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Integrating Fuzzy Integral with Multinomial Logit model to Evaluate the Effects of Service quality on Traveling Airline Choice

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Abstract: This study aims to investigate the impact of service quality on traveling airline choice by integrating the Multinomial Logit model and fuzzy integral. Linguistic variables which could deal with the ambiguity of service quality are used to measure the scores and weights of evaluating criterion. Four types of fuzzy membership functions are designed to reflect the heterogeneity of linguistic scales across individuals. Fuzzy integral and measure are employed to conduct with the dependencies of criteria in calculating the constructs of service quality. Then these quantitative constructs are specified into Multinomial Logit model to investigate their influences in choosing airlines. The empirical study is focused on the airline choice behavior of four domestic airlines in Taiwan. The results reveal that the proposed method can effectively process the fuzziness of the criteria and the non-additive of weights and even significantly enhance the explanatory and predictive powers of the discrete choice model. In addition, schedule and premium is the most critical factor among the three service quality constructs influencing airline choice behavior. In the marketing strategy, F-airline and U-airline should focus on the business travelers while T airline should adopt the discount strategy to those price-sensitivity travelers.

Key words: Criteria dependence, fuzzy measure, discrete choice model, qualitative factor, domestic airline

INTRODUCTION

The discrete choice model is frequently used to investigate travelers' choice behavior, while the multinomial logit (MNL) model, because of its convenient estimation feature, has been extensively applied in transportation (Roman *et al*., 2007; Tsai *et al*., 2007; Hess, 2010) and marketing (Tseng and Yu, 2005; Sands *et al*., 2009; Dong *et al*., 2010). Mode attributes, such as travel time, travel cost and frequency, are important factors that travelers may consider in the process of mode choice. These variables can usually be easily presented quantitatively in crisp scale. However, except for those above quantifiable factors, travelers' perceptions with service quality should also be definitely considered in choosing transport operators or service class under the same transport mode. Travelers' perceptions of service quality are usually based on their subjective valuation, which can hardly be quantified and measured. In addition, for the choice of operators or service class under the same transport mode, the importance of mode attributes would be lower, but travelers' perceptions of service quality would become relatively more important (Chang and Yeh, 2002; Tsaur *et al*., 2002; Park *et al*., 2004; Balcombe *et al*., 2009. Thus, it is an important issue that how to convert qualitative factor into measurable scale and specify it accurately into the MNL model.

The measurement of service quality begins with the evaluation of each criterion. By calculating the sum of weighted scores, the score of each construct (common criteria) can be determined. Then the score of each construct is used to evaluate the overall performance of alternatives. Most conventional weighting methods assume that the relationships between criteria are independent. However, such an assumption may be controversial in the evaluation of service quality (Tseng and Chiu, 2005; Liou and Tzeng, 2007; Shieh *et al*., 2010). For instance, when travelers evaluate an airline company's image and reputation, they would take into account the aviation safety of the company. It is obvious that the two criteria, image and reputation and aviation safety, are correlated to a certain degree. As to the dependencies of constructs or criteria, constructs tend to be more independent, but criteria under a certain construct may be interdependent. If such a phenomenon is ignored and the weighting method that assumes criteria independence is used, then the result is not comply with the additive hypothesis (Tanaka and Sugeno, 1991) and causes a biased calculation of constructs. Hence, the purpose of this study is to develop an appropriately weighing method as criteria dependencies are in place.

Fuzzy Integral (Ishii and Sugeno, 1985; Onisawa *et al*., 1986) is frequently used to conduct with the case of criteria interdependence in evaluating service quality for a finite alternative set. The concept of Fuzzy Integral has been extensively applied to research on Multiple Criteria Decision Making (MCDM) (Grabisch, 1995, Labreuche and Grabisch, 2003). The applicable domains include performance evaluation (Lee *et al*., 2001; Tzeng *et al*., 2005), service quality evaluation (Chen and Tzeng, 2001; Chen *et al*., 2006; Tsai and Lu, 2006; Liou and Tzeng, 2007) and alternative choice problem (Tseng and Chiu, 2005; Tseng and Yu, 2005; Yang *et al*., 2008; Tseng *et al*., 2009). A few studies attempt to integrate the Fuzzy Integral and the MNL model to create the Fuzzy Integral Multinomial Logic (FIMNL) model (Tseng and Chiu, 2005; Tseng and Yu, 2005). This model is developed to deal with the interdependence of evaluating criteria and specifies these quantified common construct into the discrete choice model. However, due to the ambiguity and fuzziness of service quality, the evaluation should be based on travelers' actual perceptions, not the results of laboratory scenario while most previous studies used this method to measure service quality. Hence, this study adopts the revealed preference method to measure travelers' perceptions with more reality.

