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Full Length Research Paper

Evaluating the customer perceptions on in-flight service quality

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In the competitive aviation market as a result of the emergence of charter airlines have had to reconsider their in-flight services approach to service provision. Specifically, the in-flight comfort offered based on the service quality perception. However, in-flight service quality is always vague and hard to express in exact number. Therefore, this study applies fuzzy-grey method based to deal with the vagueness and uncertainty. The objective of this study aims to deal with domestic airline in-flight service quality with uncertainty. The study is a key strategic direction of domestic airlines in Taiwan. In general, these considering criteria are self-structured. The results are as follows, (i) the weights of criteria and alternatives are described in linguistic preferences; (ii) using a grey possibility degree to result the ranking order for all alternatives; (iii) an empirical example of in-flight service quality ranking problem in customer perspective.

Key words: Grey theory, triangular fuzzy numbers, in-flight service quality, linguistic preferences.

INTRODUCTION

Airline providing high service quality to passenger is important because competition is ever increasing as airline firms try to acquire and retain customers. Price and service quality are initially used as the primary competitive weapons. Airlines realize that competition on price alone represents a no-win situation in the long term. This implies that airline's competitive advantage based on price alone is not sustainable. Airline's competitive advantage lies in service quality perceived by customers. Due to the rapid growth of alternative transportation in Taiwan, the airlines' management needs to make important efforts for improving their customers' satisfaction. Since passengers probably spend most of their time airborne, the quality of in flight service deserves more attention by the airline. And yet, the evaluation of in-flight service quality in the domestic airline is an on-going process that requires continuous monitoring to maintain high levels of in-flight service quality across a number of different service criteria.

The rapid growth of alternative transportation in Taiwan, the airlines' management needs to make important efforts for improving their customers' satisfaction. Employed fuzzy numbers is an adequate methodology to overcome the ambiguity of concepts that are associated with human being's subjective judgments. When solving real-life service quality problems, linguistic information usually appears as an important output of the process. This information is frankly more difficult to measure throughout a classical mathematical function. In marketing research, most questionnaires use Likert scales to measure respondents' attitude, which is linguistic description. In the past, some statistical methods have been employed to analyze the in the domestic airline industry, using some n-point Likert scale to weight the importance of Different criteria. This research applies the Triangular fuzzy Numbers (TFNs) that has been general applied in the field of management science (Hutchinson, 1998; Xia et al., 2000; Tseng, 2009a).

Prior studies, most of them are explored the airline service quality from a process perspective by first examine the gap between passenger's service expectations and the actual service received, and the gaps associated with passenger service expectations, perceptions of these expectations by frontline manager and employees to identify areas for improvement (Ostrowski et al., 1993; Chang and Yeh, 2002; Gursoy et al., 2005; Pakdil and Aydin, 2007; Liou and Tzeng, 2007). These studies applied traditional statistic approach to form the empirical

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model, none of them is notice the linguistic preferences and uncertain environment or even the evaluation information system might short with the information. Recent study, Balcombe et al. (2009) employed an on-line choice experiment to examine consumer choices with respect to the bundle of in flight service and airline services on offer when deciding to purchase a flight and applied the Bayesian network to reveal that in principle passengers are willing to pay a relatively large amount for enhanced service quality. Therefore, the dilemma of service quality arises from all the prior studies, that is, a hybrid method needs to be proposed to deal with this issue.

In this sense, the evaluation ranking problem in real world systems are very often in uncertainty or lack information. Grey theory is a multidisciplinary theory dealing with multi-criteria systems for which lack information. It is one of the methods that are used to study uncertainty, is superior in theoretical analysis of systems with imprecise information and incomplete samples (Tseng, 2009b). In-flight service quality is measured to assess service performance, diagnose service problems, and manage service delivery (Parasuraman, 1995). The advantage of fuzzy-grey combination is that grey theory considers the condition of the fuzziness and deal flexibly with fuzziness situation (Bellman and Zadeh, 1970; Deng, 1982; Tseng, 2009b; Tseng, 2011). This study is suitable for multi criteria decision making system's more uncertain environment than other approaches. The study objective is to ranking the domestic airlines based on in flight service quality criteria.

LITERATURE REVIEW

The term service quality has been used to explain by the customers evaluated the quality of service, numerous contributions in the literature has attempted to establish which criteria or factors they consider when evaluating service quality. Researchers have been described it into strategic, inter-organization and internal service quality perspective in order to improve firm's competitiveness (Farmer, 1997; Harland et al., 1999; Stanley and Wisner, 2001; Tseng et al., 2009). The study of Grönroos (1984) presents that the perceived quality of a given service will be the result of an evaluation process, where the consumer compares his expectations with his perception of the service received. Grönroos (1993) suggested that measuring customer experiences of service quality is a theoretically valid way of measuring perceived quality. Tsaur et al. (2002) proposed a five dimensional measurement of service quality that includes tangible, reliability, responsiveness, assurance and empathy.

The former is represented by Franceschini and Rossetto (1997) who thought in the first place that the service quality reflected in the satisfaction of customers. Parasuraman et al. (1985) thought that service quality is determined by comparing the quality expected by customers and the actual quality provided by management. They raised the five PZB gap model of service quality, bases on the customer perception more emphasized external clues related to enterprises. The service quality based on the management perception emphasizes the service procedure and in what manner service is provided and their properties include various facets of knowledge and technology such as the intangibility of service, know how, and design of service procedures. This service quality of this kind is considered as the technical quality. Furthermore, the study of Sweeney et al. (1997) and Gronroos (1988, 1990) thought that technical quality can be imitated more easily while the functional quality can focus on the interaction between staff and customers which becomes the comparative advantage of enterprises.

