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EVALUATING THE SERVICE QUALITY OF DOMESTIC AIRLINES UNDER AN INTUITIONISTIC FUZZY SETS ENVIRONMENT

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Abstract. With the development of domestic economy and the improvement of consumption level, the service industry among air transportation is now developing rapidly, and has become one of the most important modern service industry. In the intensive competition of the global aviation services, including our country, they compete based on the service quality, such as service on board, check-in, flight punctuality rate, and deliver. These greatly draw attention of many large companies. However, there still exists room for improvement. Intuitionistic fuzzy set is an extension of fuzzy set theory. Compared with the traditional fuzzy set, it uses the membership degree, non-membership degree and hesitancy degree to describe fuzzy nature of objective world. Therefore, it provides more choices when describing the attribute of an object, and has higher performance when processing uncertainty information. Based on service quality, this paper constructs the measurement criteria by taking into account related literatures and expert's opinions. We also combines the intuitionistic fuzzy set with TOPSIS to develop a fuzzy evaluation model of service quality for airlines. Taking domestic four airlines in 2018 as examples, we demonstrate the feasibility and practicality of the fuzzy evaluation model proposed in this paper. The results can help managers of airlines to measure the level of service quality, and provide an important reference for improving service quality.

1. Introduction

With the development of economic globalization and the deepening of the integration of China and the global economy, the enterprises not only face the competition from domestic counterparts, but also have to deal with the competition from foreign companies. Under the increasingly fierce competition, improving product quality and satisfying customers are the inevitable for the enterprises, and also the foundation for the survival of the enterprises and the driving force for development. Only on the basis of demand-orientation, the company's service products can truly satisfy customers and achieve the goal of maximizing economic benefits. Taking the domestic airlines as example, there still exists significant difference between their service quality. The main manifestations are uneven service levels, inadequate concepts in service and awareness, lack of uniform quality, specifications, or standards in service, and lack of a clear indicator system of service quality, which all affect

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passengers' trust and loyalty to airlines, and lead to the decrease in passengers and economics loss.

Therefore, in order to enhance the business performance and competitiveness of the enterprises, airlines have adopted diversified marketing strategies, such as lower price and joint operations, to attract customers and increase market share. In the increasingly competitive air transportation market, airlines not only provide various marketing strategies, but also improve and enhance the service quality so that the needs of different passengers can be satisfied. Furthermore, the passengers' requirements for service quality become higher. Therefore, airlines can create their competitive advantages in many dimensions such as the professionalism, service attitude, flight safety, public praise, etc. Based on these situations, how to enhance service quality has been one of the most important topics.

The choice in airlines for passengers rely on many factors, such as price, time, public praise, etc., which is a problem of multi-criteria decision making. At the same time, many criteria considered by passengers may conflict with each other, in addition, there also exists uncertainty and ambiguity regarding the importance of these criteria. Therefore, allowing the existence of fuzziness is more appropriate for explaining actual situations [4]. Because of the characteristic of continuous fuzzy interval values, fuzzy logic is able to deal with the situations that are between true and false, it can assist decision makers in handling the problems with uncertainty. However, such an approach may make decision makers unable to provide accurate information and possess some degree in hesitancy [15]. To resolve this problem, [2] proposed the intuitionistic fuzzy set (IFS) which can describe the difference and ambiguity of linguistic expression, and the intuitionistic fuzzy index is used to appropriately measure the degree of uncertainty caused by human thinking based on the degrees in the membership and non-membership of the fuzzy sets. According to the related literature in service quality of airlines and expert opinions, this paper develops an evaluation model of service quality for airlines by combining intuitionistic fuzzy sets with TOPSIS and operation procedures. Finally, taking the construction of an intuitionistic fuzzy evaluation model of airline service quality as an example, we demonstrate the feasibility and practicality of the evaluation model so as to be a reference for the aviation industry to strengthen service connotation and improve service quality.

2. Related works

2.1. **Intuitionistic fuzzy sets.**

The fuzzy set proposed by [20] can be used to describe the fuzzy phenomenon in real life. It expresses the ambiguity of the set range by means of using the membership function to, and extends the basis of traditional binary logic to interval continuous values [0, 1]. In addition, it transforms the fuzziness of the data into precise mathematical language. However, the description of this method may be incomplete for decision makers in terms of fuzzy concepts and membership degree in practical applications because the sum of the degrees of membership and non-membership many be less than 1 [10]. To resolve this situation, [2] introduced the concept of intuitionistic fuzzy sets in 1986. It is an extension of the fuzzy sets. Its characteristic is to consider the degrees of both the membership and non-membership of data at the same time, so that the intuitionistic fuzzy set can provide more choices for the description of the attributes of an object. It also has higher performance in dealing with uncertain information. Therefore, intuitionistic fuzzy sets are more suitable to handle the problems of ambiguity and uncertainty than fuzzy sets. Nowadays, intuitionistic fuzzy set has been applied in various fields such as decision analysis [9, 13], data mining [1, 12], and customer satisfaction [6] etc.