In addition, previous studies usually adopted the researcher's subjective assumption on the setting of intervals in membership function. Such method would unify all the fuzzy linguistic transformation functions. In other words, those studies which used a single membership function to represent all respondents may ignore individual heterogeneity on evaluating scale and lead to biased inference. Hence, this study designed four types of fuzzy membership functions to be selected by each traveler. This way can reflect the heterogeneity of linguistic scales across individuals.

MATERIALS AND METHODS

For clarity the whole research process, the investigating issues and applied methods are explained as follows and Fig. 1. By considering the ambiguity of service quality, linguistic variables are used to score each criterion for alternatives. For the dependencies of criteria, the Fuzzy Integral is applied to weight each criterion. Later, four membership functions are adopted to calculate the constructs of service quality and reflect the heterogeneity of linguistic scales across travelers. Finally, the FIMNL model is used to construct a traveler's choice model. Those mentioned points in the whole research process are shown as Fig. 1 to reveal the significance of this paper prior to literature. The explanation, design and construction of the research methods are explained completely as following.

Fuzzy linguistic evaluation: Considering the fuzziness of airline service quality evaluation, this study adopts five linguistic variables to assess service quality: including very dissatisfied (VDS), dissatisfied (DS), moderate (MOD), satisfied (S) and very satisfied (VS). Each criterion is scored based on the travelers' flight experiences. Moreover, the same linguistic expressions (satisfied is replaced by weight) are used to measure the importance of each criterion (Chen, 2000; Chien and Tsai, 2000; Chen *et al*., 2006; Tsai and Lu, 2006).

For convenience in computation, a triangular membership function (Hua, 2007; Amiri *et al*., 2009) is used as the transformation function of fuzzy number. In the setting of intervals in membership function, previous studies usually adopted the researcher's subjective assumption. Such a method would unify all the fuzzy linguistic transformation functions. In other words, all participants were supposed to have the same fuzzy scale on the linguistic ranks. Such an assumption was obviously inappropriate. For instance, each participant may have different fuzzy number for the same linguistic rank. Within a range of 0-10 for a triangular membership function, lenient participants may provide 8-10 points for VS, but strict ones may give only 5-8 points for the same linguistic rank. This result indicates that the fuzzy number of linguistic membership function is diverse across individual decision makers.

Since, the diversity of fuzzy number across each individual, four membership functions are designed into the questionnaire in advance. Each participant could select a type of membership function that is more

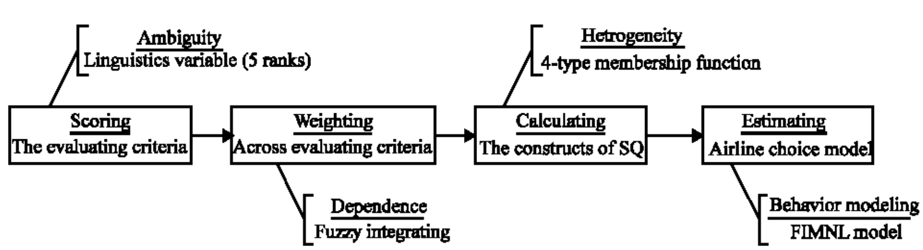

Fig. 1: Research method and procedure

Table 1: The four membership functions

Type	Range	[VDS, DS, Mod, S, VS]	Tendency of evaluation
Average	[0,10]	[(0,1,2), (1,2.5,4), (3,5,7),(6,7.5,9), (8,9,10)]	Average
Left-oriented	[0,8]	[(0,1.5,3), (2,3,4), (3,4,5), (4,5,6), (5,6.5,8)]	More strict
Right-oriented	[2,10]	[(2,3.5,5), (4,5,6), (5,6,7), (6,7,8), (7,8.5,10)]	More lenient
Concentrated	[2,8]	[(2,3,4), (3,4,5), (4,5,6), (5,6,7), (6,7,8)]	More concentrated

