Interval type-2 hesitant fuzzy set method for improving the service quality of domestic airlines in Turkey

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ABSTRACT

This study investigates the level of service quality of domestic airlines in Turkey travelling between Istanbul and London and compares those airline companies according to a set of pre-determined criteria. A practical multi-criteria decision making approach combining hesitant and interval type 2 fuzzy sets is adopted and proposed for assessing the service quality of airline companies. The main finding of this study is that passengers care for service prioritization and personalization for a better flight experience and important differences occur in the service quality among the airline companies. Hence, handling of customer complaints, flight problems and individual attention could provide better insights for improving the service quality.

Keywords: Interval type-2 hesitant fuzzy sets, Airlines, Service quality, Multi-criteria decision making; Turkey, England.

1. Introduction

As air transportation has begun to be used by large masses and as more companies have begun to provide services, this has brought about serious competition (Okumus and Asil, 2007). Given the intense competitiveness of their industry, airlines need to develop a better understanding of passengers' needs. Passengers' expectations are essential to achieving the desired service quality. Thus, efforts to measure service quality within the sector have become increasingly important for facilitating consumer satisfaction (and, therefore, achieving and maintaining a competitive advantage) (Basfirinci and Mitra, 2014). Price and service quality criteria are initially used as the primary competitive items. Airlines have noticed that

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competition in price alone is insufficient in the long term. This implies that basing an airline's competitive advantage on price alone is not sustainable. An airline's competitive advantage also lies in its service quality as customers perceive it (Chen et al., 2011). Therefore, service quality has become a significant concern for those in the airline industry (Kazancoglu and Kazancoglu, 2013).

Along with the increase in flight numbers and aviation companies in recent years, competition within the aviation sector in Turkey has intensified. It is likely that the sector will grow even further with the increase in number of airports opening all over the country. The service quality offered by the companies as well as the resulting level of customer satisfaction will be a determinant in the competition. Companies that wish to maintain their competitiveness must be able to accurately identify customer expectations, and perform the necessary work to not only meet these expectations, but also to exceed them (Çırpın and Kurt, 2016).

With the increasing development of civil aviation within the country, Ataturk and Sabiha Gokcen Airports in Istanbul have become insufficient in terms of capacity and operations, and a third airport is now being constructed on the European Side by the General Directorate of State Airports Authority (DHMI) in Istanbul. The new airport project consists of 4 phases and 6 Runway. The first phase of the new airport which is to have a total capacity of 150 million passengers, is expected to start commercial flights in 2018. Once all phases of the third airport have been completed, it is expected that it will be the world's highest passenger-capacity airport. The aim is that Turkey will have a very serious advantage in strategic terms and will meet the increasing number of international passengers. In particular, this new airport is expected to be one of the most important transfer hubs between Asia and Europe (Deveci et al., 2017).

Many service quality problems studies have been published. Abrahams (1983) presented a service quality model of air travel demand. Service quality is shown to be an important determinate of airline industry. Kazancoglu and Kazancoglu (2013) determined service quality factors of Turkish domestic airlines as well as ranking and benchmarking firms according to these factors using a fuzzy Multi Criteria Decision Making (MCDM) model. Kuo and Jou (2014) proposed a framework to investigate service quality asymmetrically. An empirical study in cross-strait direct flights (Taiwan–Shanghai) by Lerrthaitrakul and Panjakajornsak (2014) examined the relationship between five dimensions of service quality of low cost airlines and consumers' post purchase behavioural intentions. Most of the real-world strategic decisions require consideration of many conflicting factors. Multi-criteria

Decision Making (MCDM) techniques provide the means to solve such problems supporting decision makers with the best option from a set of alternatives with respect to those factors (Deveci et al., 2015; Demirel et. al, 2018).

Service quality dimensions were used to measure expectations and perceptions. The questionnaire included questions pertaining to dimensions on tangibles, responsiveness, reliability, empathy, flight pattern and, booking and ticketing services. The information obtained from the questionnaires were analysed and commented upon using the fuzzy MCDM method. The survey is composed of 6 main categories of service quality criteria and 26 related questions. For each category, the questions are shown in the following Table 10 and the responses are given as 9-point Likert-type scale.

This study uses interval type-2 fuzzy set theory to evaluate the service quality of domestic airlines by passenger surveys. In this study, we propose a decision making model by utilizing the combination of hesitant fuzzy sets and interval type 2 fuzzy sets. This combination is named as interval type 2 hesitant fuzzy sets (IT2HFSs) as shown in Hu et al. (2015)'s study. Rodríguez et al. (2013) 's dominance and non-dominance rule procedure is merged to this methodology to evaluate the outrival degree of each criterion on other criteria when type 2 based hesitant decision making is adapted. A survey is conducted of 116 passengers for comparison of airline companies with respect to diversified variables (Tangibles, Responsiveness (Responsibility), Reliability and Assurance, Empathy, Flight pattern and Booking and ticketing service) extracted from the literature review. After that, the passengers' opinions are grouped into several linguistic evaluation categories according to similar answers. Then, using the joint judgments of the passengers, the priorities of the main and sub-criteria and ranking of three airline companies are calculated considering the hierarchical model. This enables the justification of Hu et al. (2015)'s study by real life example with a correct analysis of the usefulness of proposed methodology from a practical point of view. Finally, the results gathered from IT2HFS based decision making approach are compared with the methodology discussed in Rodriguez et al. (2013)'s study for testing the validity. The comparison of proposed study approves the improvement of Rodriguez et al. (2013)'s study which is not applicable when three or more criteria are available and could not ensure the accurate order of weights. Additionally, one at a time sensitivity analysis is conducted for representing the criteria sensitivity and airlines are compared their performance to decide the best alternative.

The motivation of the adaptation of interval type-2 hesitant fuzzy set is mainly depending on the following theoretical issues:

- Better representation of uncertainty (when compared to type 1 and type 2 fuzzy sets) and also simplification of computing process when compared with type 2 fuzzy sets are shown in Hu et al. (2015)'s study. In addition to that, hesitant fuzzy sets assist the improvement of MCDM problems. The combination of these fuzzy extensions can provide better representation of uncertainty with simplified calculations.
- Compared with hesitant fuzzy sets, interval type-2 hesitant fuzzy set can reflect uncertainty of inaccurate information by primary and secondary memberships, more efficiently (Hu et al.2015).

Specifically for service quality case study, interval type-2 hesitant fuzzy set based decision making provides the following solutions:

- *Establishing the membership degree when there is a set of possible values*. Survey results indicate various interpretation of service improvement indicators which obstruct the appearance of the definition of membership degree of an element clearly. Exact membership degrees cause the failure of the reflection of real life decision making problems especially when there are considerable amount of respondents and criteria. Compared with hesitant fuzzy sets, interval type-2 hesitant fuzzy set can reflect uncertainty of inaccurate information by primary and secondary memberships, more efficiently (Onar et al., 2014).
- *Adaptation of decision making process using certain linguistic variables*. In some cases, hesitant fuzzy set based formed data cannot be directly processed as we faced in our survey results. For instance, "criterion 1 is slightly stronger than criterion 2" can be easily represented via Type-2 fuzzy sets as Onar et al. (2014) mentioned in their paper. In this regard, interval type 2 formed hesitant representation facilitates better revealing of linguistic expressions by involving all necessary linguistic expressions considering optimistic and pessimistic point of view as appeared in our survey.

The remainder of this paper is organized as follows. The literature regarding this subject is reviewed in Section 2. Airline service quality evaluation criteria problem is introduced in Section 3. In Section 4, basic hesitant fuzzy set concepts, definitions, interval type-2 fuzzy and an interval type 2 fuzzy hesitant sets are proposed. The steps of proposed methodology are given in Section 5. In Section 6, an illustrative empirical case, applying the proposed interval type 2 hesitant fuzzy MCDM method to evaluate service quality of passenger airlines, is presented. In addition, sensitivity analysis and comparative analysis are given to demonstrate the feasibility of the proposed method. Finally, conclusion and discussion are presented in Section 7.

2. Literature Review

The service quality problem in airlines is applied to the interval type 2 hesitant fuzzy set method for solving problems such as the MCDM problem. Regarding type-1 fuzzy MCDM, many papers have been published in recent years. These papers are reviewed and classified according to the types of methods used. The methods in question are Fuzzy TOPSIS, VIKOR, Servqual, GRA (Grey relational analysis), ANP/AHP, MA (Multi-criteria Analysis), integral, DEMATEL, etc. The general fuzzy MCDM service quality problems are summarized in Table 1 and Table 2.

Many of those previous studies propose fuzzy multi-criteria decision making (MCDM) techniques as a solution method. But there has not been much research work using interval type-2 fuzzy MCDM publish. Chang and Yeh (2002) proposed an effective fuzzy multi-criteria model for evaluating service quality of domestic airlines by customer surveys. Chen et al. (2011) evaluated customer perceptions on in-flight service quality. This study applies fuzzy-grey approach and main purpose of this study is to deal with domestic airline in-flight service quality where uncertainty arises. Chou et al. (2011) presented an evaluation of airline service quality using the fuzzy weighted SERVQUAL method. This study is applied to the case of Taiwanese airline. As a result, some interesting conclusions and useful suggestions are given to airlines to improve the service quality. Demir (2012) focused on evaluation of service quality of airway companies giving domestic services in Turkey with Fuzzy TOPSIS method. This study tested the service quality of four airways companies with domestic flights in Turkey. Kuo (2011) proposed a novel interval-valued fuzzy multi criteria decision making approach for improving airlines' service quality of Chinese cross-strait. Nejati et al. (2009) proposed a ranking of airlines service quality factors using a Fuzzy TOPSIS approach. Toosi and Kohanali (2011) applied fuzzy set theory for evaluating service quality of three airlines are active in Qeshm free zone in Iran via customer survey. Tsaur et al. (2002) proposed an application of the Fuzzy MCDM to determine service quality of an airline. By applying AHP in obtaining criteria weight and TOPSIS in ranking. Chen (2016) integrated a MCDM model based on DEMATEL and ANP for the selection of service quality improvement criteria in order to evaluate Taiwanese airline industry.

Table 1

A comprehensive summary of literature related to ***Fuzzy MCDM general service quality*** problems.

Author (Year)	**Subject area**	**Fuzzy Logic Type**	**Fuzzy TOPSIS**	**Fuzzy VIKOR**	**Fuzzy Servqual**	**Fuzzy GRA**	**Fuzyy ANP/AHP**	**Fuzzy P–I Gap**	**Fuzzy Integral**	**Fuzzy DEMATEL**	**Genetic Algorithm**
Afkham et al. (2012)	The evaluation of health-care centers service quality	Type 1	x		x		x				
Akdag et al. (2014)	The evaluation of hospital service quality	Type 1	x				x				
Benitez et al. (2007)	The evaluation of hotel service quality	Type 1	x								
Buyukozkan and Ciftci (2012)	Service quality in healthcare industry	Type 1	x				x				
Celik et al. (2013)	Customer satisfaction in public transportation	Type 2	x			x					
Celik et al. (2014)	Customer satisfaction for rail transit network	Type 2		x	x						
Chang (2014)	The evaluation of hospital service quality	Type 1		x							
Chiang et al. (2009)	Evaluating service quality of portal website	Type 1					x		x		
Chou and Cheng (2012)	Evaluating website quality of professional accounting firms	Type 1		x			x				
Hu (2009)	Evaluating service quality of travel websites	Type 1									x
Hu and Liao (2011)	Evaluating electronic service quality of internet banking	Type 1									x
Kuo and Liang (2011)	Evaluating service quality of airports	Type 1		x		x					
Kuo et al. (2007)	Bus companies for service quality performance	Type 1				x					

Table 2

A comprehensive summary of literature related to ***Fuzzy MCDM*** ***general service quality*** problems.