First, the fuzzy set is briefly introduced, the definition of fuzzy set in the universe of discourse X is described as follows:

$$\tilde{A} = \{< x, \mu_{\tilde{A}}(x) >, x \in X\} \tag{2.1}$$

Only the membership function $\mu_{\tilde{A}}(x)$ is explained in the fuzzy set, and its value is between 0 and 1. Later, the extended intuitionistic fuzzy set has the non-membership functions $v_{\tilde{A}}(x)$, this method can more precisely express the cognition of the decision maker. Next, let $\widehat{A}$ be an intuitionistic fuzzy sets with respect to $\tilde{A}$ shown as follows:

$$\widehat{A} = \{< x, \mu_{\tilde{A}}(x), v_{\tilde{A}}(x) >, x \in X\} \tag{2.2}$$

where $\mu_{\tilde{A}}(x)$ and $v_{\tilde{A}}(x)$ denote the degree of membership function and the degree of non-membership function of element x belonging to the intuitionistic fuzzy set $\widehat{A}$, respectively. And $\mu_{\tilde{A}}(x) \in [0, 1]$, $v_{\tilde{A}}(x) \in [0, 1]$, $0 \leq \mu_{\tilde{A}}(x) + v_{\tilde{A}}(x) \leq 1$.

In addition, the third scale is intuitionistic fuzzy index $\pi_{\tilde{A}}(x)$, which is used to express the uncertainty of x to $\tilde{A}$, and is also a measure of the degree of hesitancy.

$$\pi_{\tilde{A}}(x) = 1 - \mu_{\tilde{A}}(x) - v_{\tilde{A}}(x) \tag{2.3}$$

For all $x \in X$, $0 \leq \pi_{\tilde{A}} \leq 1$. If $\pi_{\tilde{A}}(x)$ is lower, this means that X is highly certain. On the contrary, if $\pi_{\tilde{A}}(x)$ is very high, this means that X is extremely low certain.

Therefore, the intuitionistic fuzzy set $\widehat{A}$ can be equivalently represented by

$$\widehat{A} = \{< x, [\mu_{\tilde{A}}(x), v_{\tilde{A}}(x), \pi_{\tilde{A}}(x)] >, x \in X\} \tag{2.4}$$

Further, let $\widehat{A}$ and $\widehat{B}$ be two intuitionistic fuzzy sets with respective to $\tilde{A}$ and $\tilde{B}$, respectively. The equations of calculation of intuitionistic fuzzy sets are shown below [2]:

$$\widehat{A} \oplus \widehat{B} = \{< x, \mu_{\tilde{A}}(x) + \mu_{\tilde{B}}(x) - \mu_{\tilde{A}}(x)\mu_{\tilde{B}}(x), v_{\tilde{A}}(x)v_{\tilde{B}}(x) >, x \in X\} \tag{2.5}$$

$$\widehat{A} \otimes \widehat{B} = \{< x, \mu_{\tilde{A}}(x)\mu_{\tilde{B}}(x), v_{\tilde{A}}(x) + v_{\tilde{B}}(x) - v_{\tilde{A}}(x)v_{\tilde{B}}(x) >, x \in X\} \tag{2.6}$$

2.2. **TOPSIS.** TOPSIS was proposed in [7] to determine the best alternative based on the concepts of the compromise solution. The compromise solution can be regarded as choosing the solution with the shortest Euclidean distance from the ideal solution and the farthest Euclidean distance from the negative ideal solution. It starts by normalizing columns of a decision matrix and multiplying values in columns by corresponding criterion's weights. It also identifies the best and worst values in each column and creates two sets of these values across all columns which are named as the positive ideal solution (PIS) and negative ideal solution (NIS), respectively. Next, it is based on an optimum ideal solution since the maximum level is obtained by selecting the best alternative available. The ranking of ideal solutions is done in such a way that the best alternatives are ranked. Therefore, TOPSIS is a practical and useful technique for ranking and selecting a number of externally determined alternatives through distance measures. In recent years, this method was applied on many fields [5, 8, 22].