compliant with personal linguistic scale. This approach considers the scale heterogeneity of fuzzy membership function across individuals and avoids the difficulty to ask each participant to illustrate his or her fuzzy number of linguistic scale. The four membership functions constitute an average type, left-oriented type, right-oriented type and concentrated type. Each individual is required to select a membership function according to his or her subjective perceptions. The funny numbers of each membership function are shown in Table 1.

Fuzzy measure and fuzzy integral: Earlier studies usually assumed that criteria are independent. In this study, Fuzzy Integral is adopted to conduct with the case of criteria interdependence. The theory and calculation procedure for the Fuzzy Integral are explained as follows.

Fuzzy measure is used to measure the membership degree of an object's belonging to a candidate set. In a crisp set, it is usually binomial, which implies that an element is either set 1 or set 0. Fuzzy measure is a function of a certain set; therefore, it is known as a set function. A set function has the following feature (Ishii and Sugeno, 1985; Murofushi and Sugeno, 1989). Let, X be a universal set and fuzzy measure can be defined as follows:

$$g : GP(X) \to [0,1] \tag{1}$$

In the above formula, P(X) is the power set. The function g then maps every subset $A \in P(X)$ in the interval [0,1]. The term g(A) represents the evidence or reliability that a known element in X belongs to the subset A. The subset with the highest mapped value indicates that such an element is most likely to fall within this subset.

The λ-Fuzzy measure proposed by Sugeno (1974) (also called Sugeno measure) is applied most extensively. The additivity of λ-Fuzzy measure is described by a parameter λ; thus, λ-Fuzzy measure is a measure confined to the value of λ. A λ-Fuzzy measure (g_i) satisfies the following conditions (Keon-Myung and Hyung, 1995; Chen and Tzeng, 2001):

$$\begin{aligned} &\forall A, B \in P(x),\ A \cap B = \phi \\ &g_\lambda(A \cup B) = g_\lambda(A) + g_\lambda(B) + \lambda g_\lambda(A) g_\lambda(B), \text{ for } \lambda > 1 \end{aligned} \tag{2}$$

If a Fuzzy measure satisfies the additivity of λ, it can be called a λ-Fuzzy measure.

In the case of λ-Fuzzy measure for a finite set $X = \{x_1, x_2, \ldots, x_n\}$ fuzzy density $g_i = g_\lambda(\{x_i\})$ can be expressed as follows:

$$\begin{aligned} g(X_n) &= g(\{x_1, x_2, \ldots, x_n\}) \\ &= \sum_{i=1}^{n} g_i + \lambda \sum_{i_1=1}^{n-1} \sum_{i_2=i_1+1}^{n} g_{i_1} g_{i_2} + \ldots + \lambda^{n-1} g_1 g_2 \ldots g_n \\ &= \frac{1}{\lambda}\left[\prod_{i=1}^{n}(1 + \lambda g_i) - 1\right] \end{aligned} \tag{3}$$

In Fuzzy Integral, the Choquet integral is more commonly used. The non-additive property of multi-attributes can be conducted with the Fuzzy Integral. Suppose, without loss of generality, that the function $f(x_i)$ is monotonically decreasing, i.e., $f(x_1) \ge f(x_2) \ge \ldots \ge f(x_n)$ it denotes the normalized evaluating value of the *i*th attribute. Then the fuzzy integral of fuzzy measure $f(\bullet)$ with respect to $g(\bullet)$ can be defined as follows (Ishii and Sugeno, 1985; Tseng and Yu, 2005):

$$\begin{aligned} (C)\int f dg &= f(x_n) g(H_n) + [f(x_{n-1}) - f(x_n)] \times g(H_{n-1}) + \ldots + [f(x_1) - f(x_2)] g(H_1) \\ &= f(x_n)[g(H_n) - g(H_{n-1})] + f(x_{n-1})[g(H_{n-1}) - g(H_{n-2})] + \ldots + f(x_1) g(H_1) \end{aligned} \tag{4}$$

where,

$$H_1 = \{x_1\}, H_2 = \{x_1, x_2\}, \ldots, H_n = \{x_1, x_2, \ldots, x_n\} = X$$