Author (Year)	**Subject area**	**Fuzzy Logic Type**	**Fuzzy TOPSIS**	**Fuzzy VIKOR**	**Fuzzy Servqual**	**Fuzzy GRA**	**Fuzyy ANP/AHP**	**Fuzzy P–I Gap**	**Fuzzy Integral**	**Fuzzy DEMATEL**	**Genetic Algorithm**
Lee at al. (2010)	Evaluating service quality of online auction	Type 1	x				x				
Li (2014)	Evaluating service quality of driver of firm	Type 1			x		x				
Lin (2010)	The service quality for chain supermarkets	Type 1						x			
Lin et al. (2009)	Assessing service performance of travel intermediary	Type 1					x				
Liou et al. (2014)	Improving transportation service quality	Type 1							x		
Liu et al. (2015)	Evaluating service quality in certification & inspection industry	Type 1			x						
Sun (2010)	A performance evaluation of industry	Type 1	x				x				
Toloie-Eshlaghy et al. (2011)	Evaluating service quality of banks	Type 1	x				x				
Tsai and Lu (2006)	Evaluating service quality of e-stores	Type 1			x		x		x		
Tseng (2009)	The evaluation of agent service quality	Type 1				x				x	
Tseng (2011)	The evaluation of hot spring hotel's service quality	Type 1	x							x	
Wang and Pang (2011)	Evaluating service quality of online auction	Type 1		x			x				
Wu et al. (2012)	Ranking universities based on performance evaluation	Type 1		x			x				
Yousefi et al. (2014)	Evaluating service quality of marine passenger terminal	Type 1									

3. Service Quality in the Airline Industry

Since the concept of service is an abstract element, it is relatively difficult to assess its quality. However, quality in the service sector is as important as it is in the manufacturing sector. With the growth of the airline sector in recent years, the importance of service has increased even more and the research carried out in this regard have also gained momentum. Below are the dimensions which were used in order to evaluate airline service quality and the sub-criteria of these dimensions (Çırpın and Kurt, 2016).

3.1. The Service Quality Evaluation Criteria for Airlines

Firstly, we discovered ninety-nine criteria based on our literature review, then some of those criteria were eliminated by the airline company employees (experts). Finally, the most crucial top twenty-six criteria were fixed by the experts for this study. Table 3 provides an overview of previous work each suggesting a different set of service quality evaluation criteria of airline companies.

The detailed definitions of these six main criteria are as follows: (1) Tangibles, (2) Responsiveness, (3) Reliability and assurance, (4) Empathy, (5) Flight pattern, and (6) Booking and ticketing service.

Tangibles: The tangible dimension is visible and touchable things or equipment in the services process provided for passengers' comfort on board (Lerrthaitrakul and Panjakajornsak, 2014; Pabedinskaite and Akstinaite, 2014). For this study, there are six criteria under the tangibles dimension: comfort and cleanness of seat; food service and drink services, and their quality; in-flight newspapers and books; in-flight entertainment services and programs; modern and proper aircraft; and availability of enough flight staffs and crew.

Responsiveness (Responsibility): Responsiveness dimension referred to willingness to help customers and provide prompt service (Chen, 2016). For this study, there are nine criteria under the responsiveness dimension: courtesy, prompt, ability to language, and appearance of crew; responsiveness of crew; accurate handling of missing (lost) baggage; crew's speed handling request, crew's willingness to help; customer complaint handling (delayed flights etc.); clear and precise cabin announcements; helpful attitudes and courtesy of check in personnel and boarding employee; and promptness and accuracy of baggage delivery.

Reliability and assurance: The ability to perform the promised service dependably and accurately (Chen, 2016; Lerrthaitrakul and Panjakajornsak, 2014). For this study, there are two criteria under the reliability dimension: safety (security); and on-time departure and arrival.

Empathy: Empathy dimension could be shown when the airline displayed their care to each passenger or individual attention given to the client, taking care of the client and meeting of special needs (Park et al., 2004; Kim and Lee, 2011; Chen, 2016). For this study, there are three criteria under the empathy dimension: individual attention to passenger; extent travel services; and the advertising and image of the airline company.

Flight pattern: This dimension could be explained as follows: For this study, there are three criteria under the flight pattern dimension: flight problems (cancellations, delays and deviations from schedules); convenient flight schedules, frequency of flight and non-stop flight; and convenience of pre-flight and post-flight services.

Booking and ticketing service: This dimension is given to how airline crews help customers and provide prompt service. For this study, there are three criteria under the booking and ticketing service dimension: convenience and promptness booking of and buying ticket; the quality of the reservation services; and the approach of staff at the ticket cancellations.

Table 3
The summary literature of service quality evaluation criteria of airline companies.

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}
Chang and Yeh (2002)	x	x					x		x			x		x		x	x					x	x			
Tsaur et al. (2002)	x	x		x			x	x				x				x	x		x							
Gilbert and Wong (2003)	x	x		x			x			x	x	x			x	x	x	x	x			x				
Mustafa et al. (2005)	x	x	x	x			x	x																		
Liou and Tzeng (2007)	x	x		x			x					x			x	x	x									
Aydin and Pakdil (2008)		x	x	x			x			x	x	x						x		x	x	x				
Nejati et al. (2009)	x	x	x			x	x			x			x	x	x	x	x				x			x		
Chen et al. (2011)	x			x			x				x	x	x			x	x									
Chou et al. (2011)	x	x	x	x			x			x	x	x				x	x	x	x		x	x			x	
Kuo (2011)	x			x			x	x				x			x	x	x		x							
Liou (2011)	x		x	x			x					x		x	x	x	x					x		x	x	
Liou et al. (2011a)	x		x				x		x		x	x	x	x										x		
Liou et al. (2011b)	x		x				x		x		x	x	x	x										x		
Toosi and Kohanali (2011)	x				x		x	x			x	x	x				x	x			x	x				
Wang et al. (2011)	x		x		x		x					x		x		x	x									
Demir (2012)	x	x					x	x				x	x		x	x	x		x							
Kazancoglu and Kazancoglu (2013)	x	x	x		x	x	x		x	x	x		x		x	x	x	x				x			x	
Basfirinci and Mitra (2014)	x		x		x				x		x				x							x				
Zhang et al. (2015)									x			x					x								x	x
Chen (2016)							x				x	x				x					x					
Hu and Hsiao (2016)	x	x		x	x		x			x	x	x					x							x		
Jeeradist et al. (2016)	x	x		x	x		x	x		x	x					x	x	x				x				
Jiang and Zhang (2016)	x	x	x	x							x	x	x	x	x		x					x			x	
Rajaguru (2016)					x		x	x			x						x	x			x					

4. Preliminaries

4.1. Hesitant Fuzzy Set (HFS)

The *HFSs* method was developed by Torra (2010) and Torra and Narukawa (2009). The purpose of the method is to cope with the problems that membership of an element to a given set includes several different values. The preliminaries of hesitant fuzzy sets are given in the following:

Definition 1. A hesitant fuzzy set (HFS) on a reference set X is a function of h that returns to a subset of values in [0, 1] and h could be represented as follows:

$h: X \rightarrow \{[0,1]\}$

In this respect, a HFS can be expressed as the union of the membership functions.

Definition 2. Let M is a set of n number of membership function which could be represented as $M = \{\mu_1, \mu_2 .., \mu_n\}$ and HFS with M could be defined as $h_M: M \rightarrow \{[0,1]\}$ and $h_M(x) = \{\mu_1(x) \cup \mu_2(x) \cup .. \cup \mu_n(x)\}$.

Definition 3 (Xia and Xu, 2011). For a hesitant fuzzy element (HFE) h, $s(h) = \frac{1}{\#h} \sum_{\gamma \epsilon h} \gamma$ is called the score function of h, where $\#h$ is the number of the elements in h.

For two *HFSs* h_1 and h_2, if $s(h_1) > s(h_2)$, then $h_1 > h_2$; if $s(h_1) = s(h_2)$, then $h_1 = h_2$.

Xia and Xu (2011) defined some operations on the HFEs h, h_1 and h_2:

(1) $h^\lambda = U_{\gamma \epsilon h}\{\gamma^\lambda\}$

(2) $\lambda h = U_{\gamma \epsilon h}\{1 - (1 - \gamma)^\lambda\}$

(3) $h_1 \oplus h_2 = U_{\gamma_1 \epsilon h_1, \gamma_2 \epsilon h_2}\{\gamma_1 + \gamma_2 - \gamma_1 \gamma_2\}$

(4) $h_1 \otimes h_2 = U_{\gamma_1 \epsilon h_1, \gamma_2 \epsilon h_2}\{\gamma_1 \gamma_2\}$

4.2. Interval Type-2 Fuzzy Set

The type-1 fuzzy sets (T1FSs) method was proposed Zadeh (1965), in which the membership value of an element in a T1FS is represented by a real value between 0 and 1. A trapezoidal type-1 fuzzy number $\tilde{A} = (a_1, a_2, a_3, a_4; H_1(A), H_2(A))$ in the universe of discourse, where $0 \leq H_1(A) \leq H_2(A) \leq 1$, is shown in Fig. 1.

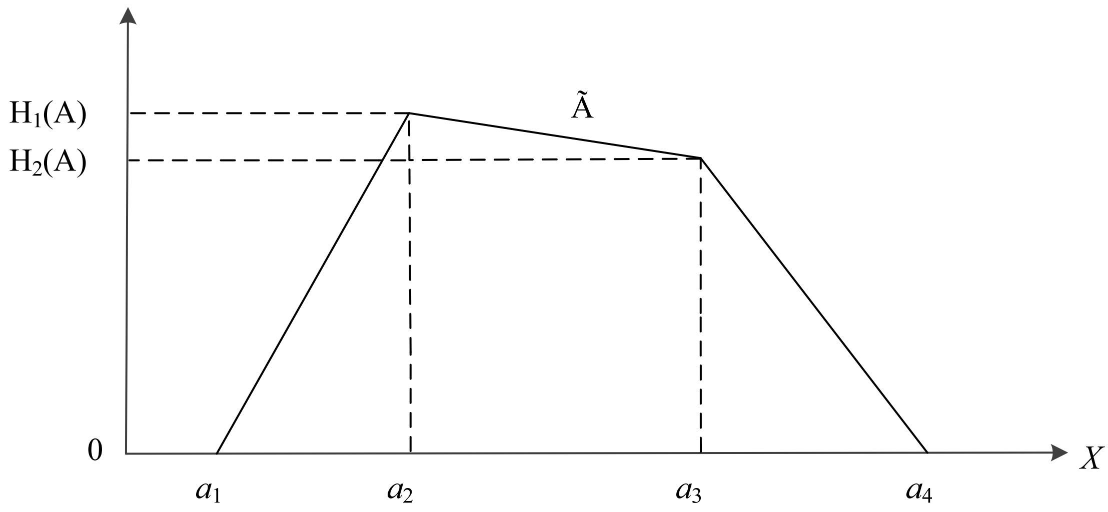


Fig. 1. A trapezoidal type-1 fuzzy number.