3. Evaluative model of intuitionistic fuzzy TOPSIS

In intuitionistic fuzzy TOPSIS, let $A = \{A_1, A_2, \dots, A_m\}$ be the set of alternatives, $X = \{X_1, X_2, \dots, X_n\}$ is the set of criteria, the steps are as follows [3].
STEP 1. Decision decision-makers' weight. Suppose there are h decision makers, and their importance is expressed in the linguistic of intuitionistic fuzzy numbers. Let $D_p = [\mu_p, v_p, \pi_p]$ be an intuitionistic fuzzy number which represents the importance of the opinion of the pth decision maker.

$$\lambda_p = \frac{(\mu_p + \pi_p(\frac{\mu_p}{\mu_p+v_p}))}{\sum_{p=1}^{h}(\mu_p + \pi_p(\frac{\mu_p}{\mu_p+v_p}))} \tag{3.1}$$

where $\Sigma_{p=1}^{h}\lambda_p = 1$.
STEP 2. Construct intuitionistic fuzzy matrix. This step is mainly to collect the opinions of all decision makers into a group opinion, and then use this group opinion to construct an intuitionistic fuzzy decision matrix. Here, the $IFWA$ method is used to derive this matrix [18], $R = (r_{ij})_{m\times n}$, where

$$\begin{aligned} r_{ij} &= IFWA_\lambda(r_{ij}^{(1)}, r_{ij}^{(2)}, \dots, r_{ij}^{(h)}) = \lambda_1 r_{ij}^{(1)} \oplus \lambda_2 r_{ij}^{(2)} \oplus \dots \oplus \lambda_h r_{ij}^{(h)} \\ &= [1 - \prod_{p=1}^{h}(1-\mu_{ij}^{(p)})^{\lambda_p}, \prod_{p=1}^{h}(v_{ij}^{(p)})^{\lambda_p}, \prod_{p=1}^{h}(1-\mu_{ij}^{(p)})^{\lambda_p} - \prod_{p=1}^{h}(v_{ij}^{(p)})^{\lambda_p}] \end{aligned} \tag{3.2}$$

Here $r_{ij} = (\mu_{\tilde{A}_i}(x_j), v_{\tilde{A}_i}(x_j), \pi_{\tilde{A}_i}(x_j))$ (i=1,2,...,m, j=1,2,...,n) is obtained by collecting the scores of all decision makers, considering their importance and the scores of intuitionistic fuzzy number for the alternative i to criterion j. Thus, intuitionistic fuzzy decision matrix R is:

$$R = \begin{bmatrix} (\mu_{\tilde{A}_1}(x_1), v_{\tilde{A}_1}(x_1), \pi_{\tilde{A}_1}(x_1)) & \cdots & (\mu_{\tilde{A}_1}(x_n), v_{\tilde{A}_1}(x_n), \pi_{\tilde{A}_1}(x_n)) \\ (\mu_{\tilde{A}_2}(x_1), v_{\tilde{A}_2}(x_1), \pi_{\tilde{A}_2}(x_1)) & \cdots & (\mu_{\tilde{A}_2}(x_n), v_{\tilde{A}_2}(x_n), \pi_{\tilde{A}_2}(x_n)) \\ \vdots & \ddots & \vdots \\ (\mu_{\tilde{A}_m}(x_1), v_{\tilde{A}_m}(x_1), \pi_{\tilde{A}_m}(x_1)) & \cdots & (\mu_{\tilde{A}_m}(x_n), v_{\tilde{A}_m}(x_n), \pi_{\tilde{A}_m}(x_n)) \end{bmatrix}$$

STEP 3. Determine the weight of criterion. To obtain w_j, the opinions regarding the importance of each evaluation criterion provided by each decision maker must be aggregated. That is, $w_j^{(p)} = [\mu_j^{(p)}, v_j^{(p)}, \pi_j^{(p)}]$ describes the intuitionistic fuzzy scores of criterion X_j provided by the pth decision maker. Similarly, $IFWA$ method is employed to obtain the corresponding weights:

$$\begin{aligned} w_j &= IFWA_\lambda(w_j^{(1)}, w_j^{(2)}, \ldots, w_j^{(h)}) = \lambda_1 w_j^{(1)} \oplus \lambda_2 w_j^{(2)} \oplus \ldots \oplus \lambda_h w_j^{(h)} \\ &= [1 - \prod_{p=1}^{h}(1-\mu_j^{(p)})^{\lambda_p}, \prod_{p=1}^{h}(v_j^{(p)})^{\lambda_p}, \prod_{p=1}^{h}(1-\mu_j^{(p)})^{\lambda_p} - \prod_{p=1}^{h}(v_j^{(p)})^{\lambda_p}] \end{aligned} \tag{3.3}$$

