality, customer service and satisfaction of customers are often considered as important factors in air transport management (Merkert and Pearson, 2015). Improving service quality may increase customers' loyalty (Tsai et al., 2021), so service quality evaluation models are required for managers. The results of this study can be used as a guidebook for the management of the different airlines to improve service quality. In this study, we construct comprehensive and detailed framework to define every detail of service quality by extending SERVQUAL model. A comprehensive literature review is conducted and interviews with experts are performed to theoretically conceptualize SERVQUAL based service quality dimensions and their inner dimensions for airline management. In addition, we apply an integrated MCDM method to show that different factors have different levels of influence in determining airline service quality. In summary, this study proposes an effective framework for managers to analyze airlines' service quality and identify the weaknesses and strengths of their services. The results of the MCDM application shows that the BWM integrated IVN-AHP methodology can be used to determine dimensions of SERVQUAL model for different levels. Indeed, neutrosophic logic is an effective tool to model hesitancy in expert opinions.

6. Sensitivity analysis

Sensitivity analysis is performed to analyze the results of the method proposed in this study. The weights are changed to show the robustness and accuracy of the results. The weights of the Level 1 criteria determined by the BWM are changed to measure the sensitivity of the integrated methodology against changes. For this purpose, in the first analysis, the weight of the Level 1 criteria are determined by IVN-AHP methodology. The pairwise comparison matrix given in Table 14 is constructed based on the experts' opinions to determine the weights of Level-1 criteria.

Once the pairwise comparison matrix is determined to be consistent, IVN-AHP methodology is employed to calculate the weights of Level 1 criteria. The weights of Level 1 criteria are determined as given in Table 15.

While Level 1 criteria weights are changing, the global weight of Level 2 criteria is changing, too. So, the weights of Level 2 criteria are calculated using Level 1 criteria weights determined by IVN-AHP.

In the second analysis, all Level 1 criteria are assumed to have equal importance weights. Then, the weights of Level 2 criteria are recalculated. Thus, each Level 2 criterion has three different importance weights according to the method used to determine Level 1 criteria weight as BWM (current), IVN-AHP and equal weights. These weights are given in Table 16.

For example, if considering the Level 2 criterion 2.1 Aircraft has a global weight of 0.062 in the currently proposed methodology (BWM). But its global weight decreases from 0.062 to 0.046 and 0.039 in the first analysis (IVN-AHP) and second analysis (equal weights), respectively. Fig. 3 shows the changes in Level 2 criteria weights according to sensitivity analysis.

According to Fig. 3, it is seen that the highest weight changes are observed for Level-2 criteria of 7.1 Hygiene and 7.2 In -flight with 0.042 and 0.038, respectively. It can be said that these criteria are more widely affected by the importance of the main risk factors. 5.3 Special services is the Level 2 criterion determined as the least affected criterion. The

Table 15
The weights of Level 1 criteria determined by IVN-AHP.

Level 1 Criteria	IVN-AHP Weight
Tangibles	0.130
Reliability	0.117
Responsiveness	0.114
Assurance	0.102
Empathy	0.116
Environment	0.097
Pandemic	0.134
Digital technology	0.090
Information systems	0.102

Table 16
The weights of Level 2 criteria for different methods.

Level 2 Criteria	Best-Worst	IVN-AHP	Equal
1.1 Aircraft	0.062	0.046	0.039
1.2 Airport	0.045	0.033	0.028
1.3 Comfort	0.037	0.027	0.023
1.4 Staff	0.033	0.024	0.021
2.1 Before flight	0.028	0.027	0.026
2.2 On flight	0.054	0.053	0.051
2.3 After flight	0.036	0.036	0.034
3.1 Behaviour and attitudes	0.048	0.046	0.045
3.2 Service and systems	0.070	0.068	0.066
4.1 In-flight	0.047	0.061	0.066
4.2 General	0.032	0.041	0.045
5.1 General	0.023	0.023	0.022
5.2 Financial empathy	0.031	0.030	0.029
5.3 Special services	0.018	0.018	0.017
5.4 Crisis management	0.023	0.023	0.022
5.5 Customer focus	0.023	0.023	0.022
6.1 General eco-efficiency	0.020	0.033	0.038
6.2 Operational eco-efficiency	0.020	0.033	0.038
6.3 Ground eco-efficiency	0.018	0.030	0.035
7.1 Hygiene	0.086	0.053	0.044
7.2 In-flight	0.079	0.049	0.040
7.3 Operational precaution	0.051	0.032	0.026
8.1 Digital interaction	0.015	0.035	0.043
8.2 Digital trust	0.015	0.035	0.043
8.3 Digital tangibles	0.009	0.020	0.025
9.1 Before flight	0.033	0.043	0.047
9.2 During flight	0.023	0.029	0.032
9.3 Information visibility	0.023	0.029	0.032