Type-2 fuzzy sets (T2FSs) were presented as the extension of T1FSs that manage uncertain information more effectively as they are characterized by primary and secondary membership (Hu et al., 2015). In this section, we present some basic definitions of type-2 fuzzy sets and interval type-2 fuzzy sets from Lee and Chen (2008), Chen and Lee (2010a, 2010b), Mendel et al. (2006), Hu et al. (2015):

Definition 4. A type-2 fuzzy set $\tilde{\tilde{A}}$ in the universe of discourse X can be represented by a type-2 membership function $\mu_{\tilde{\tilde{A}}}$, shown as follows (Mendel et al., 2006):

$$\tilde{\tilde{A}} = \{((x, u), \mu_{\tilde{\tilde{A}}}(x, u)) | \forall_x \epsilon X, \quad \forall_u \epsilon J_x \subseteq [0,1], \quad 0 \leq \mu_{\tilde{\tilde{A}}}(x, u) \leq 1)\}$$

where J_x denotes an interval in [0, 1]. Moreover, the type-2 fuzzy set $\tilde{\tilde{A}}$ also can be represented as follows (Mendel et al., 2006):

$$\tilde{\tilde{A}} = \int_{x \epsilon X} \int_{u \epsilon J_x} \mu_{\tilde{\tilde{A}}}(x, u)/(x, u),$$

where $J_x \subseteq [0,1]$ and $\iint$ denotes union over all admissible x and u.

Definition 5. Let $\tilde{\tilde{A}}$ be a type-2 fuzzy set in the universe of discourse X denoted by the type-2 membership function $\mu_{\tilde{\tilde{A}}}$. If all $\mu_{\tilde{\tilde{A}}}(x, u) = 1$, then $\tilde{\tilde{A}}$ is counted as an interval type-2 fuzzy set. An interval type-2 fuzzy set $\tilde{\tilde{A}}$ can be regarded as a special case of a type-2 fuzzy set, indicated as the following (Mendel et al., 2006):

$$\tilde{\tilde{A}} = \int_{x \epsilon X} \int_{u \epsilon J_x} 1/(x, u),$$

where $J_x \subseteq [0,1]$.

Definition 6 (Mendel et al., 2006). Type-1 membership functions are comprised of the upper membership function and the lower membership function of an interval type-2 fuzzy set, respectively. In this study, we present a method to use interval type-2 hesitant fuzzy sets for dealing with multi criteria decision-making problems. In these problems, the reference points and the heights of the upper and the lower membership functions of interval type-2 fuzzy sets are utilized to characterize interval type-2 fuzzy sets. Fig. 2 shows a trapezoidal interval type-2 fuzzy set

$\tilde{\tilde{A}}_i = (\tilde{A}_i^U, \tilde{A}_i^L) = \left(a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; H_1(\tilde{A}_i^U), H_2(\tilde{A}_i^U)\right), \left(a_{i1}^L, a_{i2}^L, a_{i3}^L, a_{i4}^L; H_1(\tilde{A}_i^L), H_2(\tilde{A}_i^L)\right)$(Lee and Chen, 2008), where $\tilde{A}_i^U$ and $\tilde{A}_i^L$ are type-1 fuzzy sets, $a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; a_{i1}^L, a_{i2}^L, a_{i3}^L$ and a_{i4}^L are the reference points of the interval type-2 fuzzy set $\tilde{\tilde{A}}_i$, $H_j(\tilde{A}_i^U)$ denotes the membership value of the element $a_{i(j+1)}^U$ in the upper trapezoidal membership function $\tilde{A}_i^U$, $1 \leq j \leq 2$, $H_j(\tilde{A}_i^L)$ denotes the membership value of the element $a_{i(j+1)}^L$ in the lower trapezoidal membership function $\tilde{A}_i^L$, $1 \leq j \leq 2$, $H_j(\tilde{A}_i^L)$

$\tilde{A}_i^L, 1 \leq j \leq 2, H_1(\tilde{A}_i^U) \epsilon [0,1],\ H_2(\tilde{A}_i^U) \epsilon\ [0,1],\ H_1(\tilde{A}_i^L) \epsilon\ [0,1],\ H_2(\tilde{A}_i^L) \epsilon\ [0,1], and\ 1 \leq i \leq n$

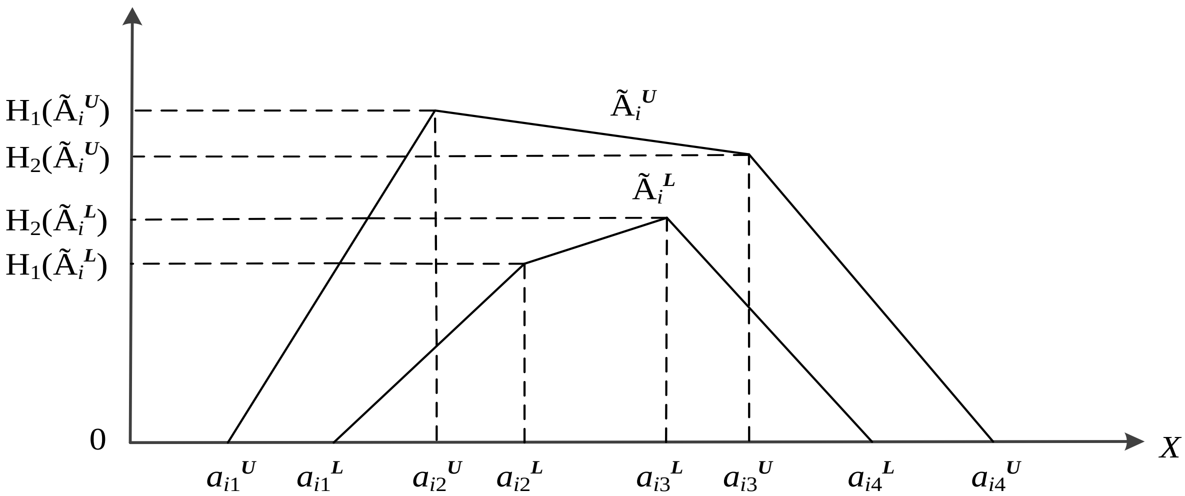


Fig. 2. The upper trapezoidal membership function $\tilde{A}_i^U$ and the lower trapezoidal membership function $\tilde{A}_i^L$ of the interval type-2 fuzzy set $\tilde{\tilde{A}}_i$ (Lee and Chen, 2008).

Some definitions will be given below (Lee and Chen, 2008):

Definition 7. The addition operation can be carried out between the trapezoidal interval type-2 fuzzy sets

$\tilde{\tilde{A}}_1 = (\tilde{A}_1^U, \tilde{A}_1^L) = \left(\left(a_{11}^U, a_{12}^U, a_{13}^U, a_{14}^U; H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \left(a_{11}^L, a_{12}^L, a_{13}^L, a_{14}^L; H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right)\right)$ and

$\tilde{\tilde{A}}_2 = (\tilde{A}_2^U, \tilde{A}_2^L) = \left(\left(a_{21}^U, a_{22}^U, a_{23}^U, a_{24}^U; H_1(\tilde{A}_2^U), H_2(\tilde{A}_2^U)\right), \left(a_{21}^L, a_{22}^L, a_{23}^L, a_{24}^L; H_1(\tilde{A}_2^L), H_2(\tilde{A}_2^L)\right)\right)$

$\tilde{\tilde{A}}_1 \oplus \tilde{\tilde{A}}_2 = (\tilde{A}_1^U, \tilde{A}_1^L) \oplus (\tilde{A}_2^U, \tilde{A}_2^L)$

$$= \begin{pmatrix} \left(a_{11}^U + a_{21}^U, a_{12}^U + a_{22}^U, a_{13}^U + a_{23}^U, a_{14}^U + a_{24}^U; min\left(H_1(\tilde{A}_1^U), H_1(\tilde{A}_2^U)\right), min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)\right), \\ \left(a_{11}^L + a_{21}^L, a_{12}^L + a_{22}^L, a_{13}^L + a_{23}^L, a_{14}^L + a_{24}^L; min\left(H_1(\tilde{A}_1^L), H_1(\tilde{A}_2^L)\right), min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)\right) \end{pmatrix}$$

Definition 8. The subtraction operation can be carried out between the trapezoidal interval type-2 fuzzy sets

$$\tilde{\tilde{A}}_1 \ominus \tilde{\tilde{A}}_2 = (\tilde{A}_1^U, \tilde{A}_1^L) \ominus (\tilde{A}_2^U, \tilde{A}_2^L)$$

$$= \begin{pmatrix} \left(a_{11}^U - a_{24}^U, a_{12}^U - a_{23}^U, a_{13}^U - a_{22}^U, a_{14}^U - a_{21}^U; min\left(H_1(\tilde{A}_1^U), H_1(\tilde{A}_2^U)\right), min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)\right), \\ \left(a_{11}^L - a_{24}^L, a_{12}^L - a_{23}^L, a_{13}^L - a_{22}^L, a_{14}^L - a_{21}^L; min\left(H_1(\tilde{A}_1^L), H_1(\tilde{A}_2^L)\right), min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)\right) \end{pmatrix}$$

Definition 9. The multiplication operation can be carried out between the trapezoidal interval type-2 fuzzy sets

$$\tilde{\tilde{A}}_1 \otimes \tilde{\tilde{A}}_2 = (\tilde{A}_1^U, \tilde{A}_1^L) \otimes (\tilde{A}_2^U, \tilde{A}_2^L)$$

$$= \begin{pmatrix} \left(a_{11}^U \, x \, a_{21}^U, a_{12}^U \, x \, a_{22}^U, a_{13}^U \, x \, a_{23}^U, a_{14}^U \, x \, a_{24}^U; min\left(H_1(\tilde{A}_1^U), H_1(\tilde{A}_2^U)\right), min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)\right), \\ \left(a_{11}^L \, x \, a_{21}^L, a_{12}^L \, x \, a_{22}^L, a_{13}^L \, x \, a_{23}^L, a_{14}^L \, x \, a_{24}^L; min\left(H_1(\tilde{A}_1^L), H_1(\tilde{A}_2^L)\right), min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)\right) \end{pmatrix}$$

Definition 10. The arithmetic operations can be done between the trapezoidal interval type-2 fuzzy sets

$\tilde{\tilde{A}}_1 = (\tilde{A}_1^U, \tilde{A}_1^L) = \left(\left(a_{11}^U, a_{12}^U, a_{13}^U, a_{14}^U; H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \left(a_{11}^L, a_{12}^L, a_{13}^L, a_{14}^L; H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right)\right)$ and the crisp value k is defined as follows:

$$k\tilde{\tilde{A}}_1 = \begin{pmatrix} \left(k \, x \, a_{11}^U, k \, x \, a_{12}^U, k \, x \, a_{13}^U, k \, x \, a_{14}^U; H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \\ \left(k \, x \, a_{11}^L, k \, x \, a_{12}^L, k \, x \, a_{13}^L, k \, x \, a_{14}^L; H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right) \end{pmatrix}$$

$$\frac{\tilde{\tilde{A}}_1}{k} = \begin{pmatrix} \left(\frac{1}{k} \, x \, a_{11}^U, \frac{1}{k} x \, a_{12}^U, \frac{1}{k} \, x \, a_{13}^U, \frac{1}{k} \, x \, a_{14}^U; H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \\ \left(\frac{1}{k} \, x \, a_{11}^L, \frac{1}{k} \, x \, a_{12}^L, \frac{1}{k} \, x \, a_{13}^L, \frac{1}{k} \, x \, a_{14}^L; H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right) \end{pmatrix}$$

where $k > 0$.