Therefore, the matrix of weight values is: $W = [w_1, \ldots, w_j, \ldots, w_n]$.
STEP 4. Construct weighted intuitionistic fuzzy decision matrix. In STEP 4, Eq. (2.6) proposed by [2] is adopted to construct weighted intuitionistic fuzzy decision matrix R.

$$\widehat{R} \otimes \widehat{W} = \{< x, \mu_{\tilde{A}_i}(x) \cdot \mu_{\tilde{W}}(x), v_{\tilde{A}_i}(x) + v_{\tilde{W}}(x) - v_{\tilde{A}_i}(x) \cdot v_{\tilde{W}}(x) >, x \in X\} \tag{3.4}$$

and

$$\pi_{\widehat{A_i} \otimes \widehat{W}}(x) = 1 - v_{\tilde{A}_i}(x) - v_{\tilde{W}}(x) - \mu_{\tilde{A}_i}(x) \cdot \mu_{\tilde{W}}(x) + v_{\tilde{A}_i}(x) \cdot v_{\tilde{W}}(x) \tag{3.5}$$

The weighted intuitionistic fuzzy decision R' is then as follows:

$$R' = \begin{bmatrix} r'_{11} & r'_{12} & \cdots & r'_{1j} \\ r'_{21} & r'_{22} & \cdots & r'_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ r'_{i1} & r'_{i2} & \cdots & r'_{ij} \end{bmatrix}$$

where, $r'_{ij} = (\mu'_{ij}, v'_{ij}, \pi'_{ij})$ presents each element in the weighted intuitionistic fuzzy decision matrix.
STEP 5. Determine the PIS and NIS for intuitionistic fuzzy number. Suppose J_1 is the set of benefit attribute/criterion, J_2 is the set of cost attribute/criterion; A^+ is the positive ideal solution (PIS) of intuitionistic fuzzy number, and A^- is the negative ideal solution (NIS) of intuitionistic fuzzy number.

The expression of A^+ and A^- are shown below.
$A^+ = (\mu_{\widehat{A} \oplus \widehat{W}}(x_j), v_{\widehat{A} \oplus \widehat{W}}(x_j))$ and $A^- = (\mu_{\widehat{A} \ominus \widehat{W}}(x_j), v_{\widehat{A} \ominus \widehat{W}}(x_j))$.

The solution of PIS is:

$$\mu_{\widehat{A} \oplus \widehat{W}}(x_j) = ((max_i \mu_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_1), (min_i \mu_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_2)) \tag{3.6}$$

$$v_{\widehat{A} \oplus \widehat{W}}(x_j) = ((min_i v_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_1), (max_i v_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_2)) \tag{3.7}$$

In addition, the solution of NIS is:

$$\mu_{\widehat{A} \ominus \widehat{W}}(x_j) = ((min_i \mu_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_1), (max_i \mu_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_2)) \tag{3.8}$$

$$v_{\widehat{A} \ominus \widehat{W}}(x_j) = ((max_i v_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_1), (min_i v_{\widehat{A_i} \otimes \widehat{W}}(x_j) | j \in J_2)) \tag{3.9}$$

STEP 6. Determine the distance of PIS and NIS for each alternative. The separation between each pair of alternatives can be calculated by standard Euclidean distance [14].

$$S_i^+ = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}[(\mu_{\widehat{A_i} \otimes \widehat{W}}(x_j) - \mu_{\widehat{A} \oplus \widehat{W}}(x_j))^2 + (v_{\widehat{A_i} \otimes \widehat{W}}(x_j) - v_{\widehat{A} \oplus \widehat{W}}(x_j))^2 + (\pi_{\widehat{A_i} \otimes \widehat{W}}(x_j) - \pi_{\widehat{A} \oplus \widehat{W}}(x_j))^2]} \tag{3.10}$$

(3.11) $S_i^- =$

$$\sqrt{\frac{1}{2n}\sum_{j=1}^{n}[(\mu_{\widehat{A_i}\otimes\widehat{W}}(x_j)-\mu_{\widehat{A}\ominus\widehat{W}}(x_j))^2+(v_{\widehat{A_i}\otimes\widehat{W}}(x_j)-v_{\widehat{A}\ominus\widehat{W}}(x_j))^2+(\pi_{\widehat{A_i}\otimes\widehat{W}}(x_j)-\pi_{\widehat{A}\ominus\widehat{W}}(x_j))^2]}$$

STEP 7. Determine the relative closeness betwen the intuitionistic fuzzy ideal solution and each alternative. After obtaining the distances of PIS and NIS (i.e. S_i^+ and S_i^-) in Step 6, we calculate the relative closeness of each alternative to the intuitionistic fuzzy ideal solution, i.e. C_i, under the distance of PIS and NIS. It is measures by

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{3.12}$$

The larger the value of C_i is, the closer the distance to the intuitionistic fuzzy ideal solution is.
STEP 8. Ranking the preference order. The values of C_i are sorted descendingly. The alternative with the highest value is the best.