Table 14
The pairwise comparison matrix for Level-1 criteria.

Level 1 Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1.Tangibles	EI	WMI	WMI	MI	WMI	MI	WLI	SMI	SMI
C2.Reliability	WLI	EI	EI	WMI	EI	MI	WLI	MI	WMI
C3.Responsiveness	WLI	EI	EI	WMI	EI	WMI	WLI	SMI	WMI
C4.Assurance	LI	WLI	WLI	EI	WLI	EI	LI	WMI	EI
C5.Empathy	WLI	EI	EI	WMI	EI	MI	WLI	WMI	WMI
C6.Environmental	LI	LI	WLI	EI	LI	EI	SLI	MI	WLI
C7.Pandemic	WMI	WMI	WMI	MI	WMI	SMI	EI	SMI	MI
C8.Digital technology	SLI	LI	SLI	WLI	WLI	LI	SLI	EI	WLI
C9.Information system	SLI	WLI	WLI	EI	WLI	WMI	LI	WMI	EI

Fig. 3. Level 2 criteria weight changes according to sensitivity analysis.

weight difference for three analysis is less than 0.001.2.2 On Flight, 3.2 Service and systems and 7.1 Hygiene are always determined as important in every analysis. Therefore, these criteria must be taken into consideration when evaluating service quality.

7. Conclusion

In this study, the SERVQUAL model is expanded from 5 main dimensions to 9 main dimensions in order to adapt to current changes and customer expectations, and to provide an evaluation framework for airline service quality. 9 main dimensions are first evaluated by the BWM and then the importance weights of the second and third level criteria are determined by the IVN-AHP method. Finally, the reliability and flexibility of the method is demonstrated by sensitivity analysis.

The results indicate that airline companies should focus on many points at the same time and every important criterion needs to be met. In the evaluation, the main criterion with the highest importance is found as Pandemic. It shows that airline companies need to improve the sub criteria for the Pandemic for better service quality. Criteria such as in-flight hygiene conditions, fast ticketing and fast baggage delivery will be important for passengers. This will directly affect the company's perception of quality. In addition, the Tangibles criterion has become an important main criterion for customer quality perception with its high importance. Environment and digital technologies have been found to be less important for customers than Pandemic. The application study provides guidance to airlines on which sub-criteria customers may pay more attention to.

Additionally, the importance of the study, its contributions to the literature and real life can be listed as follows: The study is a new and most detailed airway service research in the literature. It is the extension of the classical SERVQUAL method with the pandemic, environment, digital technology and information technologies criteria, and it serves as an up-to-date and detailed research tool for users. It is a guide to decision makers about the importance of the criteria and actions to be taken. As far as we know, this is the first study in which SERVQUAL and neutrosophic sets are used together. Also, this study presents the first integration of BWM and IVN-AHP methodologies. Since it is a current and real-life application, it is thought to contribute to future researches in the relevant sector.

The proposed methodology can be used to evaluate the quality of services in airline companies. The proposed methodology can also be applied for different types of transportation; such as public transportation. Future studies can adopt additional multi-criteria decision-making approaches and the results of future studies can be compared with results of this study. The results can be compared to recent SKYTRAX ranking.

Author statement

Bahar Yalcin: Writing- Original draft preparation, Methodology, Software. Pelin Gulum: Data Collection, Application. Ertugrul Ayyildiz: Data correction, Software, Data Collection, Application. Alev Taskin: Supervision, Validation, Writing- Reviewing and Editing.

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