In the passenger airline is difficult to describe and measure the service quality due to its heterogeneity, intangible and inseparability. Quite a few studies devoted to investigate the service quality issues in passenger airline industry. An empirical study by Ostrowski et al. (1993) presents that continuing to provide perceived high quality service would help airline acquire and retain customer loyalty. Hence, to evaluate the in-flight service quality, the basic service quality concept applied in the study.

Airline service quality

An airline would lead the market if they offer superior quality service relatively to their competitors. It is strategic importance for airlines to understand their competitive advantages on service quality. Some recent empirical studies show the different way of approaching to airline service quality. Chang and Yeh (2002) using fuzzy multi-criteria analysis modeling to formulate the service quality of airlines due to the hardness of evaluation approaches. They applied Fuzzy set theory was used to describe the ambiguity between the criteria weight and performance ratings of airlines. Gilbert and Wong (2003) developed 26 attributes model considering reliability, assurance, facilities, employees, flight patterns, customization and responsiveness dimensions to measure and compare the differences in passenger's expectations of desired airlines service quality. Park et al. (2004) developed a conceptual model to understand of air passenger's decision making process, the model considers service expectation, service perception, service value, passenger satisfaction, airline image and behavioral intentions in analysis of Korean international air passengers, the result shows that service value, passenger satisfaction and airline image have direct impact on passenger decision making process.

Moreover, the study of Chen and Chang (2005) examined airline service quality from a process perspective by first examine the gap between passenger's service passenger's service expectations and the actual service received, and the gaps associated with passenger service expectations, perceptions of these expectations by frontline manager and employees. Importance-performance analysis was then used to construct service attribute evaluation map to identify areas for improvement. Gursoy et al. (2005) considered 15 attributes of service quality when explore 10 major US airlines using canonical analysis to further establish a positioning map using the data in the US department of transportation's air travel consumer report. Pakdil and Aydin (2007) measures airline service quality in 8 dimensions which are employees, tangibles, responsiveness, reliability and assurance, flight patterns, availability, image and empathy using factor analysis to present the result that responsiveness and availability are most important dimensions in Turkish airline. Liou and Tzeng (2007) developed a non-additive model for evaluating the service quality of airlines the measurement dimension included employees service, safety and reliability, on board service, schedule, on time performance and free ticket and upgrading using factor analysis, fuzzy integral and grey relation analysis to ranking among the six dimension which is important for the other competitors. Balcombe et al. (2009) examine how charter airlines might differentiate their products and consider the attributes of in-flight cabin comfort and service have a value to consumers by analyzing consumer willingness to pay for in-flight attributes that are derived from an Internet delivered choice experiment. With a survey respondents choose between alternative options that contain a number of attributes of different levels. Few of the literatures focus on the in-flight service quality.

Previous studies on the service quality and encounter the services had the common characteristics. The studies focused on the quality relation model or customer behavior or making verification (Parasuraman et al., 1994; Price et al., 1995; Adelman et al., 1994; King and Garey, 1997; Meuter et al., 2000; Pakdil and Aydin, 2007; Balcombe et al., 2009). Yet, this study discusses the in-flight service quality from the viewpoint of customer perceptions in linguistic preferences. Most of them used statistical and multivariate analyses other than the nonlinear fuzzy neural network model. This model breaks the limitations of the prerequisite of the grey system approach and exerts the fuzzy set theory to the customer perceptions to complete the limitations of prior studies.

For the implication of service quality, this study makes the arguments from the viewpoint of customers' perceptions and to measure in grey system and fuzzy environment. Tseng (2009) combined grey-fuzzy DEMATEL method to present a perception approach to deal with real estate agent service quality expectation ranking with uncertainty. The ranking of best top five real estate agents might be a key strategic direction of other real estate agents prior to service quality expectation. The result of existing studies on service quality suggests that the definitions and perceptions of airline service quality are quite diverse. Those studies imply that service quality criteria are context dependent and should be selected to reflect the business environment investigated. The definition of service quality and its influential characteristics continues to be important research issues. This research is focusing on the in-flight service quality, which is most concerning and stay longer time with the passengers and it is rare to be studied by the previous studies.

METHODS

This section is aimed to operationalize the service quality by developing a multi-item five-point measurement scale to evaluate the different evaluation criteria of in-flight service quality with regard to the domestic airline in Taiwan. To help support scale generalization for in-flight service quality customers, it is important to collect data and survey instrument composition. Using purpose sampling method (α=0.05) a total of 340 customer's responses were obtained. Samples for the study were collected from Airlines customers

Instrument reliability and validity

The questionnaires were tested using reliability and followed by exploratory factor analysis (EFA) (Lai et al., 2002). Initially, this study presents 22 questions to assess the service quality evaluation from difference group, and yet from the item to total and EFA the 15 questions are remained. However, in the survey process, two sets of linguistic terms (very low, low, medium, high, very high) (very poor, poor, fair, good, very good) are used for assessing the service quality of each criteria category respectively. Each respondent is rating of each evaluation criteria by using one of the linguistic terms defined in the corresponding term set. It is important to remark that each of the linguistic terms is linked to some graphical expression of the human face that appears at the beginning of the questionnaire, and that the respondent needs to tick off below one of the expressions of the faces for each evaluation criteria.