Fuzzy Integral does not require the assumption of attribute independence and therefore, it can be applied to non-additive situations. Even if a certain attribute is objectively independent from other attributes, it may not be independent from the subjective viewpoint of an evaluator. Therefore, it is more appropriate to use Fuzzy Integral to make an overall evaluation. Moreover, even for an objective factor, subjective evaluation is based on the difference between the ideal value and the actual value of the attribute. As everyone may perceive a different ideal value, it is hard to measure. Therefore, using subjective values should be more appropriate.

FIMNL MODEL

The main purpose of this study is to examine travelers' choice of airline companies. The factors affecting travelers' choice of airline companies can be divided into three categories, including quantitative mode attributes, service quality perception (SQ) and trip and socioeconomic characteristics (Z). In the market of domestic airlines, the difference in quantitative mode

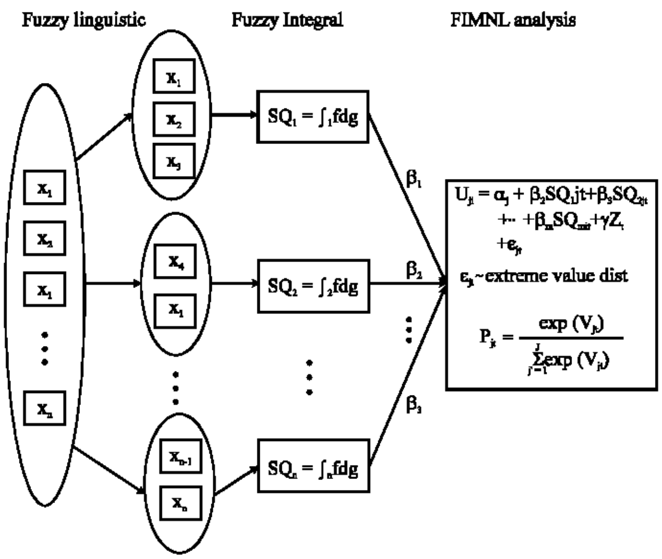

Fig. 2: The framework of the FIMNL model

attributes (such as airfare, flight time and flight schedule) among airline companies is minimal (due to strict control and short flight distance); therefore, SQ is most concern for travelers in choosing airlines as well as travelers' socioeconomic characteristics. The constructing process of the FIMNL model is shown as Fig. 2.

The FIMNL model, including the measure of service quality constructs and the MNL formulation, is constructed according to the above framework. The attribute of each construct ($SQ = \{SQ_1, SQ_2, \cdots, SQ_m\}$) can be calculated with the mapped criteria ($X = \{x_1, x_2, \cdots, x_n\}$) using Fuzzy Integral. In the construction of the MNL model, it is assumed that the utility function of an airline company j (j = 1,2,..,J) for a decision maker t (t = 1,2,...,T) is as follows:

$$U_{jt} = \alpha_j + \beta_1 SQ_{1jt} + \beta_2 SQ_{2jt} + \cdots + \beta_m SQ_{mjt} + \gamma Z_t + \varepsilon_{jt} = V_{jt} + \varepsilon_{jt} \tag{5}$$

Where:

SQ_{mjt} = A variable of the individual t for airline company j and the service quality m
Z_t = The socio-economic covariance matrix of individual t
ε_{jt} = Random error term
α, β, γ = Parameters to be estimated

α_j is an alternative specific constant of airline company j and V_{ji} is the observable utility. Suppose that ε_{jt} is an independent and identical distribution (i.i.d): the MNL model can be derived as follows:

$$P_{jt} = \frac{\exp(V_{jt})}{\sum_{j'=1}^{J} \exp(V_{j't})} = \frac{\exp(\alpha_j + \beta_1 SQ_{1jt} + \beta_2 SQ_{2jt} + \cdots + \beta_m SQ_{mjt} + \gamma Z_t)}{\sum_{j'=1}^{J} \exp(\alpha_{j'} + \beta_1 SQ_{1j't} + \beta_2 SQ_{2j't} + \cdots + \beta_m SQ_{mj't} + \gamma Z_t)} \tag{6}$$

The above is the choice probability equation of the FIMNL model. By using the maximum likelihood method (ML), the parameters of explanatory variables can be estimated to examine the relative importance and to discuss the sensitivity analysis.