4. Empirical analysis and application

4.1. **Construct evaluation model of service quality.**

Based on the framework constructed by [16], first, we consider a preliminary model by taking related literatures [11, 23, 19, 21] into account. Next, five experts with relevant fields are interviewed so as to construct a suitable evaluation model for service quality of domestic airlines. There are five dimensions and sixteen criteria, as shown in Fig. 1, of the evaluation model.

4.2. **Instance illustration.**

This section discusses the instance of domestic aviation industry and applies the proposed evaluation model to this instance. According to service quality provided by airlines, we select top 4 major domestic airlines in 2018 under study. The panel consists of five experts who are required to conduct the research and they give appropriate evaluation linguistic values. Table 1 shows the linguistic score of the importance for five experts, and Table 2 is the linguistic score of each evaluative criterion given by five experts. In addition, Table 3 and 4 express the linguistic score of five experts regarding the four airlines under each criterion. Expert 1 is a senior pilot, his flight time is over twenty years. Expert 2 is an airline manager who operates domestic flights with rich experience. The 3rd and 4rd experts are academic professors. Their research domains are about the area of aviation industry. In addition, Expert 3 works in Key University and has rich experience on university-industry cooperation. As for Expert 5, she is a senior manager of low-cost carrier. The related data is strictly evaluated by these experts so as to obtain effective results.

4.2.1. *Obtaining weighted intuitionistic fuzzy decision matrix.*

First, we calculate the importance linguistic scores in Table 1 and the items corresponding with intuitionistic fuzzy numbers in Table 5, and then obtain the weight of each expert through Eq. (3.1), the values are summarized in Table 6. Secondly, we use the

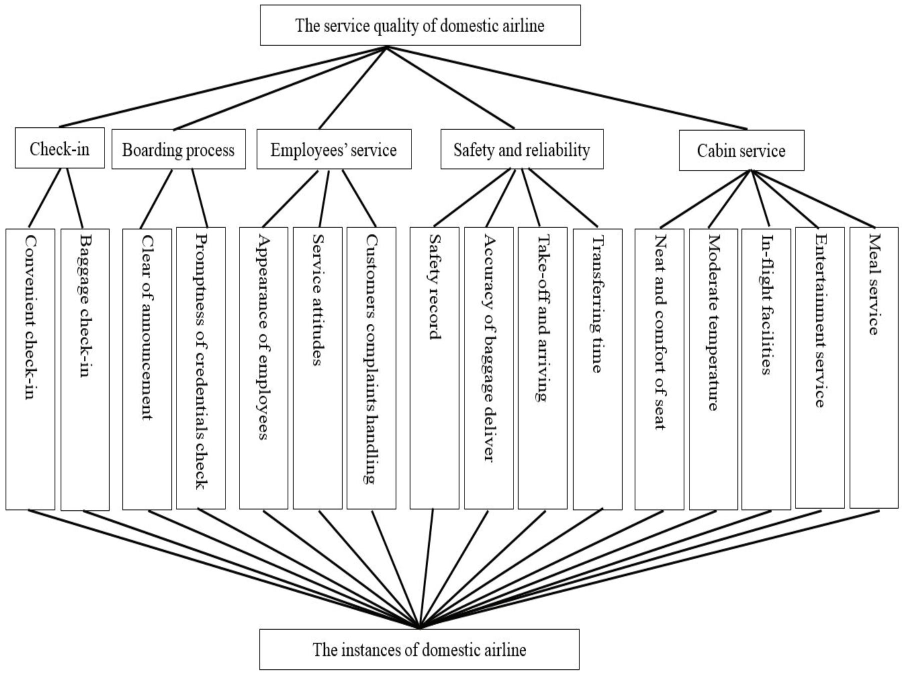

FIGURE 1. The evaluation model of service quality of domestic airline

TABLE 1. The linguistic score for each expert importance

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Linguistic score	VI	VI	I	M	I