To be convinced that the question of this instrument is valid, this research applied the difference scores between perceptions and expectations to EFA of statistical method (Parasuraman et al., 1988, Parasuraman et al. 1991). Similarly, the measurement of difference scores has also been used by some researchers (Teas, 1993, Babakus and Boller, 1992).

Reliability is frequently defined as the degree of consistency of a measurement. Thus, the internal consistency of a set of measurement items refers to the degree to which items in the set are homogeneous. Reliability analysis is a correlation-based procedure. Internal consistency for the five elements was estimated using the reliability coefficient (Cronbach, 1951). Typically, reliability coefficients of 0.60 or higher are considered adequate, with reliability Cronbach's α 0.914. Hair et al. (1998) further stated that permissible alpha values can be slightly lower (0.50) for newer scales. Using SPSS 12.0 reliability scale, an internal consistency analysis was performed separately for each of the model elements shown in Tables 2. The analysis revealed that maximization of the Cronbach's α coefficient would require elimination of items for whole evaluation criteria. Tables 2 shows the revised construct and meet or exceed prevailing standards of reliability for survey instruments. The factor loading ranges from 0.760 to 0.661, total variance extracted 61.1 % and KMO sampling adequacy 0.929, thereby, presenting evidence of convergent validity. Each of the categories did form a "solid" construct, from both theoretical and statistical perspective.

Fuzzy set theory

Fuzzy set theory (Zadeh, 1965) is a mathematical theory designed

Table 1. Factor loading of in-flight service quality of domestic airlines evaluation criteria.

Item	In-flight service quality evaluation criteria Cronbach's α(0.914)	Mean	Factor loading
C1	Clear and precise cabin announcements	3.368	0.760
C2	Cabin safety demonstration	3.364	0.748
C3	Pax guidance and information by cabin crew	3.683	0.723
C4	Cabin crew are proactive	3.618	0.723
C5	Cabin crew are courteous, polite and respectful	3.432	0.717
C6	Cabin crew's ability to handle customer complaints	3.443	0.709
C7	Cabin crew's ability to handle unexpected situations, consistently and dependably	3.394	0.694
C8	Cabin crews are willing and able to provide service in a timely manner	3.408	0.693
C9	Clean and pleasant interior	3.462	0.689
C10	Good cabin equipment conditions	3.358	0.687
C11	Appearance of crew member	3.608	0.684
C12	Speed at In-flight snack service	3.717	0.678
C13	Inspection of passenger's seat belt	3.591	0.674
C14	Seat and space are comfortable	3.585	0.667
C15	In-flight entertainment materials and programs	2.911	0.661
	Total variance explained		61.10%

Table 2. Linguistic scales for the importance weight of criteria

Linguistic variable	Corresponding TFNs($\otimes w$)	
Very low (VL)	(0.0,	0.3)
Low (L)	(0.3,	0.5)
Medium (M)	(0.3,	0.7)
High (H)	(0.5,	0.9)
Very high (VH)	(0.7,	1.0)

This table is the linguistic scale and their corresponding fuzzy numbers defined by Wang and Chang (1995) and used in Chen (2000)

to model the fuzziness of cognitive processes. It is essentially a generalization of set theory, where the classes lack sharp boundaries. The membership function $\mu_A(\mathrm{x})$ of a fuzzy set operates over the range of real numbers on the interval of [0, 1]. An expert's uncertain judgment can be represented by a fuzzy number. A TFN is a fuzzy number with a membership function that is defined by three real numbers (*a, b, c*), where *a*, *b*, and *c* are real numbers and $a \le b \le c$. This membership function is described mathematically below (Tseng et al., 2008; Tseng et al., 2009; Tseng, 2010). In the proposed method, the linguistic preferences used to derive the priorities of the alternatives and the grey numbers used to establish the selection criteria were uncertain. The triangular fuzzy membership function employed in the proposed model is presented as follows (Lin et al., 2007). A fuzzy weighted sum performance matrix (P) was derived for the criteria by multiplying the fuzzy weight vector by the decision matrix.

$$p = \begin{bmatrix} \begin{pmatrix} a_1 & ,b_1 & ,c_1 \\ \dots & \dots & \dots \\ a_n & ,b_n & ,c_n \end{pmatrix} \end{bmatrix} \tag{1}$$

where *n* represents the number of criteria.

Defuzzification was conducted according to the method of Pan (2008); thus, TFN were used to transform the total weighted performance matrices into interval performance matrices, providing α_a and α_c for each criterion:

$$p_\alpha = \begin{bmatrix} \begin{pmatrix} \alpha_{a1} & \alpha_{b1} & ,\alpha_{c1} \\ \dots & \dots & \dots \\ \alpha_{an} & \alpha_{bn} & ,\alpha_{cn} \end{pmatrix} \end{bmatrix} \tag{2}$$

where *n* is the number of criteria.

$$\begin{cases} \alpha_a = \alpha \times (b-a) + a \\ \alpha_c = c - \alpha \times (c-b) \end{cases} \tag{3}$$

The last step of the defuzzification process was to convert interval matrices into crisp values by applying the Lambda function, which represents the attitude of the evaluator. Evaluators with optimistic, moderate and pessimistic attitudes take on maximum, intermediate or minimum Lambda values on the interval [0, 1], respectively:

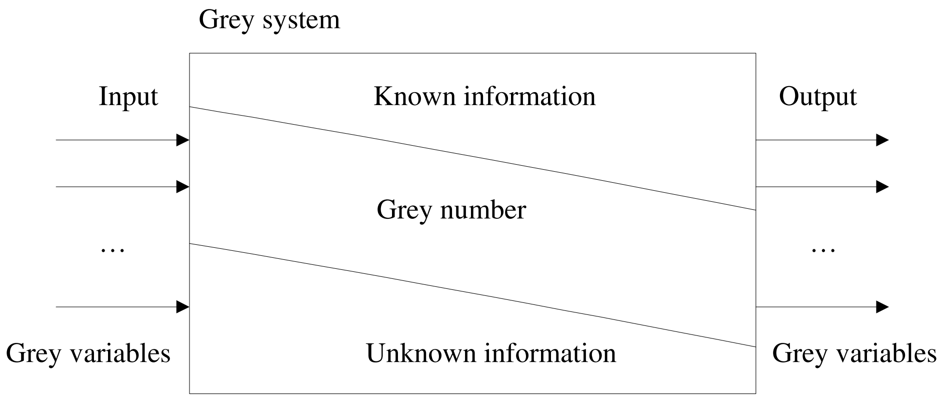

Figure 1. The concept of a grey system.

$$W_j = \begin{pmatrix} W_j^1 \\ W_j^2 \\ \ldots\ldots \\ W_j^k \end{pmatrix} \quad (4)$$

$$W_j = \lambda \times \alpha_c + (1-\lambda) \times \alpha_b$$

where W_j are crisp values corresponding to Lambda, and were normalized to comparable scales.

Grey theory

Grey theory is proposed by Deng (1982), is a mathematical theory born out of the grey set. It is an effective method used to solve uncertainty problems with discrete data. In this research, we apply basic definitions of grey systems with TFNs, grey set and grey number in grey theory (Zhang et al., 2005, Chen and Tzeng, 2004). The concept of a grey system is shown in Figure 1.

A grey system is shown as a system containing uncertain information presented by a grey number and grey variables, shown in Figure 1. Let X be the universal set. Then a grey set G of X is defined by its two mappings $\overline{\mu}_G(x)$ and $\underline{\mu}_G(x)$.

$$\begin{cases} \overline{\mu}_G(x): x \to [0,1] \\ \underline{\mu}_G(x): x \to [0,1] \end{cases} \quad (5)$$

$\overline{\mu}_G(x) \geq \underline{\mu}_G(x), x \in X, X = R, \overline{\mu}_G(x)$ and $\underline{\mu}_G(x)$ are the upper and lower membership functions in G respectively. When $\overline{\mu}_G(x) = \underline{\mu}_G(x)$, the grey set G becomes a fuzzy set. It shows the grey theory considers the condition of the fuzziness and can deal flexibly with the fuzziness situation. The grey number can be defined as a number with uncertain information. For example, the rating of attributes are described by the TFNs, there will be a numerical interval expressing it. This numerical interval will contain uncertain information, the grey number is as $\otimes G, (\otimes G = G\big|_{\underline{\mu}}^{\overline{\mu}})$.

The lower and upper limit of G can be possibly estimated and G is defined as a lower limit grey number.

$$\begin{cases} \otimes G = [\underline{G}, \infty) \\ \otimes G = (-\infty, \overline{G}] \end{cases} \begin{cases} \otimes G = [\underline{G}, \infty) \\ \otimes G = (-\infty, \overline{G}] \end{cases} \quad (6)$$

The lower and upper limits of G can be estimated and G is defined as an interval grey number

$$\otimes G = [\underline{G}, \overline{G}] \quad (7)$$

Grey number operation is an operation defined on sets of intervals, rather than real numbers. This research cited the basic operation laws of grey numbers. $\otimes G = [\underline{G}_1, \overline{G}_1]$ and $\otimes G = [\underline{G}_2, \overline{G}_2]$, on intervals where the four basic grey number operations on the interval are the exact range of the corresponding real operation. In this research only apply the proofs of addition and subtraction formulas.

$$\begin{cases} \otimes G_1 + \otimes G_2 = [\underline{G}_1 + \underline{G}_2, \overline{G}_1 + \overline{G}_2] \\ \otimes G_1 - \otimes G_2 = [\underline{G}_1 - \underline{G}_2, \overline{G}_1 - \overline{G}_2] \end{cases} \quad (8)$$

The length of grey number $\otimes G$ is defined as

$$\text{L}(\otimes G) = [\underline{G} - \overline{G}] \quad (9)$$

For the two grey numbers $\otimes G_1 = [\underline{G}_1, \overline{G}_1]$ and $\otimes G_2 = [\underline{G}_2, \overline{G}_2]$, the possible degree of $\otimes G_1 \leq \otimes G_2$ can expressed as follows

$$P\{\otimes G_1 \leq \otimes G_2\} = \frac{\max(0, L^* - \max(0, \overline{G}_1 - \underline{G}_2)}{L^*} \quad (10)$$

where $L^* = L(\otimes G_1) + L(\otimes G_2)$.

The positive relationship between $\otimes G_1$ and $\otimes G_2$ is determined as

Table 3. Linguistic scales for the importance weight of alternative.