DATA SURVEY AND ANALYSIS

Here, the questionnaire design and data analysis of empirical study are described as follows. The first part deals with the questionnaire design and survey and the second part covers the discussion of data analysis.

Questionnaire design and survey: This study conducted a survey on domestic airlines (excluding offshore routes) and four airlines-namely F-airline, T-airline, U-airline and M-airline were selected. Since the relative performances of service quality in the four airlines are the most concern of this study, eligible participants were those travelers with taking-flight experiences more than two airlines. These participants were asked to provide a linguistic evaluation with each criterion on service quality for experienced airlines and the relative weights between criteria.

The designed questionnaire consisted of the following four sections.

- **Trip characteristics:** Trip purpose, allowance for business trips, current and past experiences in airline choice

Table 2: The constructs and criteria of airline service quality

Construct	Criteria
SQ1: Schedule and premium	C1: Price premium and promotion
	C2: Frequency flight program
	C3: Convenience and accuracy of flight schedule
	C4: On-time performance
SQ2: Attendant attitude and in-flight service	C5: Ticketing efficiency
	C6: Attendant courtesy
	C7: In-flight meal and entertainment service
	C8: Cabin cleanness and seat comfort
	C9: Customer complaint handling
SQ3: Flight safety	C10: Age and model of airplane
	C11: Guideline of emergency exit and escape facility
	C12: Safety image and record

- **Selection of membership function:** This section is intended to understand each participant's linguistic scale. Each participant was required to select a membership function most compliant with his or her preferred linguistic scale from four predefined membership functions (average, left-oriented, right-oriented and concentrated)
- **Scoring of criteria:** This section is aimed to obtain each participant's scores of service quality among the four airlines by evaluating 12 criteria. In addition, it also investigated the weights of the criteria from participants' viewpoint
- **Participants' socioeconomic characteristics:** Age, gender, education, income and occupation

With regards to the measurement of service quality, most studies are based on the concept of service quality is perceived and evaluated by customers (Gronroos, 1984). The developments of evaluating criteria are frequently referred to the SERVQUAL measure (Parasuraman *et al*., 1985, 1988; Keshavarz *et al*., 2009). On the basis of following literatures (Chang and Yeh, 2002; Tsaur *et al*., 2002; Park *et al*., 2004; Chen and Chang, 2005; Gursoy *et al*., 2005; Chiou and Chen, 2006; Liou and Tzeng, 2007), twelve criteria corresponding to three constructs were proposed to evaluate airline service quality. As seen in Table 2, the evaluation of airline service quality is segmented into three independent constructs including schedule and premium, attendant attitude and In-flight service and Flight safety. Each construct is composed of 3-5 criteria to measure service quality.

The survey was carried out in the waiting room of Taipei Songshan Airport, which is the major domestic airport in northern Taiwan, through face-to-face interviews with randomly selected participants at the end of 2008. By means of this survey method, participants were collected from among the customers of all four airlines and were guaranteed to have had travelling experience with more than two airlines. A total of 441 questionnaires were distributed. Excluding questionnaires with incomplete or invalid answers, 375 valid copies were obtained. The valid response rate was 85.03%.

Data analysis: With regard to survey participants' socio-economic characteristics, male travelers accounted for nearly 60% of the total samples and most of the participants were in the age group of 31~40 (38.13%). Most of the participants received a monthly income between NT$30,000 and 40,000 (26.93%) and a household income between NT$100,000 and 150,000 (31.47%). In the analysis of trip characteristics, long-distance trips (over 250 km) amounted to approximately 65.33% and nearly 60% of the travelers took the flights for business purposes. Booking tickets over the counter (44.27%) was the most common way to purchase tickets, followed by online ticketing (23.73%). In addition, 43.74% of the participants reported having taken a flight at least once a month.

