A FUZZY DECISION MAKING APPROACH IN EVALUATING FERRY SERVICE QUALITY

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Abstract
The service quality evaluation is undeniably important especially in highly competitive service related industry. However, service quality evaluation is not always straightforward as criteria in evaluation and customer perceptions toward services are intangible measures. This paper presents a fuzzy multi-criteria decision making approach for evaluating the service quality of ferry that transport customers between the mainland of Peninsular Malaysia and a tourist spot island. Service quality is a composite of various criteria, among them many criteria are intangible and difficult to measure. Fuzzy numbers and linguistic level based on fuzzy sets theory as a method to overcome vaguely judgment in evaluation. The crisp survey results were collected via a ten-service criteria questionnaire from eighty seven customers and computed using Best non-Fuzzy Performance and Degree of Similarity. Based on the concept of the defuzzification, the ranking of service performance is obtained. Degree of Similarity provides the level of satisfaction and its degrees for each criterion. The criterion of 'service efficiency of ferry personnel' was the first in the ranking. All the criteria received 'good' and 'very good' for the level of satisfaction. These evaluation results facilitate the ferry operator to upgrade its ferry services and eventually meet its customers' needs.

Keywords: Service quality, fuzzy number, satisfaction level, defuzzification.

1. INTRODUCTION

Tourism industry in Malaysia has been identified as one of the sectors that can boost economic growth. The Malaysian government recognized the tourism industry had the potential to expand and become one of the main resources contributing to the national revenues. In the Ninth Malaysian Plan Document, Economic Planning Unit (2006) maintains that during this development period, concerted efforts will be geared towards realizing the full potential of the tourism industry in order to enhance its contribution to the service sector in particular, and the economy in general. There have been numerous measures taken by the government to promote tourism. Develop a new tourism destination with high quality infrastructure is one of them. In 1984, the first announcement was made by the government that Langkawi Island was to be developed as a major tourist centre of the country and will continue to be promoted internationally as the latest tourism product. More efforts have been undertaken to mobilize infrastructures and facilities as well as develop tourism related services. In 1996, the government has appointed a company to ferry customers to Langkawi from Kuala Kedah, Kuala Perlis, Penang, Puala Payar Marine Park and Satun (Thailand) as one of the measures to

develop the island as tourism spot. This company is expected to ensure fast, efficient, safe and comfortable ferry service to customers at all times. Ferry service quality indeed plays an enormous impact to the development of Langkawi Island as one of the prime tourism destinations in Malaysia. In other words, service quality is a very important component in sustaining the flowing of tourist and eventually making tourism industry remains strong.

In recent years, service quality has become one of the most important issues in tourism management, transport management and marketing literature (Akbaba, 2006; Hensher, et. al. 2003; Rendeiro, 2006; Mei et al. 1999) and is considered a vital element for service industries in management strategies in order to succeed in competitive environments (Goodale et al. 1997; Prioni and Hensher, 2000; Reichheld and Sasser, 1990). Many researches have shown that service quality is an essential strategy for winning and retaining customers (Ghobadian et. al, 1994; Zeithaml, 2000). One of the mechanisms to gauge service quality is through proper evaluation process. Thus, the evaluation of ferry service can be used by decision makers as a tool to benchmark the quality. Decision makers will appreciate the availability of such tool which enables them to monitor the offered quality, as perceived from the point of view of their customers, and call attention to the specific areas which require improvement.

The evaluation of service quality in the ferry service is an on going process that requires continuous monitoring to maintain high levels of service quality across a number different service area and criteria. There are many criteria used for service quality evaluation. Criteria that include tangibility, reliability, responsiveness, assurance and empathy proposed by Parasuraman et al. (1985a; 1985b) are being considered as the representative of criteria in service quality of transportation industries. In airlines transportation industries for example, Chang and Yeh (2002) specifically proposed the criteria in evaluation are on-board comfort, airlines employees, reliability of service, and convenience of service and also handling of abnormal condition. A composition of all these criteria becomes an indicator in service quality. In other words, service quality can be regarded as a composite of various criteria. It not only consists of tangible criteria or physical appearance criteria, but also intangible or subjective criteria such as safety, comfort, which are difficult to measure accurately. The ferry service evaluation takes into account all these criteria based on perceptions and attitude of customers.