Linguistic variable	Corresponding TFNs $(\otimes G)$
Very poor (VP)	(0,3)
Poor (P)	(1,5)
Fair (F)	(3,7)
Good (G)	(5,9)
Very good (VG)	(7,10)

This table is the linguistic scale and their corresponding fuzzy numbers defined by Wang and Chang (1995) and used in Chen (2000).

follows:

1. If $\underline{G_1} = \underline{G_2}$ and $\overline{G_1} = \overline{G_2}$, that $\otimes G_1 = \otimes G_2$, then $P\{\otimes G_1 \le \otimes G_2\}$ =0.5
2. If $\underline{G_2} > \overline{G_1}$, that $\otimes G_2 > \otimes G_1$, then $P\{\otimes G_1 \le \otimes G_2\}$ =1
3. If $\overline{G_2} < \underline{G_1}$ and $\overline{G_1} > \overline{G_2}$, that $\otimes G_2 < \otimes G_1$, then $P\{\otimes G_1 \le \otimes G_2\}$ =0
4. If there is an intercrossing part in them, when $P\{\otimes G_1 \le \otimes G_2\}$ > 0.5, that is $\otimes G_2 > \otimes G_1$. When $P\{\otimes G_1 \le \otimes G_2\}$ < 0.5, that is $\otimes G_2 < \otimes G_1$

Research approach

Grey- fuzzy approach bases on a grey possibility degree is proposed for ordering the preference of in flight service quality domestic airlines ranking. This approach is for ranking the decision making problem in uncertainty. Assume that A = {A_1, A_2, …. A_m} is a discrete set of m domestic airline alternatives. C = {C_1, C_2,….C_n}is a set of n criteria of possible alternatives. The criteria are additively independent $\otimes w = \{\otimes w_1, \otimes w_2, \ldots\ldots\ldots, \otimes w_n\}$ is the vector of criteria weights. In this research, the criteria weights and ratings of alternatives are considered as number scale, the number scale, criteria weights, can be expressed in fuzzy numbers by the TFNs scale, shown in Table 2. The criteria ratings $\otimes G$ can also be expressed in fuzzy numbers by TFNs scale, shown in Table 3. And build the expert opinions with TFNs following Equation.(5). The procedures are summarized as follows:

Step 1: Defuzzified the linguistic preferences uses Equation (1) to (4). A sampling group of customer identified the criteria weights of airlines. Assume that a decision group has K sampling customers, the criteria weights w_j can be calculated as

$$\otimes w_j = \frac{1}{K}\left[\otimes w_j^1 + \otimes w_j^2 + \ldots\ldots + \otimes w_j^k\right] \quad (11)$$

Where $\otimes w_j^k \, (j = 1,2,\ldots\ldots\ldots n)$ is the criteria weight of Kth experts and can be described by grey number $\otimes w_j^k = [\underline{w}_j^k, \overline{w}_j^k]$

Step 2: Use TFNs for the rating to make a criteria rating value. The rating value can be calculated as:

$$\otimes G_{ij} = \frac{1}{K}\left[\otimes G_{ij}^1 + \otimes G_{ij}^2 + \ldots\ldots + \otimes G_{ij}^k\right] \quad (12)$$

Where $\otimes G_{ij}^k (i = 1,2,\ldots.m; \; j = 1,2,\ldots\ldots\ldots n)$ is the criteria weight of Kth experts and can be described by grey number $\otimes G_j^k = [\underline{G}_j^k, \overline{G}_j^k]$

Step 3: Establish the grey decision matrix

$$D = \begin{bmatrix} \otimes G_{11} & \otimes G_{12} & .. & .. & \otimes G_{1n} \\ \otimes G_{21} & \otimes G_{22} & .. & .. & \otimes G_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \otimes G_{m1} & \otimes G_{m2} & .. & .. & \otimes G_{mn} \end{bmatrix} \quad (13)$$

Where, $\otimes G_{ij}$ are TFNs based in the grey number.

Step 4: Normalized the grey decision matrix

$$D^* = \begin{bmatrix} \otimes G^*_{11} & \otimes G^*_{12} & .. & .. & \otimes G^*_{1n} \\ \otimes G^*_{21} & \otimes G^*_{22} & .. & .. & \otimes G^*_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \otimes G^*_{m1} & \otimes G^*_{m2} & .. & .. & \otimes G^*_{mn} \end{bmatrix} \quad (14)$$

Where, for a benefit criteria, $\otimes G_{ij}^*$ is expressed as

$$\otimes G_{ij}^* = \left[\frac{\underline{G}_{ij}}{G_j^{\max}}, \frac{\overline{G}_{ij}}{G_j^{\max}}\right] \quad (15)$$

$G_j^{\max} = \max_{1 \le i \le m}\{\overline{G}_{ij}\}$ for a criteria, $\otimes G_{ij}^*$ is expressed as

$$\otimes G_{ij}^{*} = \left[\frac{G_j^{\min}}{\overline{G}_{ij}}, \frac{G_j^{\min}}{\underline{G}_{ij}} \right] \quad (16)$$

$G_j^{\min} = \min_{1 \le i \le m} \{\underline{G}_{ij}\}$ The normalization is to preserve the property that the ranges of the normalized grey number belong to [0, 1]