Considering the difference in the fuzzy linguistic scale used by each traveler, this study provided four membership functions as (Table 1) for survey participants to select the one function that was most compliant with their scale. The survey results revealed that most of them chose the average membership function (52.80%), followed by the concentrated membership function (27.47%). A significant difference in proportion between the two functions could be observed. The left-oriented membership function had the smallest proportion (8.27%). The proportions of four membership functions indicate that nearly 50% of the participants did not adopt the average membership function for their fuzzy linguistic scale. These results also highlighted that membership function subjectively assigned in previous studies could lead to biased results during the defuzzification of linguistic variables.

EMPIRICAL STUDY

Here, the empirical data is first to examine the reliability and validity of evaluating criteria for service quality. Then Fuzzy Integral is applied to calculate the constructs of service quality. Finally, these quantified constructs of service quality are specified into the MNL model to modelling airline choice behavior and investigate the influences of service quality.

Service quality construct: The reliability and validity analysis can be used to understand whether each criterion

Table 3: Reliability, validity, λ and fuzzy measure of each construct

Construct	Cronbach's α	λ	Criteria	Factor loading	Fuzzy measure g(•)
SQ1	0.68	-0.990	C1	0.564	0.924
			C2	0.546	1.00
			C3	0.621	0.984
			C4	0.533	0.734
SQ2	0.73	-0.997	C5	0.559	0.912
			C6	0.683	0.977
			C7	0.525	1.00
			C8	0.481	0.687
			C9	0.531	0.996
SQ3	0.69	-0.981	C10	0.573	0.949
			C11	0.539	1.00
			C12	0.723	0.758

CFA:χ^2, df = 51, p-value = 0.000, CFI = 0.934, RMR = 0.05, AGFI = 0.904, GFI = 0.937

in the questionnaire is consistent. This study first tested the reliability of the items of each construct. The empirical result revealed that all the service quality constructs have a Cronbach's α of approximately 0.7 (Table 3), which is considered reliable. Therefore, the items of each construct have good consistency. Furthermore, for the above construct-criteria relation, this study used the Confirmatory Factor Analysis (CFA) to investigate whether each criterion can effectively measure the three service quality constructs (the constructs are independent). The fitness indices of the CFA model are shown in Table 3. The CFI, GFI and AGFI are greater than 0.9 and RMR is lower than 0.05, indicating a high convergence validity of the items. According to the above reliability test and CFA analysis, each service quality construct has a high reliability and explanatory power.

Next, the evaluation of airline service quality is used to illustrate the application of Fuzzy measures and Fuzzy Integral to calculate each individual's total score for each independent construct, which is based on the score of each correlated criterion.

Step 1: Calculate the average fuzzy score and fuzzy weight: The average fuzzy score of the construct of Schedule and Premium (SP) of F-airline ($\tilde{x}^F_{SP\,i}$) is derived from all scores ($\tilde{x}^F_{SP\,ik}$) of K travelers who have taken the flights of F-airline. Suppose that $\tilde{x}^F_{SP\,ik}$ can be expressed as (a_i^k, m_i^k, b_i^k), the average fuzzy score is calculated as follows:

$$\tilde{x}^F_{SP\,i} = \frac{1}{K}(\cdot)\left\{(\tilde{x}^F_{SP\,i\,1})(+)\cdots(+)(\tilde{x}^F_{SP\,i\,K})\right\} = \left(\frac{\sum_{k=1}^{K} a_i^k, \sum_{k=1}^{K} m_i^k, \sum_{k=1}^{K} b_i^k}{K}\right) \tag{7}$$

The obtained $\tilde{x}^F_{SP\,i}$ is converted into a value between 0-1, according to the scale. The average fuzzy weight $\tilde{w}^F_{SP\,i}$ is calculated on the basis of the total number of travelers (T). The result is shown following:

$$\tilde{w}_{SP\,i} = \frac{1}{T}(\cdot)\left\{(\tilde{w}_{SP\,i\,1})(+)(\tilde{w}_{SP\,i\,2})(+)\cdots(+)(\tilde{w}_{SP\,i\,T})\right\} \tag{8}$$