linguistic scores of intuitionistic fuzzy numbers in Table 7 and adopt Eq. (3.2) to calculate and construct the intuitionistic fuzzy number matrix R. Moreover, by means of the $IFWA$ method, the data in Table 2 is used to aggregate the weight of each evaluation criterion via Eq. (3.3), the weights of all evaluation criteria are presented in Table 8. It can be seen in Table 8 that the top four criteria with the highest weight values are c_{41}-safety record, c_{11}-convenient check-in, c_{22}-promptness of credentials check and c_{43}-take-off and arriving. Experts believe that safety record is an important factor affecting the aviation industry. The factors of flight safety includes human carelessness, mechanical failure, and weather environment such as improper operation or mechanical failure, outdated equipment, no update in time and bad weather. Therefore, airlines must strictly enforce and improve their safety records to reduce the occurrence of accidents. The convenient check-in and the promptness of credentials check can save time for passengers, and can select seats and print boarding passes earlier to facilitate passengers' time arrangements. Whether or not the departure or arriving is on time is an important factor that airline maintains passenger loyalty. Because some domestic flights are often delayed, the numbers

TABLE 2. The linguistic score of each evaluative criterion for five experts

Criterion	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
c_{11}	VI	VI	I	VI	I
c_{12}	I	I	VI	VI	VI
c_{21}	VI	I	I	I	VI
c_{22}	I	VI	VI	I	VI
c_{31}	I	M	VI	M	I
c_{32}	VI	I	I	M	I
c_{33}	I	M	M	I	I
c_{41}	VI	VI	VI	VI	VI
c_{42}	I	VI	VI	I	VI
c_{43}	VI	I	VI	I	VI
c_{44}	I	I	M	M	M
c_{51}	I	M	I	M	I
c_{52}	M	I	I	M	M
c_{53}	I	VI	VI	I	I
c_{54}	M	M	I	I	M
c_{55}	I	M	M	M	I

of passenger is gradually reduced. If this factor can be improved, the company's carrying capacity will increase and bring great benefits. Finally, the weight of each criterion is combined with the intuitionistic fuzzy decision matrix. Here, Eq. (3.4) and (3.5) proposed by [2] are used to construct the weighted intuitionistic fuzzy number decision matrix R' .

$$R = \begin{bmatrix} (1.00, 0.00, 0.00) & (0.75, 0.15, 0.11) & \cdots & (0.71, 0.17, 0.12) \\ (0.71, 0.17, 0.12) & (1.00, 0.00, 0.00) & \cdots & (0.69, 0.20, 0.12) \\ (0.69, 0.20, 0.12) & (1.00, 0.00, 0.00) & \cdots & (0.64, 0.23, 0.13) \\ (0.71, 0.17, 0.12) & (0.61, 0.27, 0.13) & \cdots & (1.00, 0.00, 0.00) \end{bmatrix}$$

$$R' = \begin{bmatrix} (0.87, 0.12, 0.11) & (0.65, 0.25, 0.10) & \cdots & (0.47, 0.37, 0.16) \\ (0.62, 0.27, 0.11) & (0.86, 0.12, 0.02) & \cdots & (0.45, 0.39, 0.15) \\ (0.59, 0.29, 0.11) & (0.86, 0.12, 0.02) & \cdots & (0.42, 0.42, 0.16) \\ (0.62, 0.27, 0.11) & (0.53, 0.35, 0.12) & \cdots & (0.66, 0.24, 0.09) \end{bmatrix}$$

4.2.2. *Determine the distance of PIS and NIS.* Let J_1 and J_2 be the benefit attribute and the cost attribute, respectively. A^+ is the PIS of the intuitionistic fuzzy number, and A^- is the NIS of the intuitionistic fuzzy number. In this instance, only one of the 16 attributes is a cost attribute ($c_{44} \in J_2$), and the remaining 15 attributes are all benefit attributes ($c_{11}, c_{12}, \ldots, c_{43}, c_{51}, \ldots, c_{55} \in J_1$). Consequently, according to the characteristics of each evaluation criterion, we calculate the distance the PIS and NIS, the results are shown in Table 9. Next, Eq. (3.10) and

TABLE 3. The linguistic score of four airlines under each evaluative criterion for four experts