Step 5: Establish the weighted normalized grey decision matrix. Considering the different importance of each criteria, the weighted normalized grey decision matrix can be established as

$$D^{*} = \begin{bmatrix} \otimes V_{11} & \otimes V_{12} & .. & .. & \otimes V_{1n} \\ \otimes V_{21} & \otimes V_{22} & .. & .. & \otimes V_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \otimes V_{m1} & \otimes V_{m2} & .. & .. & \otimes V_{mn} \end{bmatrix} \quad (17)$$

Where, $\otimes V_{ij} = \otimes G_{ij}^{*} \times \otimes w_j$

Step 6: Make the ideal alternative as a referential alternative. For m possible alternatives set A = {A_1, A_2,…., A_m} the ideal referential domestic airline alternative $A^{\max} = \{\otimes G_1^{\max}, \otimes G_2^{\max}, ... \otimes G_n^{\max},\}$ can be obtained by:

$$A^{\max} = \left\{ \left[\max_{1 \le i \le m} \underline{V_{i1}},\ \max_{1 \le i \le m} \overline{V_{i1}} \right], \left[\max_{1 \le i \le m} \underline{V_{i2}},\ \max_{1 \le i \le m} \overline{V_{i2}} \right], ... \left[\max_{1 \le i \le m} \underline{V_{in}},\ \max_{1 \le i \le m} \overline{V_{in}} \right] \right\} \quad (18)$$

Step 7: Calculate the grey possibility degree between compared domestic airline alternatives set A = {A_1, A_2, …. A_m} and ideal airline alternative A^{max}.

$$P\left\{ A_i \le A^{\max} \right\} = \frac{1}{n} \sum_{j=1}^{n} p\left\{ \otimes V_{ij} \le \otimes G_j^{\max} \right\} \quad (19)$$

Step 8: Rank the order for domestic airline alternatives. When $P\{ A_i \le A^{\max} \}$ is smaller, the ranking order of A_i is better. Or, the ranking order is worse. According to described procedures, this research is able to determine the ranking order of all domestic airline alternatives and select the best from domestic airlines.

RESULTS

An approach based on a grey possibility degree is proposed for ordering the preference of airline by customer perception. This method is very suitable for solving this solving this assess problem in an uncertain environment There are five alternatives A_i (i = 1,2,…5) against fifteen criteria C_j (j = 1,2,3….15) which are five domestic airlines. The fifteen criteria are show in Table 1. The criteria are additively independent. $\otimes w = \{\otimes w_1, \otimes w_1, \otimes w_1 .... \otimes w_n\}$ is the vector of criteria weights. This research, the criteria weights and rating of alternatives are considered as linguistics variables. Here, these linguistic variables can be expressed in grey numbers by 5 point scale. The criteria rating $\otimes G$ can also be expressed in five point scale as well. The computational procedures are summarized as follows:

1. Step 1- Make the weights of criteria C_j (j = 1,2,3….,15). 340 sampling respondents has been formed to express their preferences and to select their best domestic airline. From Equation (11), the evaluation criteria weights can be obtained and results are summarized and shown in Table.
2. Step 2- Make criteria rating values for five alternatives. According to Equation (12), the results of criteria rating values are shown in Table 5.
3. Step 3- Follows Equation (13) the grey decision matrix of alternatives can be obtained
4. Step 4- Follows Equations (14) the normalized grey decision matrix can be obtained. The grey normalized decision table is shown Table 6.
5. Step 5- Follows Equations (16) and (17) the weighted normalized grey decision matrix can be obtained. For example, the grey number (0.245, 0.785) of alternative A1, where 0.245 = 0.350 x 0.700 and 0.785 = 0.255 x 0.325
6. Step 6- Make the ideal alternative A^{max} a referential alternative following Equation. (18), the ideal alternative A^{max} .
7. Step 7- Calculate the grey possibility degree between the compared alternative of 5 domestic airlines A_i (i= 1,2,3,4,5) and the ideal referential alternative A^{max}. According to Equation.(10) and (19), the results of the grey possibility degree are shown as follows:

$P(A_1 \leqq A^{max}) = 0.586$; $P(A_2 \leqq A^{max}) = 0.575$; $P(A_3 \leqq A^{max}) = 0.557$; $P(A_4 \leqq A^{max}) = 0.525$; $P(A_5 \leqq A^{max}) = 0.508$

Step 8: Rank the order of five alternative airlines A_i (i= 1, 2, 3, 4, 5). According to step 7, the result of ranking order as shown as follows:

$A_5 > A_3 > A_4 > A_2 > A_1$

This research can identify Airline 5 is the best domestic airline out of five. Airline 5 should be best alternative from the customer perception. The next alternative is A_3, due to the fuzzy-grey possibility, degree of A_5 and A_3 against the ideal A^{max} are most equal.

Conclusions

The competition of domestic airline market is very intensive

Table 4. Criteria weights for 5 alternatives.