4.3. Interval Type-2 Hesitant Fuzzy Set

In the real world problem, fuzzy sets are a method used by decision makers (DMs) to assess an unlimited environment in the problem. In terms of IT2FS, IT2HFS under hesitant fuzzy linguistic environment is presented, which not only simplifies the computation process of hesitant fuzzy linguistic set but also begins to model uncertainty more accurately (Hu et al., 2015).

Definition 11 (Xia and Xu, 2011; Hu et al., 2015). Let X be a fixed set. An IT2HFS on X is in terms of a function that returns a subset of some interval type-2 fuzzy numbers (IT2FNs) when applied to each x in X. Xia and Xu (2011) expressed the IT2HFS by a mathematical symbol:

$E = \{< x, \tilde{h}_E(x) > |x \in X\}$,

where $\tilde{h}_E(x)$ is a set of some values in [0,1], denoting the possible membership degrees of the element $x \in X$ to the set E. For convenience, Hu et al. (2015) present $\tilde{h}_E(x)$ as $= \tilde{h} = \left\{\tilde{A}_i \in \tilde{h} | \tilde{A}_i = \left(\left(a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; H_1(\tilde{A}_i^U), H_2(\tilde{A}_i^U)\right), \left(a_{i1}^L, a_{i2}^L, a_{i3}^L, a_{i4}^L; H_1(\tilde{A}_i^L), H_2(\tilde{A}_i^L)\right)\right)\right\}$ to reflect the notation of interval type-2 hesitant fuzzy elements (IT2HFE).

Definition 12 (Hu et al., 2015). Assume

$\tilde{h}_1 = \left\{\tilde{A}_1 \in \tilde{h}_1 | \tilde{A}_1 = \left(\left(a_{11}^U, a_{12}^U, a_{13}^U, a_{14}^U; H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \left(a_{11}^L, a_{12}^L, a_{13}^L, a_{14}^L; H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right)\right)\right\}$

and $\tilde{h}_2 = \left\{\tilde{A}_2 \in \tilde{h}_2 | \tilde{A}_2 = \left(\left(a_{21}^U, a_{22}^U, a_{23}^U, a_{24}^U; H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \left(a_{21}^L, a_{22}^L, a_{23}^L, a_{24}^L; H_1(\tilde{A}_2^L), H_2(\tilde{A}_2^L)\right)\right)\right\}$

are two IT2HFEs and $\lambda > 0$. We define the operation laws of IT2HFEs as follows:

(1) $\tilde{h}_1^\lambda = U_{\tilde{A}_1 \in \tilde{h}_1} \left\{ \begin{pmatrix} \left(k^{-1}(\lambda k(a_{11}^U)), k^{-1}(\lambda k(a_{12}^U)), k^{-1}(\lambda k(a_{13}^U)), k^{-1}(\lambda k(a_{14}^U));\ H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \\ \left(k^{-1}(\lambda k(a_{11}^L)), k^{-1}(\lambda k(a_{12}^L)), k^{-1}(\lambda k(a_{13}^L)), k^{-1}(\lambda k(a_{14}^L));\ H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right) \end{pmatrix} \right\}$

(2) $\lambda \tilde{h}_1 = U_{\tilde{A}_1 \in \tilde{h}_1} \left\{ \begin{pmatrix} \left(l^{-1}(\lambda l(a_{11}^U)), l^{-1}(\lambda l(a_{12}^U)), l^{-1}(\lambda l(a_{13}^U)), l^{-1}(\lambda l(a_{14}^U));\ H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \\ \left(l^{-1}(\lambda l(a_{11}^L)), l^{-1}(\lambda l(a_{12}^L)), l^{-1}(\lambda l(a_{13}^L)), l^{-1}(\lambda l(a_{14}^L));\ H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right) \end{pmatrix} \right\}$

(3) $\tilde{h}_1 \oplus \tilde{h}_2 = U_{\tilde{A}_1 \in \tilde{h}_1, \tilde{A}_2 \in \tilde{h}_2} = \{((l^{-1}(l(a_{11}^U) + l(a_{21}^U)), l^{-1}(l(a_{12}^U) + l(a_{22}^U)), l^{-1}(l(a_{13}^U) + l(a_{23}^U)), l^{-1}(l(a_{14}^U) + l(a_{24}^U)); \min\left(H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)), (l^{-1}(l(a_{11}^L) + l(a_{21}^L)), l^{-1}(l(a_{12}^L) + l(a_{22}^L)), l^{-1}(l(a_{13}^L) + l(a_{23}^L)), l^{-1}(l(a_{14}^L) + l(a_{24}^L)); min\left(H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right), min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)))\}$

(4) $\tilde{h}_1 \otimes \tilde{h}_2 = U_{\tilde{A}_1 \in \tilde{h}_1, \tilde{A}_2 \in \tilde{h}_2} = \{((k^{-1}(k(a_{11}^U) + k(a_{21}^U)), k^{-1}(k(a_{12}^U) + k(a_{22}^U)), k^{-1}(k(a_{13}^U) + k(a_{23}^U)), k^{-1}(k(a_{14}^U) + k(a_{24}^U)); \min\left(H_1(\tilde{A}_1^U), H_2(\tilde{A}_1^U)\right), \min\left(H_2(\tilde{A}_1^U), H_2(\tilde{A}_2^U)\right)), (k^{-1}(k(a_{11}^L) + k(a_{21}^L)), k^{-1}(k(a_{12}^L) + l(a_{22}^L)), l^{-1}(l(a_{13}^L) + l(a_{23}^L)), k^{-1}(k(a_{14}^L) + k(a_{24}^L)); min\left(H_1(\tilde{A}_1^L), H_2(\tilde{A}_1^L)\right), min\left(H_2(\tilde{A}_1^L), H_2(\tilde{A}_2^L)\right)))\}$

5. Proposed Methodology

Step 1. Formulate the multi criteria decision making problem by determining criteria set as C={$c_1, c_2, \ldots, c_n$} and alternatives set as A={$a_1, a_2, \ldots, a_m$} with the criteria weight vector W={$w_1, w_2, \ldots w_n$} and $\sum_{j=1}^{n} w_j = 1$.

Step 2. Determine the linguistic term set, semantic and linguistic expressions. Let V^g is the context free expression of linguistic term set and S be a linguistic term set as {s_0, s_1, s_2,.., s_f } which has an order of terms as S: $s_i \leq s_j$ where $i \leq j$ and has a maximization and minimization operator as max (s_i, s_j)= s_i and min (s_i,s_j)=s_j where $i \geq j$. V^g could be presented as follows:

V^g={*at least, at most, between, is* and $s_0, s_1, s_2,.., s_f$} The production rules are defined as:

$$R = \{\text{ at least} \coloneqq \text{"}\geq\text{"}; \text{"at most}\coloneqq \text{"}\leq\text{"}; \text{ between} \coloneqq \text{"}<..<\text{"}; is\coloneqq \text{ " = "}\}$$

Step 3. Define linguistic term set, scale and corresponding values according to the following Table 4:

Table 4
Linguistic term set and their corresponding values (Hu et al., 2015).

Label	Linguistic terms	Corresponding IT2HFNs
AL	Absolutely low	(0.0, 0.0, 0.0, 0.0;1,1) (0.0, 0.0, 0.0, 0.0;1,1)
VL	Very low	(0.0075, 0.0075, 0.015, 0.0525; 0.8,0.8),(0,0,0.02,0.07; 1.0,1.0)
L	Low	(0.0085, 0.12, 0.16, 0.1825;0.8,0.8),(0.04,0.10,0.18,0.23;1.0,1.0)
ML	Slightly low	(0.2325, 0.255, 0.325, 0.3575;0.8,0.8),(0.17,0.22,0.36,0.42;1.0,1.0)
M	Middle	(0.4025, 0.4525, 0.5375, 0.5675;0.8,0.8),(0.32,0.41,0.58,0.65;1.0,1.0)
MH	Slightly high	(0.65, 0.6725, 0.7575, 0.79;0.8,0.8),(0.58,0.63,0.80,0.86;1.0,1.0)
H	High	(0.7825, 0.815, 0.885, 0.9075;0.8,0.8),(0.72,0.78,0.92,0.97;1.0,1.0)
VH	Very high	(0.9475, 0.985, 0.9925, 0.9925;0.8,0.8),(0.93,0.98,1.0,1.0;1.0,1.0)
AH	Absolutely high	(1.0, 1.0, 1.0, 1.0;1.0,1.0), (1.0, 1.0, 1.0, 1.0;1.0,1.0)

Step 4. Collect passengers' pessimistic and optimistic preference relations (R^l) for both criteria, sub criteria and alternatives by k number of passengers where $l \in \{1,2,..,k\}$ and express IT2HFLTS according to the lower and upper linguistic bounds as $([{r_{ij}}^{l-}, {r_{ij}}^{l+}])$.

Note that maximum value of the HFE reflects optimistic point of view, whereas the minimum one of the HFE reflects pessimistic point of view.

The pairwise comparison matrix will be given in application phase.

Step 5. Gather numerical representations of interval type 2 hesitant fuzzy terms (IT2HFTs) using Table 4 to acquire the corresponding ratings $\tilde{h}_{ij}$ where i denotes alternatives and j denotes criterion and IT2HFT based H matrix is obtained as follows:

$$\tilde{h} = \left\{\tilde{A}_i \,\epsilon\, \tilde{h} | \tilde{A}_i = \left(\left(a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; H_1(\tilde{A}_i^U), H_2(\tilde{A}_i^U)\right), \left(a_{i1}^L, a_{i2}^L, a_{i3}^L, a_{i4}^L; H_1(\tilde{A}_i^L), H_2(\tilde{A}_i^L)\right)\right)\right\}.$$

Here, ${h_{ij}}^e = [{h_{ij}}^-, {h_{ij}}^+]$ where ${h_{ij}}^-$ implies pessimistic numerical representation and ${h_{ij}}^+$ denotes optimistic representation of each passengers.

Step 6. Aggregate the individual preferences using interval type 2 hesitant fuzzy weighted average (IT2HFWA) linguistic aggregation operator (based on weighted average) in order to acquire optimistic and pessimistic preference relations. The aggregation operator is given in the following:

$$\tilde{h}_i = IT2HFWA(\tilde{h}_{i1}, \tilde{h}_{i2}, \dots, \tilde{h}_{in}) = \sum_{j=1}^{n} w_j \tilde{h}_{ij} \ (i = 1,2 \dots m),$$

$$= \cup_{\tilde{A}_{i1}\in\tilde{h}_{i1}, \tilde{A}_{i2}\in\tilde{h}_{i2}, \dots, \tilde{A}_{in}\in\tilde{h}_{in}} \left\{ \left(\begin{array}{c} \left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij1}^U)\right)\right), \left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij2}^U)\right)\right), \left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij3}^U)\right)\right), \\ \left(\left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij3}^U)\right)\right); \min_j \left(H_1(\tilde{A}_{ij}^U)\right), \min_j \left(H_2(\tilde{A}_{ij}^U)\right) \right) \end{array} \right) \right\}$$

$$\left\{ \left(\begin{array}{c} \left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij1}^L)\right)\right), \left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij2}^L)\right)\right), \left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij3}^L)\right)\right), \\ \left(\left(l^{-1}\left(\sum_{j=1}^{n} w_j l(a_{ij3}^L)\right)\right); \min_j \left(H_1(\tilde{A}_{ij}^L)\right), \min_j \left(H_2(\tilde{A}_{ij}^L)\right) \right) \end{array} \right) \right\}$$

Step 7. Calculate the scores $s(\tilde{h}_{ij})$ $(i = 1,2, \dots, m)$ for aggregated $\tilde{h}_i$ $(i = 1,2, \dots, m)$ using the score function definition given below:

Let $\tilde{h} = \left\{\tilde{A}_i \epsilon \tilde{h} | \tilde{A}_i = \left(\left(a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; H_1(\tilde{A}_i^U), H_2(\tilde{A}_i^U)\right), \left(a_{i1}^L, a_{i2}^L, a_{i3}^L, a_{i4}^L; H_1(\tilde{A}_i^L), H_2(\tilde{A}_i^L)\right)\right)\right\}$ be an IT2HF element. The score function could be expressed as follows:

$$score\ (\tilde{h}) = \frac{1}{\#\tilde{h}} \sum_{\tilde{A}\in\tilde{h}} score\ (\tilde{A})$$

$$= \frac{1}{\#\tilde{h}} \sum_{\tilde{A}\in\tilde{h}} \left[\frac{a_1^U + a_4^U}{2} + \frac{H_1(A^U) + H_2(A^U) + H_1(A^L) + H_2(A^L)}{4} \right]$$

$$\times \frac{a_1^U + a_2^U + a_3^U + a_4^U + a_1^L + a_2^L + a_3^L + a_4^L}{8}$$

where $\#\tilde{h}$ is the number of IT2HF element that $\tilde{A} \in \tilde{h}$ and $score\ (\tilde{h_\iota})$ is a crisp value appeared in [0,1].Let $\tilde{h_\iota}$ and $\tilde{h}_2$ are two IT2HFSs and if $score\ (\tilde{h_\iota}) \geq score\ (\tilde{h}_2)$ then $\tilde{h_\iota} \geq \tilde{h}_2$

According to the forementioned definition, scores should be calculated for both pessimistic and optimistic values and finally, the average of pessimistic and optimistic values is denoted as “final score” for each criteria and sub-criteria.

Step 8. Build dominance matrix considering the difference between preference relations as shown in the following:

Let I_1=$[a_1, b_1]$ and I_2=$[a_2, b_2]$ be interval utilities. Preference relation of I_1 over I_2 ($I_1 > I_2$) is calculated as;

$$R(I_1 > I_2) = \frac{\max(0, b_1 - a_2) - \max(0, a_1 - b_2)}{(b_1 - a_1) + (b_2 - a_2)}$$

Similarly, preference relation of I_2 over I_1 ($I_2 > I_1$) could be calculated. Note that $R(I_1 > I_2)$+ $R(I_2 > I_1)$=1 and when $a_1 = a_2$ and $b_1 = b_2$, the interval utilities are equal ($I_1 = I_2$) and $R(I_1 > I_2)$=$R(I_2 > I_1)$=0.5 .

For instance if we compare how much I_1 is greater than I_2, the following equation should be conducted:

$$DM_{12} = \max(0, \ (R(I_1 > I_2) - R(I_2 > I_1))$$

Step 9. Adopt Rodriguez et al. (2012)’s non dominance rule approach according to i^{th} criterion or alternative according to the following expression:

$$NDM_i = |\min((1 - DM_1), (1 - DM_2), \dots, (1 - DM_n))|$$

where $n \neq i$.

Step 10. Rank the alternatives after the normalization process as $Normalized\ NDM_i = \frac{NDM_i}{\sum_{i=1}^{n} NDM_i}$

6. Case Study

In this section, which illustrates how the interval type-2 fuzzy MCDM approach works, this paper examines the overall quality level of certain service criteria of three major domestic airlines that travel from Istanbul to London. These airlines are denoted A_1, A_2, and A_3. Istanbul – London was selected as the target routes for the domestic airlines because travel to these destinations is offered by the three domestic airlines. These destinations and airlines are summarised in Table 5. The destination routes are shown in Fig. 3.

Table 5
Number of respondents by flight destinations and airlines.

Route	Domestic airline	n (total data)
Istanbul ----- London	A_1	116

Istanbul ----- London	A_2	116
Istanbul ----- London	A_3	116

An online survey system was used to collect data, and the passengers needed to have used all the three airlines before to be able to complete the questionnaire. In this study, the survey was conducted using a group consisting of 116 passengers. The demographic statistics are presented in Table 6 and 8.

Firstly, both the perceptions and expectations of the 116 respondents are converted to fuzzy numbers. Evaluations defined using a 9-point Likert-type scale of linguistic expressions are converted to trapezoidal interval type-2 fuzzy numbers (see Table 4).

Fig. 3. Map of England region showing the destination routes from Istanbul.

6.1. Survey

The questionnaire about service quality for the three major Turkish passenger airlines consists of four parts: (1) passenger profiles; (2) passenger flight information; (3) identification of the service quality evaluation criteria of airline companies; and (4) comparison of airline companies. These parts are compiled as follows:

Part 1. Passenger profiles were classified according to sex, age, education, occupation, and net income (Table 6).

Part 2. Passenger flight information was classified according to travel frequency, booking channel, seat class, travel purpose, and more (Table 8).

Part 3. Forming the interval type-2 fuzzy model using the determined criteria (Table 9).

Part 4. Interval type-2 fuzzy weights of each alternative are computed.

According to the above-mentioned evaluation criteria, a survey using questionnaires was conducted online over a period of six weeks. The results were usable replies from one business class and 115 economy class passengers who had flown on the designated airlines. The majority of the participants in this study were male (55.17%); their ages were between 21-30 years (75.0%); their single-largest educational level was a Master's degree (40.63%); the single-largest occupation grouping (35.93%) was students; the single-largest monthly income grouping was 1,201-1,500 Euros (35.93%); the single-largest travelling frequency grouping was once every three months (37.5%); the majority's purpose for travelling (54.69%) was visiting friends/relatives; and the majority used the A_1 airline company (59.38%) (see Table 6 and 8). Female passengers were generally younger (between 21-30 years [90.38%]) and more frequent flyers (once every three months [46.55%]) than male passengers. The single-largest travelling purpose grouping (48.08%) was visiting friends/relatives.

Table 6
Passenger profiles.

Attributes/distribution	Sample number	Frequency (%)
Gender		
Female	52	44.83

	Male	64	55.17
Age			
	20 or younger	1	0.86
	21-30	95	81.90
	31-40	16	13.79
	41-50	2	1.72
	51-60	2	1.72
	61 or older	0	0.00
Education			
	Primary school	1	0.86
	High school or equivalent	1	0.86
	Two-year collage	2	1.72
	University	46	39.66
	Masters	41	35.34
	Doctorate and above	24	20.69
	Others	1	0.86
Occupation			
	Student	49	42.24
	Government employee	20	17.24
	Private-sector employee	33	28.45
	Self employed/own business	1	0.86
	Management	4	3.45
	Retired	1	0.86
	Others	8	6.90
Net incomes			
	< 300 Euro	8	6.90
	300-600 Euro	10	8.62
	601-900 Euro	23	19.83
	901-1200 Euro	28	24.14
	1201-1500 Euro	34	29.31
	> 1500 Euro	13	11.21

The data were further analysed to explain the possible relationship between average monthly income and travel frequency in both groups. The chi-squared test results showed significant (<0.05) relationships between these variables for both groups (Table 7).

Table 7
Chi-Square Tests.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	40.165[a]	25	.028
Likelihood Ratio	36.964	25	.058
N of Valid Cases	116		

Table 8
Passenger flight information.

Attributes/distribution		Sample number	Frequency (%)
Travel frequency			
	Once a month	12	10.34

	Couple of times a month	7	6.03
	Once in three months	49	42.24
	Once in six months	21	18.10
	Once a year	3	2.59
	Fewer than once a year	24	20.69
Booking channel			
	Internet	113	97.41
	Telephone	0	0.00
	Travel agency	3	2.59
	Airline counter	0	0.00
	Others	0	0.00
Seat class			
	Economy	115	99.14
	Business	1	0.86
Travel purpose			
	Visiting friends/relatives	60	51.72
	Tourism	25	21.55
	Business	11	9.48
	Education / Conference or Seminar	16	13.79
	Others	4	3.45
Generally which airline do you use ?			
	A	70	60.34
	B	2	1.72
	C	36	31.03
	D	6	5.17
	E	1	0.86
	F	0	0.00
	Others	1	0.86
The most important reason for choosing the airline ?			
	Price	56	48.70
	Past experience	10	8.70
	Brand realiability	17	14.78
	Advertisements / Image	8	6.96
	Recommendation	7	6.09
	Use of flyer points	7	6.09
	Other	10	8.70
You often use airline compared to the previous year increased ?			
	No	85	73.28
	Yes	31	26.72

The third part contained 26 service quality criteria measuring passengers' expectations and perceptions. In order to measure the service quality of the airline, a questionnaire was designed based on a 9-point linguistic scale, using "(0.0, 0.0, 0.0, 0.0;1,1) (0.0, 0.0, 0.0, 0.0;1,1) = absolutely low" to "(1.0, 1.0, 1.0, 1.0;1.0,1.0), (1.0, 1.0, 1.0, 1.0;1.0,1.0) = absolutely high (most important)" (see Table 4). The service quality evaluation criteria of airline companies is shown in Table 9.

Table 9

Service quality evaluation criteria of airline companies.

Criteria category	Evaluation criteria
Tangibles	
C_1	Comfort and cleanness of seat, enough space between seats
C_2	Food service and drink services, and their quality
C_3	In-flight newspapers, magazines and books
C_4	In-flight entertainment services and programs
C_5	Modern and proper aircraft
C_6	Availability of enough flight staffs and crew
Responsiveness (Responsibility)	
C_7	Courtesy, prompt, ability to language, and appearance of crew
C_8	Responsiveness of crew
C_9	Accurate handling of missing (lost) baggage
C_{10}	Crew’s speed handling request
C_{11}	Crew’s willingness to help
C_{12}	Customer complaint handling (delayed flights etc.)
C_{13}	Clear and precise cabin announcements
C_{14}	Helpful attitudes and courtesy of check in personnel and boarding employee
C_{15}	Promptness and accuracy of baggage delivery
Reliability and assurance	
C_{16}	Safety (security)
C_{17}	On-time departure and arrival
Empathy	
C_{18}	Individual attention to passenger
C_{19}	Extent travel services
C_{20}	The advertising and image of the airline company
Flight pattern	
C_{21}	Flight problems (cancellations, delays and deviations from schedules)
C_{22}	Convenient flight schedules, frequency of flight and non-stop flight
C_{23}	Convenience of pre-flight and post-flight services
Booking and ticketing service	
C_{24}	Convenience and promptness booking of and buying ticket
C_{25}	The quality of the reservation services
C_{26}	The approach of staff at the ticket cancellations

Part 4 evaluated airlines’ performance with regard to each criterion, and the questionnaire used a 9-point linguistic expression scale to measure the expressed performance as corresponding to criteria for three airline. The performance for each criterion was rated in linguistic terms from “(0.0, 0.0, 0.0, 0.0;1,1) (0.0, 0.0, 0.0, 0.0;1,1) = Absolutely low” to “(1.0, 1.0, 1.0, 1.0;1.0,1.0), (1.0, 1.0, 1.0, 1.0;1.0,1.0) = Absolutely high” (using the rating linguistic scales of Table 4). Here, we use one criteria –comfort and cleanliness of seats and enough space between them – to explain how passengers fill completed this questionnaire, as shown in Table 10.

Table 10
Example.