Step 2: Defuzzification: Defuzzify $\tilde{w}^F_{SP\,i}$ of the i criterion of SP construct with the relative distance equation (Chen, 2000). Suppose that the triangular membership function of $\tilde{w}^F_{SP\,i}$ can be expressed as (α_i, m_i, b_i) the defuzzified value $S(\tilde{w}^F_{SP\,i})$ can be derived as follows:

$$d^-_{SP\,i} = \sqrt{\frac{1}{3}(a_i^2 + m_i^2 + b_i^2)},$$

$$d^*_{SP\,i} = \sqrt{\frac{1}{3}[(1-a_i)^2 + (1-m_i)^2 + (1-b_i)^2]}, \tag{9}$$

$$S(\tilde{w}^F_{SP\,i}) = \frac{d^-_{SP\,i}}{d^-_{SP\,i} + d^*_{SP\,i}}$$

The defuzzified fuzzy score of individual k on SP construct ($S(\tilde{x}^F_{SP\,ik})$) can also be calculated using the same method.

Step 3: Calculate λ value: Map the defuzzified fuzzy weight ($S(\tilde{w}^F_{SP\,i})$) of each criterion of SP construct (i=1,2,...,n) to the fuzzy density function (g_i). Let, $S(\tilde{w}^F_{SP\,i})$ and use the following equation to calculate λ:

$$\lambda + 1 = \prod_{i=1}^{n}(1 + \lambda g_i) \tag{10}$$

The MATHEMATIC 4.0 software is used to obtain the λ value of each service quality construct.

Step 4: Calculate Fuzzy density function: Rank the criteria according to $S(\tilde{w}^F_{SP\,i})$ and use Eq. 3 to derive the Fuzzy density function (g(H), i= 1,2,...n)

Step 5: Calculate the total score: Apply λ-Fuzzy Integral to calculate each F-airline traveler's total score for the SP construct. Based on the group weight ($g(H_i)$) and individual score ($S(\tilde{x}^F_{SP\,ik})$), Eq. 4 with the specification of $S(\tilde{x}^F_{SP\,ik}) = f(x_i)$ is composed to derive each individual's total score for the SP construct (h^F_{SP})

In the calculation of each construct, this study takes into account the correlation between criteria; therefore, Fuzzy Integral is used to resolve the non-additive characteristic of the criteria. According to the steps described earlier the λ value and fuzzy measure g(•) of each construct are shown in Table 3. Substitute the two figures into Eq. 4 to obtain each individual's score for each construct as a variable in the subsequent FIMNL model. In addition, if each λ value of three service quality constructs is negative, it means that there are substitutive effects between those criteria on a particular construct.

Estimation of airline choice model: This section aims to use the MNL model to construct an airline choice model. The main difference in this method from those used in previous studies is the calculation of service quality constructs. Fuzzy Integral is used to process the dependencies between criteria. In the aspect of model estimation, through various model specifications, it was found the best combinations of explanatory variables include the following: alternative specific constants, service quality constructs (Schedule and Premium, Attendant attitude and In-flight service and Flight safety) and alternative specific variables (trip distance, trip purpose, ticketing method and household income) (Table 4).

In the estimation of the MNL model, the number of alternative specific constants is specified at most J-1 in the case of J alternatives (Louviere *et al*., 2000). F-airline is the referent alternative on the specification of alternative specific constants. Specifying any airline to be the referent alternative makes no difference for model estimation. In addition, the specification of alternative specific variables is used to reflect the difference in choice probability between different airlines. This specification is used in the trip characteristics and socio-economic variables. For example, if a high-income traveler has higher probability to choose the high-fare airline, then the income variable should be specified to the high-fare airline. Table 4 shows the MNL model estimated with four construct calculation methods, where the coefficient and sign of each explanatory variable are compliant with a priori knowledge and statistically significant. As the coefficients of the four calculation methods for each variable are similar, Fuzzy Integral is selected as an example to explain the variable estimation results and meanings.