C_j	D_1	D_2	…..	D_{340}	$\otimes wj$	$\otimes w^* j$
C1	H	H	…..	M	[0.520,0.800]	[0.456,0.820]
C2	H	VH	…..	H	[0.425,0.845]	[0.475,0.825]
C3	M	M	…..	M	[0.3750,0.750]	[0.432,0.738]
C4	M	H	…..	L	[0.425,0.800]	[0.445,0.835]
C5	H	VH	…..	VH	[0.600,0.925]	[0.525,0.910]
C6	M	H	…..	H	[0.500,0.887]	[0.555,0.875]
C7	H	H	…..	H	[0.600,0.950]	[0.635,0.975]
C8	H	VH	…..	H	[0.445,0.875]	[0.430,0.835]
C9	H	H	…..	H	[0.550,0.825]	[0.506,0.911]
C10	H	H	…..	H	[0.575,0.875]	[0.481,0.875]
C11	M	VH	…..	VH	[0.450,0.750]	[0.450,0.757]
C12	M	H	…..	H	[0.575,0.975]	[0.465,0.886]
C13	H	H	…..	M	[0.475,0.675]	[0.375,0.785]
C14	M	M	…..	M	[0.425,0.740]	[0.425,0.759]
C15	H	VH	…..	VH	[0.675,0.958]	[0.685,1.000]

intensive. The airlines must realize the key point of passenger service quality and read the customer's mind in fuzzy-grey environment. To help airlines understand the importance of customer-driven of in-flight service quality, this study developed the measurement instrument adopted the purposing sampling method from all the passengers of domestic airlines, tested in validity and reliability scale for further presenting that the measurement is solid constructed.

In real situations ranking judgments are often uncertain and can not be estimated by an exact numerical value. The problem of justify the best domestic airline based on certain criteria has many uncertainties and becomes more difficult. This research applied different perspective and look from a different angle at a real grey fuzzy world. The advantage of grey-fuzzy combination is that grey theory considers the condition of the fuzziness and deal flexibly with fuzziness situation. The rating of criteria are described by linguistic information that can be re-solved by TFNs, therefore airline ranking can be viewed as a fuzzy-grey process. The empirical result of domestic airline in Taiwan is presented the best airline; the result might be other airlines' strategic benchmark in terms of in flight service quality.

The framework can be used to evaluate the impact of various multi-selection activities and can provide a monitoring and establishing evaluation platforms for customers in the perception choices and the result provides the guideline for airline firms to improve the service quality. In previous studies, the airline firm's in-flight service quality was highly variable; however, a clear link to the customer decision was not observed in the past studies. Indeed, the analyses presented in previous studies were based on only a traditional statistic approach and single variable models were not sufficient at explaining the in-flight service quality in imprecise and incomplete information. These results indicate that in-flight service quality is a multi-criteria concept based on customer perceptions. When evaluating the impact of an airline firm's in-flight service quality activities, the overall enhancement in structural and infra-structural and its effect on the organization must be considered.

By examining the 15 criteria, the proposed framework allows the management and researchers to better understand the differences in operations, activities and specific management interventions. The framework allows the customer to evaluate in-flight management practices. For example, in Step 8, a value is placed on the overall importance of the evaluator's perception to the five alternatives. The proposed criteria were analyzed by the customers. To achieve the customer needs, the management should understand the in-flight service quality evaluation, including the presence of linguistic preferences and incomplete information.

This study proved that the management must be aware that the service quality is not just a black box. That evaluation framework should capture a fairly complete picture of the proposed criteria. In other words, managers may find that the proposed framework for the assessment of in-flight service quality criteria is a useful method for reviewing and improving strategic development plans and performance evaluations of airline firms, which may lead to enhanced productivity and competitive advantage.

The model developed in this study provides an overview of airline firm's improving implied in the presence of incomplete information and vagueness

Table 5. Criteria rating value for alternatives.

C_i	A_i	D_1	D_2	…..	D_{340}	$\otimes Gij$
C1	A1	G	G	…..	F	[5.35,7.25]
	A2	G	G	…..	G	[5.25,8.50]
	A3	G	G	…..	G	[5.30,9.25]
	A4	F	G	…..	G	[4.85,8.75]
	A5	G	G	…..	G	[4.20,8.00]
C2	A1	G	F	…..	F	[4.75,8.25]
	A2	G	G	…..	F	[4.50,8.00]
	A3	VG	G	…..	VG	[6.75,9.75]
	A4	G	G	…..	P	[4.45,8.12]
	A5	F	G	…..	G	[3.55,7.50]
C3	A1	G	F	…..	F	[3.75,7.75]
	A2	G	F	…..	F	[4.75,8.35]
	A3	F	F	…..	F	[3.25,7.55]
	A4	G	F	…..	F	[3.50,7.45]
	A5	G	G	…..	M	[6.55,9.37]
C4	A1	G	G	…..	F	[3.25,7.56]
	A2	G	G	…..	P	[3.25,8.25]
	A3	G	G	…..	P	[4.50,8.50]
	A4	F	G	…..	P	[4.25,8.25]
	A5	G	G	…..	G	[4.75,6.75]
C5	A1	F	G	…..	F	[3.50,7.50]
	A2	F	P	…..	P	[1.75,5.75]
	A3	G	G	…..	F	[4.75,8.62]
	A4	F	G	…..	F	[3.50,7.50]
	A5	P	F	…..	VG	[4.25,7.00]
…..	…..	…..	…..	…..	…..	…..
…..	…..	…..	…..	…..	…..	…..
…..	…..	…..	…..	…..	…..	…..
C15	A1	G	G	…..	G	[4.00,7.50]
	A2	VG	G	…..	P	[6.00,8.77]
	A3	G	G	…..	F	[6.00,8.50]
	A4	G	F	…..	G	[4.25,8.25]
	A5	G	G		F	[6.00,8.70]

information. Moreover, firms can better understand the evaluation criteria of in-flight service quality by applying the proposed model. The methodology outlined in this study is particularly useful for the evaluation in the presence of linguistic preferences and incomplete information. To apply the proposed methodology, the evaluator must remove irrelevant criteria and include criteria that are applicable to their firm. Thus, an airline firm can be based on many different types of criteria and can be modified and refined as necessary.