Alternatives	C_1: Comfort and cleanness of seat, enough space between seats								
	Absolutely low	Very low	Low	Medium low	Medium	Medium high	High	Very high	Absolutely high
A_1									x
A_2			x						
A_3					x				

6.2. The Proposed Method Adaptation

In this study, 116 passengers participated for the evaluation of three airlines. The linguistic assessments for the twenty-six criteria are determined by the questionnaire using rating scales, which also evaluate the three alternatives for each of the twenty-six criteria and fix major criteria (using rating scales of Table 4). After they filled the survey, they also see the other's results. Additionally, the criteria evaluations for 116 passengers' individual evaluations are collected according to most encountered linguistic terms. The pairwise transformation process is explained as follows: For instance, let the passenger evaluates "Responsiveness" with "Empathy". After passenger sees the entire evaluations of other passengers for "Responsiveness", he/she realizes that number of responses for "Responsiveness" is appeared as 3 "AL", 20 "VL", 29 "L", 47 "ML", 118 ”M", 181 "MH", 297 "H", 206 "VH", 143 "AH". Additionally, "Empathy" is evaluated as 6 "AL", 12 "VL", 17 "L", 41 "ML", 66 "M", 74 "MH", 75 "VH",36 "H", 21"AH" from the survey. If he/she compares "Responsiveness" with "Empathy", he/she can first conclude that responses for "Responsiveness" densify especially between ML and AH. Similarly, "Empathy" appeared between ML and VH. This combination is written as [ML, AH] and [ML, VH] respectively. On the other hand, other passenger can say that "Responsiveness" can range between M and AH and the combination can be renewed as [M, AH] and [ML, VH]. This is the transformation process of individual responses considering overall evaluation of others. Here, minority of the responses are ignored due to insufficient number of responses such as 3 of "AL" in "Responsiveness" and 17 of "VL" in "Empathy". This ignorance can cause information loss but here, 116 passengers were asked in order to capture the diversified perspectives to eliminate subjectivity. Also this process is the main reason for the adaptation of interval type 2 hesitant fuzzy decision making mechanism in order to reflect uncertainty.

Suppose that the passenger concluded that "Responsiveness" densify especially between ML and AH and "Empathy" appeared between ML and VH. If these two criteria are compared, "Responsiveness" become more important than "Empathy". The level of the importance is considered by both pessimistic and optimistic point of view separately. From the pessimistic point of view, "Responsiveness" is equal to "Empathy". On the other hand, "Responsiveness" is more important than "Empathy" as "H". (From Table 4, AH represents high level of importance than VH and the difference between AH and VH implies one level importance level, "H".)

For all of these reasons, hesitant based interval type 2 decision making allows us to collect possible scores for an alternative under a sub criterion with different perspectives. This causes involving different perspectives of different passengers to improve service quality in airline industry.

Step 1. The main criteria and sub criteria are taken from the survey as given in Table 9. Three famous Turkish airline companies are assessed for service quality.

Step 2 and Step 3. Define linguistic term set and semantics according to Table 4.

Step 4. Collect passengers' preference relations (R^l) for both criteria, sub criteria and alternatives by k number of passengers where $l \in \{1,2,..,k\}$ and express IT2HFLTS according to the lower and upper bounds as ($\left[r_{ij}{}^{l-}, r_{ij}{}^{l+}\right]$). For instance, when we compare Tangibles with Responsiveness, lower bound is appeared as "AL" as the pessimistic point of view and upper bound is appeared as "ML" as the optimistic point of view.

As seen from the conducted survey, six categories of passengers are appeared as "Once a month", "Couple of times a month", "Once in three months", "Once in six months", "Once a year" and "Fewer than once a year". To make the calculations easily, passengers are grouped as three categories: The first group contains the passengers as "Once a month", "Couple of times a month", the second group involves "Once in three months" and "Once in six months" and finally, third group includes "Once a year" and "Fewer than once a year". The collected preferences of major criteria for each group are given in Table 11.

Table 11
Pairwise comparison matrix of three groups of passengers according to travel frequency.

	Tangibles	Responsiveness	Reliability	Empathy	Flight pattern	Booking and Ticketing
Tangibles	-	[AL,ML]	[AL,MH]	[L,L]	[VH,AH]	[H,VH]
Responsiveness	[MH,AH]	-	[H,AH]	[M,H]	[H,H]	[M,AH]

Reliability	[ML,AH]	[AL,L]	-	[H,AH]	[MH,AH]	[M,H]
Empathy	[H,H]	[L,M]	[AL,L]	-	[AL,VL]	[AL,MH]
Flight pattern	[AL,VL]	[L,L]	[AL,ML]	[VH,AH]	-	[M,AH]
Booking and Ticketing	[VL,L]	[AL,M]	[L,M]	[ML,AH]	[AL,M]	-
	Tangibles	Responsiveness	Reliability	Empathy	Flight pattern	Booking and Ticketing
Tangibles	-	[AL,MH]	[AL,MH]	[VL,L]	[VH,AH]	[H,VH]
Responsiveness	[ML,AH]	-	[H,AH]	[ML,H]	[H,H]	[M,AH]
Reliability	[ML,AH]	[AL,L]	-	[H,AH]	[MH,AH]	[M,H]
Empathy	[H,VH]	[L,MH]	[AL,L]	-	[AL,VL]	[AL,MH]
Flight pattern	[AL,VL]	[L,L]	[AL,ML]	[VH,AH]	-	[M,AH]
Booking and Ticketing	[VL,L]	[AL,M]	[L,M]	[ML,AH]	[AL,M]	-
	Tangibles	Responsiveness	Reliability	Empathy	Flight pattern	Booking and Ticketing
Tangibles	-	[AL,MH]	[AL,MH]	[VL,L]	[VH,AH]	[H,AH]
Responsiveness	[ML,AH]	-	[H,AH]	[ML,H]	[H,AH]	[M,AH]
Reliability	[ML,AH]	[AL,L]	-	[H,AH]	[H,AH]	[VH,AH]
Empathy	[H,VH]	[L,MH]	[AL,L]	-	[AL,VL]	[AL,MH]
Flight pattern	[AL,VL]	[AL,L]	[AL,L]	[VH,AH]	-	[M,AH]
Booking and Ticketing	[AL,L]	[AL,M]	[AL,VL]	[ML,AH]	[AL,M]	-

Step 5. Gather numerical representations of pairwise comparison matrices.

After pairwise linguistic evaluations are obtained, evaluations should be transformed into numeric intervals according to the corresponding IT2HLTS appeared in Table 4. Due to the page limitations, we only present a sample. For instance, the pairwise comparison of the evaluations for "Responsiveness" and "Empathy" is defined as [M,H] and [ML,H]. For [ML,H], the corresponding IT2HFE is given as (0.2325, 0.255, 0.325, 0.3575;0.8,0.8),(0.17,0.22,0.36,0.42;1.0,1.0) ; (0.7825, 0.815, 0.885, 0.9075;0.8,0.8),(0.72,0.78,0.92,0.97;1.0,1.0) and similarly, for [M,H] is determined as (0.4025, 0.4525, 0.5375, 0.5675;0.8,0.8),(0.32,0.41,0.58,0.65;1.0,1.0); (0.7825, 0.815, 0.885, 0.9075;0.8,0.8),(0.72,0.78,0.92,0.97;1.0,1.0).

Step 6. Aggregate the individual preferences using interval type 2 hesitant fuzzy weighted average (IT2HFWA) linguistic aggregation operator. For instance, aggregated preference relation for "Responsiveness" with respect to "Empathy" is calculated in the following according to the aggregation operator discussed in *Step 6*:

$$\tilde{h}_{24} = IT2HFWA\left(\tilde{h}_{i1}, \tilde{h}_{i2}, \ldots, \tilde{h}_{in}\right) = \sum_{j=1}^{n} w_j \tilde{h}_{ij} \; (i = 1, 2 \ldots m)$$

$$= \left[\frac{1}{3}\begin{matrix}(0.4025, 0.4525, 0.5375, 0.5675; 0.8, 0.8), (0.32, 0.41, 0.58, 0.65; 1,1), (0.7825, 0.815, 0.885, 0.9075; 0.8, 0.8),\\ (0.72, 0.78, 0.92, 0.97; 1,1)\end{matrix}\right]$$

$$\oplus \frac{1}{3}\left[\begin{matrix}(0.2325, 0.255, 0.325, 0.3575; 0.8, 0.8)(0.17, 0.22, 0.36, 0.42; 1,1), (0.7825, 0.815, 0.885, 0.9075; 0.8, 0.8)\\ (0.72, 0.78, 0.92, 0.97; 1,1)\end{matrix}\right]$$

$$\oplus\frac{1}{3}\begin{bmatrix}(0.2325,0.255,0.325,0.3575;0.8,0.8)(0.17,0.22,0.36,0.42;1,1),(0.7825,0.815,0.885,0.9075;0.8,0.8),\\(0.72,0.78,0.92,0.97;1,1)\end{bmatrix}$$

$$=\begin{bmatrix}(0.294,0.328,0.405,0.437;0.8,0.8)(0.223,0.289,0.444,0.510;1,1),(0.782,0.815,0.885,0.907;0.8,0.8)\\(0.72,0.780,0.920,0.970;1,1)\end{bmatrix}$$

Here, passenger weights are equal.

Step 7. Calculate the scores $s(\tilde{h}_{ij})$ $(i=1,2,\dots,m)$ for aggregated $\tilde{h}_i$ $(i=1,2,\dots,m)$ using the score function definition. The scores of pairwise comparison matrix are given in Table 12. For example, score function results for "Responsiveness" with respect to "Empathy" is calculated in the following:

$$pessimistic\ score\ (\tilde{h}_{24}) = \frac{1}{\#\tilde{h}}\sum_{\tilde{A}\in\tilde{h}} score\ (\tilde{A})$$

$$= \frac{1}{\#\tilde{h}}\sum_{\tilde{A}\in\tilde{h}}\left[\frac{(0.294+0.437)}{2}+\frac{(0.8+0.8+1+1)}{4}\right]$$

$$\times\frac{(0.294+0.328+0.405+0.437+0.223+0.289+0.444+0.510)}{8}=0.463$$

$$optimistic\ score\ (\tilde{h}_{24}) = \frac{1}{\#\tilde{h}}\sum_{\tilde{A}\in\tilde{h}} score\ (\tilde{A})$$

$$= \frac{1}{\#\tilde{h}}\sum_{\tilde{A}\in\tilde{h}}\left[\frac{(0.792+0.907)}{2}+\frac{(0.8+0.8+1+1)}{4}\right]$$

$$\times\frac{(0.782+0.815+0.885+0.907+0.72+0.780+0.920+0.970)}{8}=1.479$$

Table 12
Scores of pairwise comparison matrix.

	Tangibles	Responsiveness	Reliability	Empathy	Flight pattern	Booking and Ticketing
Tangibles	-	0.4700	0.5012	0.1012	1.9148	1.7133
Responsiveness	1.3333	-	1.5155	**0.9712**	1.6894	1.8681
Reliability	1.1748	0.0711	-	1.7394	1.6446	2.0873
Empathy	1.6281	0.5824	0.0594	-	0.0100	0.6978
Flight pattern	0.0100	0.1180	0.1182	1.9148	-	1.6386
Booking and Ticketing	0.0778	0.1748	0.2376	1.1748	0.5688	-

The overall score function for "Responsiveness" is the average of optimistic and pessimistic scores (0.9712).

Step 8. Build dominance matrix considering the difference between preference relations. The dominance matrix for main criteria are given in Table 13. The sample calculation is conducted for "Responsiveness" and "Empathy" as follows:

$$DM_{24}=\max(0,\ (R(I_2>I_4)-R(I_4>I_2))=max\big(0;(0.9711-0.5824)\big)=0.3887$$

Table 13
Dominance matrix for main criteria.