Table 4: Estimation results of the 4 construct calculation methods

	Fuzzy integral	
Explanatory variable	Coefficiency	t-ratio
T airline constant	-0.153	-0.65
U airline constant	-0.272	-1.48
M airline constant	-1.375	-4.57
Schedule and premium	9.403	3.95
Attendant attitude and In-flight service	4.027	1.56
Flight safety	2.911	1.71
Long trip (F and T airline)	0.774	2.92
Business trip-Age≥40 (F and U airline)	1.000	2.10
Network ticketing-Age≤30 (F airline)	1.060	2.60
Low family income (T airline)	0.374	1.31
LL (0)	-375.7413	
LL (β)	-311.5108	
ρ^2	0.1709	

In terms of model performance, ρ^2 is 0.1709, which indicates a good explanatory power. In the aspect of service quality constructs, Schedule and Premium, Attendant attitude and In-flight service and Flight safety have a positive coefficient. This reveals that higher satisfaction with a certain airline leads to a higher probability of choosing the airline. Among these constructs, the impact of Schedule and Premium on traveler's airline choice is most significant, followed by Flight safety and Attendant attitude and In-flight service.

With regard to trip characteristics and socio-economic background, long-distance trip (F-airline and T-airline) has a positive coefficient, reflecting that the two airlines have provided more long-distance flights and that when travelers take long-distance flights, they are more likely to choose F-airline and T-airline. Business trip (age over 40) also has a positive coefficient. Since, F-airline and U-airline are specified, it can be inferred that the probability that business travelers receive an allowance for a business trip is high and therefore, they prefer airlines with higher airfares. For Network ticketing (age below 30), F-airline is specified. The estimation result shows that the coefficient is positive, meaning that F-airline provides a convenient online ticketing service and that such a service is more appealing to younger travelers in their choice of airline companies. For those with low family income (less than NT$100,000), T-airline is assigned. The estimation result reveals the coefficient is positive, indicating that travelers with low family income are more likely to choose T-airline.

CONCLUSIONS

This study aimed to investigate the impact of service quality on traveler airline choice. As the difference in flight cost and time difference among domestic flights is limited, airline service quality has become an important factor affecting travelers' choice. In this study, considering the heterogeneity of travelers' linguistic scales, four membership functions were provided in the questionnaire survey. Fuzzy Integral was used to calculate the service quality and reflect the dependencies of criteria. Finally, the FIMNL was constructed to investigate travelers' airline choice behaviour and conduct a sensitivity analysis of service quality. This study proposes the non-additive weighting method between criteria and four types of fuzzy membership function to consider individual heterogeneity in constructing airline choice model. To our knowledge, this is the first study of combining fuzzy integral and multinomial logit model to investigate the influences of service quality on airline choice behavior, comparing to earlier studies (Park *et al*., 2004; Balcombe *et al*., 2009).

The 12 criteria and 3 service quality constructs adopted in this study were analyzed for reliability and validity. The result indicated that the questionnaire could effectively measure and reflect travelers' perception of airline service quality. The estimation of the FIMNL model showed that schedule and premium is the most critical factor among the three service quality constructs, followed by attendant attitude and in-flight service and flight safety. This finding is coincided with most previous studies of airline service quality (Tsaur *et al*., 2002; Chen and Chang, 2005; Lu and Ling, 2008). The significant differences in schedule and premium across four airlines influence travelers' choice behaviour markedly. In other words, airline operators should focus on the item of price premium and promotion, frequent flier programmes, convenience and accuracy of flight schedule and on-time performance.

In addition, long-distance flight, trip purpose, network ticketing, family income and age were also significant variables. The airlines can segment the whole market into several sub markets by the above variables, e.g. business traveler and leisure traveler. Each airline can focus on its target market and propose marketing strategies with a competitive advantage. According the results of FIMNL model, F-airline and U-airline can focus on the targeted market of business trip while T airline should adopt the discount strategy to those travelers with price-sensitivity. Moreover, F airline can enhance the service of network ticketing to attract the younger generation.

This study adopted Fuzzy Integral to conduct an analysis with the case of interdependence across criteria and applied these constructs of service quality to the MNL model to investigate airline choice behavior. The empirical results reveal that the FIMNL model can precisely explore airline choice behaviour based on the perceptions of the individual traveler. Furthermore, there are similar situations in evaluating the competitiveness of air cargo service providers (Tsai *et al*., 2007; Park *et al*., 2009). In comparison with the problem structure of airline choice and air cargo, the proposed method of this study may be quite naturally extended to the air cargo sector. Future studies could apply the FIMNL model to the case of the air cargo sector and validate its practical application.

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