As knowledge takes on an important strategic role in enhancing the in-flight service quality performance, the airline firms are expected the proposed criteria to be performed effectively and efficiently and transfer into airline firm's competitive advantages in uncertainty. This suitable approach can deal with many criteria interactive problems in uncertainty systematically, unlike traditional statistic approaches which always applied independence assumption. In order to promote and deepen continuing research in future, it is worthwhile to investigate more

Table 6. Grey normalized decision.

	C1	C2	C3	C4	C5	C6	C7	C8
A1	[0.525, 0.838]	[0.425, 0.758]	[0.435, 0.785]	[0.487, 0.873]	[0.313, 0.853]	[0.353, 0.844]	[0.406, 0.780]	[0.575, 1.000]
A2	[0.556, 1.000]	[0.410, 0.821]	[0.427, 0.853]	[0.419, 1.000]	[0.344, 0.844]	[0.353, 0.824]	[0.203, 0.767]	[0.435, 0.971]
A3	[0.556, 0.825]	[0.667, 1.000]	[0.320, 0.747]	[0.452, 0.968]	[0.350, 0.844]	[0.555, 0.971]	[0.451, 1.000]	[0.455, 1.000]
A4	[0.535, 0.972]	[0.436, 0.833]	[0.347, 0.773]	[0.419, 0.935]	[0.375, 1.000]	[0.529, 1.000]	[0.406, 0.870]	[0.485, 1.000]
A5	[0.525, 0.889]	[0.455, 0.769]	[0.655, 1.000]	[0.574, 1.000]	[0.535, 1.000]	[0.529, 1.000]	[0.493, 0.928]	[0.535, 0.971]

	C9	C10	C11	C12	C13	C14	C15
A1	[0.529, [0.529,	[0.475, 0.722]	[0.558, 1.000]	[0.443, 0.845]	[0.558, 0.944]	[0.529, 1.000]	[0.421, 0.842]
A2	[0.471, [0.471,	[0.361, 0.778]	[0.343, 0.778]	[0.429, 0.886]	[0.478, 0.722]	[0.285, 0.735]	[0.526, 0.934]
A3	[0.372, [0.372,	[0.378, 0.722]	[0.487, 0.861]	[0.371, 0.829]	[0.361, 0.778]	[0.324, 0.794]	[0.632, 1.000]
A4	[0.441, [0.441,	[0.675, 1.000]	[0.454, 0.889]	[0.543, 1.000]	[0.378, 0.722]	[0.375, 0.794]	[0.457, 0.868]
A5	[0.595, [0.595,	[0.585, 0.944]	[0.556, 0.972]	[0.429, 0.886]	[0.611, 1.000]	[0.324, 0.794]	[0.526, 0.947]

Table 7. Grey weighted normalized decision table.

	C1	C2	C3	C4	C5	C6	C7	C8
A1	[0.245, 0.743]	[0.199, 0.718]	[0.132, 0.687]	[0.157, 0.782]	[0.590, 0.782]	[0.254, 0.692]	[0.236, 0.815]	[0.268, 0.899]
A2	[0.275 , 0.810]	[0.187, 0.696]	[0.140, 0.626]	[0.170, 0.758]	[0.209, 0.812]	[0.214, 0.792]	[0.188, 0.624]	[0.288, 0.872]
A3	[0.265, 0.850]	[0.375, 0.848]	[0.105, 0.548]	[0.183, 0.744]	[0.209, 0.812]	[0.374, 0.934]	[0.321, 0.937]	[0.758, 0.899]
A4	[0.245, 0.788]	[0.225, 0.707]	[0.114, 0.568]	[0.170, 0.758]	[0.209, 0.812]	[0.352, 0.962]	[0.236, 0.815]	[0.523, 0.819]
A5	[0.187, 0.720]	[0.174, 0.652]	[0.202, 0.734]	[0.196, 0.810]	[0.304, 0.962]	[0.322, 0.962]	[0.287, 0.869]	[0.653, 0.872]

	C9	C10	C11	C12	C13	C14	C15
A1	[0.228, 0.806]	[0.269, 0.675]	[0.338, 0.952]	[0.208, 0.770]	[0.351, 0.909]	[0.322, 0.962]	[0.256, 0.850]
A2	[0.275, 0.905]	[0.219, 0.648]	[0.283, 0.748]	[0.270, 0.842]	[0.249, 0.695]	[0.161, 0.707]	[0.320, 0.779]
A3	[0.255, 0.821]	[0.542, 0.895]	[0.253, 0.888]	[0.266, 0.797]	[0.289, 0.748]	[0.197, 0.784]	[0.384, 0.962]
A4	[0.286, 0.877]	[0.371, 0.962]	[0.270, 0.865]	[0.330, 0.962]	[0.169, 0.695]	[0.197, 0.764]	[0.272, 0.835]
A5	[0.375, 0.962]	[0.304, 0.909]	[0.338, 0.975]	[0.260, 0.852]	[0.371, 0.962]	[0.197, 0.824]	[0.320, 0.911]

studies to hybrid the two methods together. This hybrid approach is a relatively new approach to justify the linguistic preference and incomplete information together.

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