	Tangibles	Responsiveness	Reliability	Empathy	Flight pattern	Booking and Ticketing

Tangibles	-	0.000	0.000	0.000	1.905	1.635
Responsiveness	0.863	-	1.444	0.389	1.571	1.693
Reliability	0.674	0.000	-	1.680	1.526	1.850
Empathy	1.527	0.000	0.000	-	0.000	0.000
Flight pattern	0.000	0.000	0.000	1.905	-	1.070
Booking and Ticketing	0.000	0.000	0.000	0.477	0.000	-

Step 9. Adopt Rodriguez et al. (2012)'s non dominance rule. According to "Responsiveness" criterion following expression is adopted for calculating non dominance rule:

$$NDM_2 = |\min((1 - DM_1), (1 - DM_2), \dots, (1 - DM_n))|$$
$$= |\min((1 - 0.4700), (1 - 0.0711), \dots, (1 - 0.1747))| = 1$$

The non-dominance rule results are given in Table 14.

Table 14
Non dominance rule results (According to Rodriguez et al. (2013)).

	Non dominance scores
Tangibles	0.527
Responsiveness	1.000
Reliability	0.444
Empathy	0.905
Flight pattern	0.905
Booking and Ticketing	0.850

Step 10. Rank the alternatives after the normalization process as $Normalized\ NDM_i = \frac{NDM_i}{\sum_{i=1}^{n} NDM_i}$

The normalized weights of the main are given in Table 15.

Table 15
Normalized weights of the main criteria.

	Weights
Tangibles	0.114
Responsiveness	0.216
Reliability	0.096
Empathy	0.195
Flight pattern	0,195
Booking and Ticketing	0.183

The steps are both followed for sub criteria and alternatives. The weights are determined as Table 16.

Table 16
Defuzzifed values of alternatives and main and sub criteria.

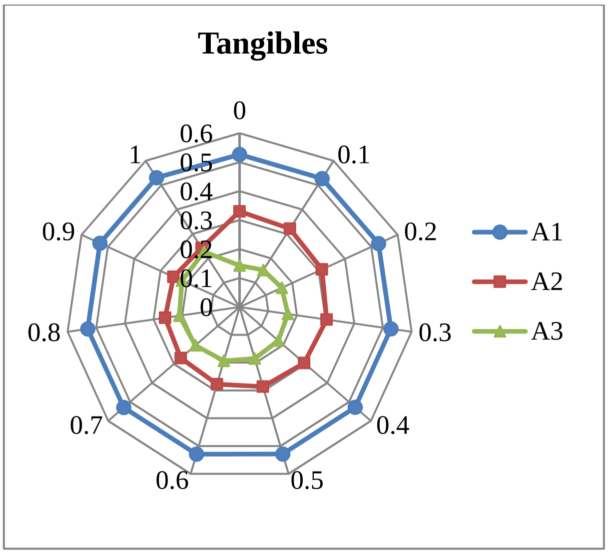
	Criteria Weight	Sub criteria weight	Global Sub criteria weight	Evaluation of alternative		
				A_1	A_2	A_3
Tangibles	0.114					

C_1		0.306	0.035	0.442	0.373	0.185
C_2		0.058	0.007	0.422	0.386	0.192
C_3		0.155	0.018	0.722	0.225	0.054
C_4		0.188	0.021	0.552	0.120	0.328
C_5		0.036	0.004	0.566	0.176	0.257
C_6		0.257	0.029	0.525	0.163	0.312
Responsiveness	0.216					
C_7		0.149	0.032	0.598	0.367	0.036
C_8		0.001	0.000	0.517	0.250	0.233
C_9		0.133	0.029	0.657	0.296	0.047
C_{10}		0.037	0.008	0.441	0.341	0.219
C_{11}		0.121	0.026	0.469	0.288	0.244
C_{12}		0.052	0.011	0.578	0.068	0.354
C_{13}		0.121	0.026	0.591	0.070	0.339
C_{14}		0.155	0.034	0.599	0.368	0.033
C_{15}		0.230	0.050	0.469	0.288	0.244
Reliability	0.096					
C_{16}		0.816	0.078	0.592	0.364	0.044
C_{17}		0.184	0.018	0.561	0.322	0.117
Empathy	0.195					
C_{18}		0.500	0.098	0.592	0.364	0.044
C_{19}		0.086	0.017	0.539	0.286	0.175
C_{20}		0.414	0.081	0.432	0.252	0.315
Flight pattern	0.195					
C_{21}		0.439	0.086	0.348	0.607	0.045
C_{22}		0.198	0.039	0.485	0.237	0.278
C_{23}		0.363	0.071	0.485	0.237	0.278
Booking and Ticketing	0.183					
C_{24}		0.126	0.023	0.654	0.297	0.049
C_{25}		0.531	0.097	0.577	0.282	0.141
C_{26}		0.342	0.063	0.553	0.406	0.041
Total score				***0.527***	***0.321***	***0.153***

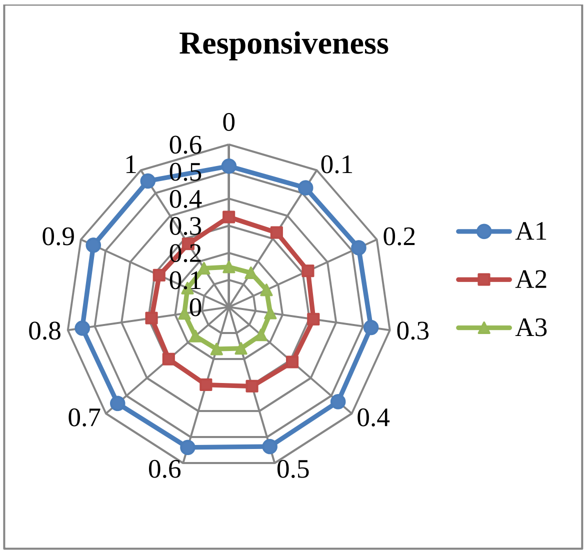
6.2.1. Sensitivity Analysis

In order to monitor the changes in the weights of criteria and sub criteria, one-at-a-time sensitivity analysis is applied. In the sensitivity analysis, possible changes in terms of ranking the alternatives are determined for main criteria by changing the related criterion from 0.1 to 1 while other criteria weights are fixed. All sensitivity analysis results are shown Fig. 4. For instance, if "Tangibles" (Fig. 4 (a)) changes from the remaining value to 0.3, then “responsiveness” should be updated by retaining the importance level using the following calculation $\frac{0.216}{(1-0.114)}\, x\,(1-0.3)=0.1706$. Similar calculations are conducted for the other criteria. The changes are presented in Fig. 4.

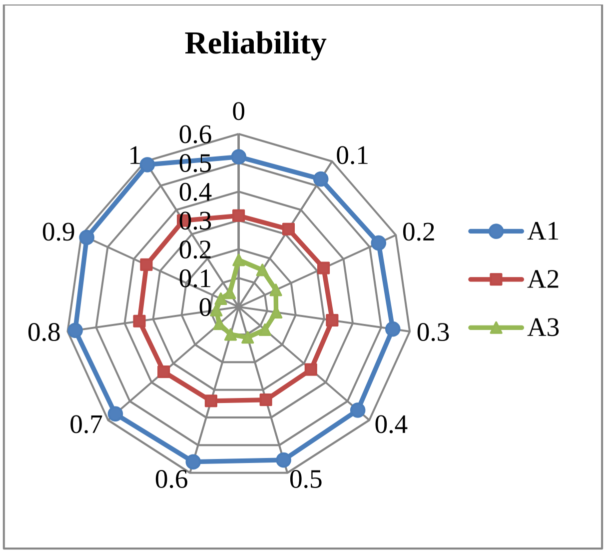
According to the figures, one could conclude that Empathy has not any reaction to the changes in criteria weights. On the other hand, if the criterion weight, “Tangibles” increases, then *Alternative 3* approximates to *Alternative 2*. The similar comments could be said to “Flight Patterns” where *Alternative 1*’s score decreases and “*Alternative 2*” ’s score increases while the criterion weight increases. For Reliability and Booking and Ticketing, if criterion weight increases, then *Alternative 3* ‘s score decreases while *Alternative 1* and *Alternative 2* have slight increase. The opposite situation could be observed while Responsiveness weight increases. In this situation *Alternative 1* and *Alternative 3* have slight increase but on the contrary, *Alternative 2* has a slight decrease.



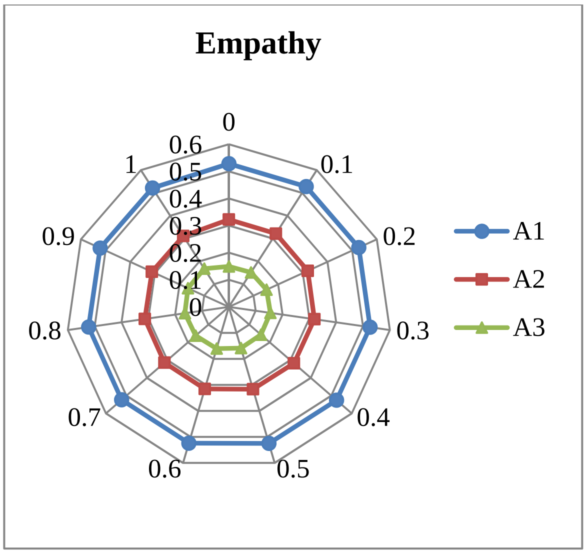
(a) Tangibles



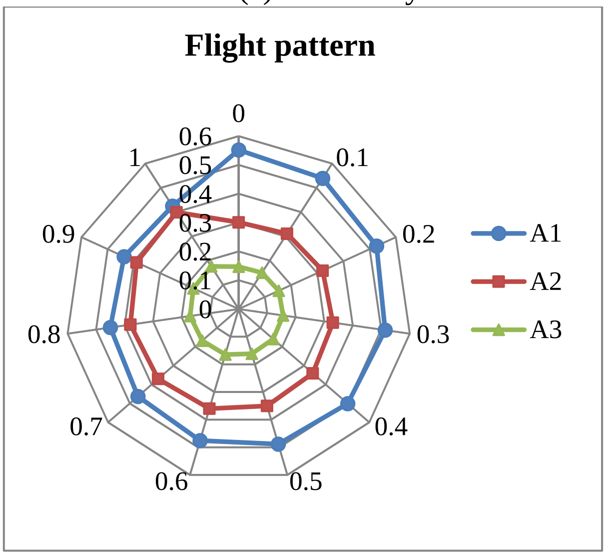
(b) Responsiveness



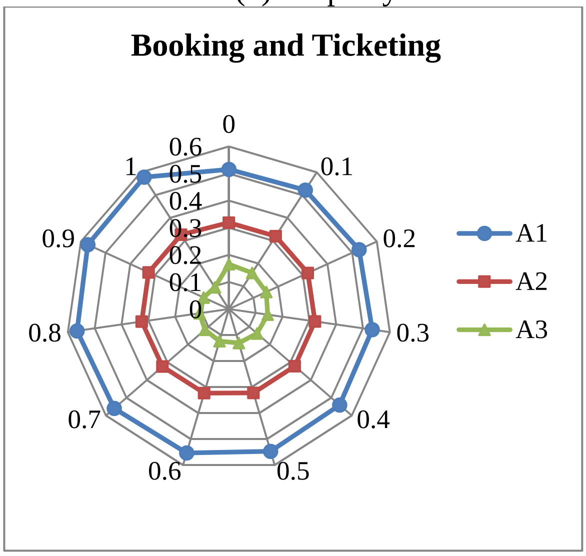
(c) Reliability



(d) Empathy



(e) Flight pattern



(f) Booking and Ticketing

Fig. 4. One at a time sensitivity analysis results for main criteria.