Criterion	Expert 1				Expert 2				Expert 3			
A_i	A_1	A_2	A_3	A_4	A_1	A_2	A_3	A_4	A_1	A_2	A_3	A_4
c_{11}	H	H	H	H	EH	VH	VH	VH	H	H	H	H
c_{12}	VH	H	H	H	VH	H	EH	H	H	H	H	M
c_{21}	VH	H	H	EH	H	VH	H	H	H	VH	M	H
c_{22}	VH	VH	H	H	H	H	H	H	H	H	H	H
c_{31}	H	EH	H	H	EH	H	H	H	H	VH	H	H
c_{32}	VH	H	EH	H	H	VH	H	H	H	VH	H	M
c_{33}	VH	H	VH	H	H	H	H	H	VH	EH	VH	EH
c_{41}	EH	VH	H	VH	H	H	VH	H	H	H	H	H
c_{42}	H	VH	H	H	VH	H	M	H	VH	M	H	H
c_{43}	H	H	M	M	M	H	H	H	H	EH	H	H
c_{44}	H	H	M	M	H	H	H	H	H	VH	M	H
c_{51}	EH	H	H	H	H	H	H	H	VH	VH	EH	VH
c_{52}	M	H	H	VH	H	H	H	VH	H	H	H	H
c_{53}	VH	H	H	VH	H	H	H	H	VH	EH	EH	VH
c_{54}	H	VH	H	H	H	H	H	H	M	M	H	H
c_{55}	VH	H	H	EH	H	VH	H	VH	M	M	M	M

(3.11) are used to determine the distance between each alternative and the PIS and NIS, where n is set to be 16. The results are shown in Table 10.

4.2.3. *Ranking the alternative order.* Finally, the relative closeness C_i of each alternative to the ideal solution is calculated. The larger the value is, the closer the distance to the PIS is. Therefore, the corresponding values of C_i for all alternatives are ranked. The results are summarized in Table 11. The alternative with the highest value is the best evaluative alternative. The highest value in Table 11 is 0.525. This means that A_3 is the best alternative. At the same time, the intuitionistic fuzzy GRA model proposed by [17] is also employed used for the purpose of comparison, and the corresponding results are presented in Table 12. It is shown that the performance of A_3 is the highest, that is, A_3 is the best solution. For this practical application, this paper uses the intuitionistic fuzzy TOPSIS evaluation model to select the alternative, and then compares the results with those obtained by the intuitionistic fuzzy GRA model. The best solutions for both evaluative methods are the same, i.e. A_3 is the best alternative. Such a result is the same as the ranking published in 2018, which means that this evaluation model is practicality and feasibility.

TABLE 4. The linguistic score of four airlines under each evaluative criterion for Expert 4 and 5

Criterion	Expert 4				Expert 5			
A_i	A_1	A_2	A_3	A_4	A_1	A_2	A_3	A_4
c_{11}	H	H	H	H	H	H	M	H
c_{12}	H	EH	H	H	H	H	H	M
c_{21}	H	H	H	H	H	H	H	H
c_{22}	EH	H	M	H	M	VH	EH	VH
c_{31}	H	VH	VH	H	H	H	EH	H
c_{32}	EH	H	EH	VH	VH	H	VH	H
c_{33}	H	H	H	H	M	H	M	H
c_{41}	VH	H	H	H	H	H	H	H
c_{42}	H	H	H	H	H	H	EH	VH
c_{43}	VH	H	VH	H	M	H	H	M
c_{44}	VH	H	H	H	M	H	H	H
c_{51}	H	H	M	H	H	H	H	VH
c_{52}	H	EH	H	VH	H	H	H	H
c_{53}	EH	H	H	VH	H	M	H	H
c_{54}	M	H	H	M	M	M	M	M
c_{55}	H	H	H	H	H	H	H	H

TABLE 5. Each linguistic score corresponding the intuitionistic fuzzy number

The items of linguistic score	IFNs
Very Important (VI)	(0.90, 0.10, 0)
Important (I)	(0.80, 0.15, 0.05)
Neutral (M)	(0.50, 0.35, 0.15)
Non-Important (NI)	(0.20, 0.60, 0.20)
Very Non-Important (VNI)	(0.10, 0.90, 0)

TABLE 6. The weights of each expert

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Weight	0.221	0.221	0.207	0.144	0.207

5. CONCLUSION

With the flourishing development of our country aviation industry, airlines with humanized service concepts, advanced information technology and strong capital

Table 7. Each linguistic score corresponding the intuitionistic fuzzy number

The items of linguistic score	IFNs
Extremely High (EH)	(1.00, 0, 0)
Very High (VH)	(0.82, 0.10, 0.08)
High (H)	(0.67, 0.20, 0.13)
Neutral (M)	(0.50, 0.40, 0.10)
Low (L)	(0.35, 0.50, 0.15)
Very Low (VL)	(0.20, 0.70, 0.10)
Extremely Low (EL)	(0.10, 0.90, 0)