6.3. Comparative Analysis

To present the validation of the proposed methodology, a comparative analysis with the method proposed by Rodriguez et al. (2013) for hesitant fuzzy decision making process is conducted. The same problem with the same data is utilized for facilitating the comparison process. The main criteria evaluations are taken into account for the comparison. In that case, the same linguistic evaluations and linguistic term set are obtained as we present in *Step 2* in our proposed methodology. After using the minimum and maximum operators, linguistic intervals are determined in the similar manner in the proposed methodology. The preference relations are shown in the Table 17. The dominance matrix is given Table 18.

Table 17
Preference relations of main criteria.

	Tangibles	Responsiveness	Reliability	Empathy	Flight pattern	Booking and Ticketing
Tangibles	-	0.11	0.72	0.88	0.74	0.84
Responsiveness	0.89	-	1.00	1.00	1.00	1.00
Reliability	0.28	0.00	-	1.00	0.75	0.75
Empathy	0.12	0.00	0.00	-	0.34	0.52
Flight pattern	0.26	0.00	0.25	0.66	-	0.66
Booking and Ticketing	0.16	0.00	0.10	0.48	0.34	-

Table 18
Dominance matrix of main criteria (Rodriguez et al., 2013).

	Tangibles	Responsiveness	Reliability	Empathy	Flight pattern	Booking and Ticketing
Tangibles	-	0.00	0.44	0.76	0.47	0.67
Responsiveness	0.79	-	1.00	1.00	1.00	1.00
Reliability	0.00	0.00	-	1.00	0.50	0.65
Empathy	0.00	0.00	0.00	-	0.00	0.05
Flight pattern	0.00	0.00	0.00	0.32	-	0.32
Booking and Ticketing	0.00	0.00	0.00	0.00	0.00	-

The non-dominance choice degree NDD_1 is applied to the preference relation and given Table 19.

Table 19
Non dominance choice degrees of main criteria (Rodriguez et al., 2013).

	Non dominance choice degrees
Tangibles	0.212
Responsiveness	1.000
Reliability	0.000
Empathy	0.000
Flight pattern	0.000
Booking and Ticketing	0.000

After the normalization process the weights are calculated just for Tangibles and Responsiveness. The other criteria weights are not calculated due to the Dominance matrix values. As seen in the results, Responsiveness is selected as the most important criteria. Tangibles is represented as the second important criterion. Thus, Rodriguez et al. (2013) study is not applicable when three or more criteria are available and could not ensure the accurate order of weights. After applying the weights extracted from normalized dominance choice degree, the alternative scores are calculated as *Alternative 1* (0.549) > *Alternative 2* (0.271) > *Alternative 3* (0.180) which indicates the similar ranking result using the method in this paper. The main finding obtained from the proposed interval type-2 hesitant fuzzy methodology is that dimension pertaining to responsiveness has the highest score among other service quality dimensions for the passengers and the dimension of reliability has the lowest expectation score.

By considering Rodriguez et al. (2013) study, we checked whether the addition of dominance and non-dominance rule contribute the proposed method in terms of overcoming the limitation of the hesitant linguistic decision making method or not in order to justify interval type 2 hesitant fuzzy set decision making approach. Other methods such as Lee & Chen (2013) did not consider the requirement of the hesitant linguistic evaluating terms as an ordered finite set and consecutive in nature. Rodriguez et al. (2013) study enables this point of view which facilitates the comparison procedure. The proposed method translates the linguistic fuzzy terms into IT2HFS, which models uncertainty more accurately than type-1 fuzzy values. Thus, the comparison of the proposed study with Rodriguez et al. (2013) study demonstrates the advantages of IT2HFS over type 1 based hesitant fuzzy sets.

7. Conclusion and Discussion

An airline company should provide services targeting customer satisfaction, accurately identifying customer/passenger expectations and preferences in order to gain a competitive advantage over the other airline companies. In this study, expectations for the quality of service and the performance of the operators were evaluated. The results of this study can help airlines to understand their relative positions with respect to competitors leading them to improved and more effective strategies for fulfilling the needs of customers. The customer-driven approach to service quality used in this study enables airlines to determine their position, including their strengths and weaknesses in service quality relative to their competitors. In addition, airlines are compared using their performance based on each criterion. The results can enable airlines to manage their competitive advantages and provide incentives to develop quality levels of specific services as compared to their competitors.

The most important criteria for passengers (see Appendix A) are as follows: (1) Individual attention to passenger, (2) The quality of the reservation services, (3) Flight problems (cancellations, delays and deviations from schedules), (4) The advertising and image of the airline company, and (5) Safety (security). The less important criteria for passengers are as follows: (1) Responsiveness of crew, (2) Modern and proper aircraft, (3) Food service and drink services, and their quality, (4) Crew's speed handling request, and (5) Customer complaint handling, and more.

Another finding in this study is that the manager of an airline company may be interested in the top five service criteria *A_1 airline* has to improve as soon as possible. These criteria are as follows:

(1) Flight problems (cancellations, delays and deviations from schedules) (2) Food service and drink services, and their quality (3) The advertising and image of the airline company (4) Crew's speed handling request, and (5) Comfort and cleanness of seat, enough space between seats.

The top five service criteria *A_2 airline* has to improve as soon as possible. These criteria are as follows:

(1) Customer complaint handling (delayed flights etc.) (2) Clear and precise cabin announcements (3) In-flight entertainment services and programs (4) Availability of enough flight staffs and crew, and (5) Modern and proper aircraft.

The top five service criteria *A_3 airline* has to improve as soon as possible. These criteria are as follows:

(1) Helpful attitudes and courtesy of check in personnel and boarding employee (2) Courtesy, prompt, ability to language, and appearance of crew (3) The approach of staff at the ticket cancellations (4) Individual attention to passenger, and (5) Safety (security).

The main finding of this analysis is that passengers care for service prioritization and personalization for a better flight experience. Thus, companies should focus on strengths and weaknesses in their service quality and try to put their strengths forward to have the upper hand in the competition. Generally, just responsiveness or supplying modern aircrafts can be expected to achieve passenger satisfaction, but this study indicates that handling customer complaints, flight problems and individual attention could provide better insights for improving the service quality.

By using the proposed approach, the main findings are given as follows:

- Sometimes, survey respondents could not exactly say that "Responsiveness" is three times more important than "Tangibles". Despite of using triangular or trapezoidal fuzzy numbers, interval valued hesitant fuzzy numbers enables us to model uncertainty by primary and secondary memberships as an indicator of optimistic and pessimistic point of view when evaluating criteria and alternatives. This provides better understanding of respondents' doubts of making the pairwise comparisons of criteria while conducting the survey.

- When compared with Type 2 fuzzy sets based approaches, interval type 2 hesitant fuzzy decision making process can be managed by the simplification of computing process.
- As seen from the results of proposed methodology, decision maker could realize the alternatives overall scores' variations according to each criteria and sub criteria (See Table 15 and Appendix A). This provides the better understanding of the service quality problems' reasons and encourage airline companies to make strategic decisions for improving these criteria. Analyzers can also make comparisons of the difference between the most successful airline company and their company as well.

The practical implications are listed in the following:

- In this study, passenger expectations for the quality of service and the performance of the operators were evaluated by survey without information loss by using interval valued type 2 hesitant fuzzy decision making approach.
- The most important criteria for passengers (see Appendix A) are extracted and additionally, most powerful and weakest sides of service quality criteria according to each airline company are gathered before making strategic decisions for improving domestic airlines' competiveness.
- Additionally, one at a time sensitivity analysis is conducted for representing the criteria sensitivity and airlines are compared according to their performance of each criterion. This provides the ability to decide the best airline company for each criterion and variations can be interpreted for further service quality improvement suggestions.

From the comparison process, one could conclude that the application range of the linguistic terms used in the decision making method as proposed in Hu et al. (2015)'s paper is wider than that of most existing methods, such as seen in Lee and Chen (2013) and Rodriguez et al. (2013)'s studies. Additionally, the method used in this paper has an obvious advantage over that proposed by Rodriguez et al. (2013), due to its more accurate result as seen from the calculations of non-dominance choice degrees whereas that proposed by Rodriguez et al. (2013) leads to information loss. Furthermore, the proposed method translates the linguistic fuzzy terms into IT2HFS, which models uncertainty more accurately than type-1 fuzzy values indicated in Hu et al. (2015)'s study as an advantage. First and foremost, this paper also presents a real life application and demonstrates the validity of the proposed methodology of Hu et al. (2015)'s study.

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Appendix A

The importance ranking of all criteria.

All Airline	Weight	A_1 Airline	Weight	A_2 Airline	Weight	A_3 Airline	Weight
C_{18}	0.09770	C_3	0.72155	C_{21}	0.60687	C_{12}	0.35431
C_{25}	0.09749	C_9	0.65697	C_{26}	0.40550	C_{13}	0.33896
C_{21}	0.08574	C_{24}	0.65411	C_2	0.38627	C_4	0.32774
C_{20}	0.08092	C_{14}	0.59942	C_1	0.37293	C_{20}	0.31542
C_{16}	0.07829	C_7	0.59761	C_{14}	0.36762	C_6	0.31163
C_{23}	0.07101	C_{16}	0.59213	C_7	0.36651	C_{22}	0.27833
C_{26}	0.06281	C_{18}	0.59213	C_{16}	0.36364	C_{23}	0.27833
C_{15}	0.04976	C_{13}	0.59145	C_{18}	0.36364	C_5	0.25723
C_{22}	0.03864	C_{12}	0.57772	C_{10}	0.34067	C_{11}	0.24361
C_1	0.03482	C_{25}	0.57678	C_{17}	0.32165	C_{15}	0.24361
C_{14}	0.03351	C_5	0.56647	C_{24}	0.29703	C_8	0.23315
C_7	0.03228	C_{17}	0.56125	C_9	0.29611	C_{10}	0.21875
C_6	0.02926	C_{26}	0.55318	C_{11}	0.28754	C_2	0.19166
C_9	0.02869	C_4	0.55213	C_{15}	0.28754	C_1	0.18504
C_{13}	0.02613	C_{19}	0.53902	C_{19}	0.28645	C_{19}	0.17453
C_{11}	0.02602	C_6	0.52499	C_{25}	0.28206	C_{25}	0.14116
C_{24}	0.02319	C_8	0.51729	C_{20}	0.25216	C_{17}	0.11709
C_4	0.02141	C_{22}	0.48466	C_8	0.24956	C_3	0.05389
C_{17}	0.01766	C_{23}	0.48466	C_{22}	0.23701	C_{24}	0.04886
C_3	0.01763	C_{11}	0.46885	C_{23}	0.23701	C_9	0.04692
C_{19}	0.01678	C_{15}	0.46885	C_3	0.22456	C_{21}	0.04533
C_{12}	0.01127	C_1	0.44203	C_5	0.17630	C_{16}	0.04423
C_{10}	0.00803	C_{10}	0.44058	C_6	0.16339	C_{18}	0.04423
C_2	0.00663	C_{20}	0.43242	C_4	0.12013	C_{26}	0.04132
C_5	0.00405	C_2	0.42207	C_{13}	0.06958	C_7	0.03587
C_8	0.00026	C_{21}	0.34780	C_{12}	0.06797	C_{14}	0.03297