Table 8. The weights of all evaluative criteria

Criterion	IFNs		
c_{11}	0.87	0.12	0.01
c_{12}	0.86	0.12	0.02
c_{21}	0.85	0.13	0.02
c_{22}	0.87	0.12	0.01
c_{31}	0.76	0.19	0.05
c_{32}	0.80	0.15	0.04
c_{33}	0.70	0.22	0.08
c_{41}	0.90	0.10	0.00
c_{42}	0.86	0.13	0.01
c_{43}	0.87	0.12	0.01
c_{44}	0.67	0.24	0.09
c_{51}	0.72	0.20	0.08
c_{52}	0.66	0.24	0.09
c_{53}	0.85	0.13	0.02
c_{54}	0.64	0.26	0.10
c_{55}	0.66	0.24	0.09

strength have come to the market to seek development opportunities. At the same time, the rapid development of High-Speed Rail and other transportation and diversification of passenger demand make airlines face severe challenges. In this background, it is important for airlines to quickly improve service quality and enhance corporate competitiveness through effective service quality management. Based on service quality, this paper constructs a set of evaluation model for airline service

TABLE 9. The PIS and NIS of each evaluative criterion

Criterion	A^+(PIS)	A^-(PIS)
c_{11}	(0.87, 0.12, 0.01)	(0.59, 0.29, 0.11)
c_{12}	(0.86, 0.12, 0.02)	(0.53, 0.35, 0.12)
c_{21}	(0.85, 0.13, 0.02)	(0.55, 0.33, 0.13)
c_{22}	(0.87, 0.12, 0.01)	(0.62, 0.27, 0.11)
c_{31}	(0.76, 0.19, 0.05)	(0.51, 0.35, 0.14)
c_{32}	(0.80, 0.15, 0.04)	(0.54, 0.33, 0.13)
c_{33}	(0.70, 0.22, 0.08)	(0.51, 0.35, 0.14)
c_{41}	(0.90, 0.10, 0.00)	(0.64, 0.25, 0.11)
c_{42}	(0.87, 0.12, 0.01)	(0.60, 0.29, 0.11)
c_{43}	(0.87, 0.12, 0.01)	(0.53, 0.35, 0.12)
c_{44}	(0.40, 0.44, 0.15)	(0.47, 0.37, 0.16)
c_{51}	(0.72, 0.20, 0.08)	(0.51, 0.34, 0.15)
c_{52}	(0.66, 0.24, 0.09)	(0.42, 0.42, 0.16)
c_{53}	(0.85, 0.13, 0.02)	(0.65, 0.24, 0.10)
c_{54}	(0.42, 0.43, 0.15)	(0.37, 0.48, 0.15)
c_{55}	(0.66, 0.24, 0.09)	(0.42, 0.42, 0.16)

TABLE 10. The distances of PIS and NIS for each alternative

A_i	S^+	S^-
A_1	0.673	0.740
A_2	0.715	0.715
A_3	0.984	0.755
A_4	0.922	0.422

TABLE 11. The closeness degree of each alternative and ideal solution

C_i	The closeness degree	Ranking
C_1	0.524	2
C_2	0.500	3
C_3	0.525	1
C_4	0.314	4

quality by taking into account literature and expert opinions. Next, the intuitionistic fuzzy TOPSIS evaluation model is used to select the best airline. This method transforms the original single value in the matrix into an intuitionistic fuzzy set. Moreover, intuitionistic fuzzy set provides more choices in the description of the

TABLE 12. The sum of GRA for each alternative

Alternative	The sum of GRA	Ranking
A_1	10.5738	2
A_2	10.4703	3
A_3	11.2925	1
A_4	7.9445	4

attributes of an object, therefore, it exhibits higher performance when dealing with uncertain information. It can be seen from the instance that the top four with the highest weight values are safety record, convenient check-in, promptness of credentials check and take-off and arriving. These criteria are also valued by passengers. Finally, The final evaluation result is A_3 airline possesses the highest performance based on our evaluation model. Such a result is the same as that obtained in the intuitionistic fuzzy GRA model. Therefore, our evaluation model is practical and feasible.

For the follow-up research, data mining is recommended for study, such as fuzzy rule and fuzzy clustering, which can find out the corresponding advantages and shortcomings. In such a way, it can help to develop methods in improvement for specific problems. As a result, the airline can provide better service to passengers and determine the development of the company's new service products.

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