The mainstream research on service quality has been conducted based on the belief that quality of service is perceived and evaluated by customers (Gronroos, 1990). Different individual or customer usually has wide range of perceptions and attitude toward quality service. Attitude can be regarded as an overall evaluation of a service perceive by customers based on their likes and dislikes (Bolton and Drew, 1991; Engel et al.,1995). Thus evaluation of service quality is depending on customers' preference structures and attitude. To measure service quality, conventional measurement tools are devised on cardinal or ordinal scales. To explore the

past related research document, most of the methods for evaluating transportation service quality employs statistical measures method. A 5-point of Likert scales instrument is the major means to evaluate service quality in the past. For example Bai and Yee (2005) investigated public service companies using statistical analyses of reliability and validity in service quality evaluation model. They employed a questionnaires adopt 7-point Likert scale with 1 indicates very unsatisfied to 7 indicates very satisfied and analysed the scale using Cronbach alpha realibility test. Most of the criticism about scale based on measurement is that scores do not necessarily represent user preference. This is because respondents have to internally convert preference to scores and the conversion may introduce misrepresentation of the preference being captured. In view of the fact that customer service evaluation depends largely on what customers perceived, perhaps linguistics judgement is a good option in avoiding such inconvenience.

Since service industry contains vague elements such as intangibility, inseparability and heterogeneity, it makes peoples more difficult to measure service quality. Lingual expressions, for example, satisfied, fair, dissatisfied, are regarded as the natural representation of the preference or judgement. These characteristics indicate the applicability of fuzzy set theory in capturing the decision makers' preference structure fuzzy set theory aids in measuring the ambiguity of concepts that are associated with human being's subjective judgment. Since the evaluation is resulted from the different evaluator's view of linguistic variables, its evaluation must therefore be conducted in an uncertain, fuzzy environment. Nowadays, the fuzzy set theory has been applied to the field of management science, like decision making (Viswanathan, 1999; Xia et. al, 2000;) and airline service (Tsaur, et. al. 2001; Chang and Yeh, 2002). However, it is hardly used in the field of ferry service quality. Therefore, this study includes fuzzy multiple criteria decision making (MCDM) approach to strengthen the comprehensiveness and reasonableness of the decision-making process. Based on these premises, the purpose of this paper is to measure the quality of a ferry service from customer perceptions using a fuzzy decision making approach. Specifically, the objectives are to rank the performance of the ferry service criteria using a defuzification method and to measure satisfaction levels of the service using a fuzzy similarity approach.

2. FUZZY MCDM ANALYSIS APPROACH

Since fuzzy set theory proposed by Zadeh (1965), and Bellman and Zadeh (1970) described the decision making method in fuzzy environments, an increasing number of studies have dealt with uncertain fuzzy problems by applying fuzzy set theory. Based on such initiatives, this study applies fuzzy decision making theory, considering the possible fuzzy subjective judgment of the evaluators during ferry service quality evaluation. This method for establishing ferry service quality can be made more objective. Data to evaluate the service quality of a ferry are based on customer perceptions. The applications of fuzzy MCDM in this study are elaborated as follows.

The service quality evaluation procedures are divided into two subsections. The first subsection describes the steps in obtaining performance for each criterion while the second subsection elucidates the steps in obtaining level and degree of satisfaction.

2.1. Performance Criteria

Measurement of performance especially in service quality has been conducted with the objective of getting a ranking order of criteria. Tsaur et al. (2001) applied Analytic Hierarchy Process in obtaining criteria weight and Technique for Order Preference by Similarity to Ideal Solution to achieve the final ranking results in evaluation of airline service quality. Chang and Yeh, (2002), employed fuzzy multi-criteria analysis model to formulate the evaluation of service quality for domestic airlines. The model is solved by an effective algorithm which incorporates the decision maker's attitude or preference for customers' assessments on criteria weights and performance ratings. With a very much straight forward approach, the present study utilized the supremacy of triangular fuzzy number and defuzzification to obtain ranking of performance criteria. The following steps are proposed to obtain ranking of performance criteria.

Step 1: Setting a triangular fuzzy number, *A* based on responses from questionnaire

Fuzzy numbers are a fuzzy subset of real numbers, and they represent the expansion of the idea of confidence interval. According to the definition made by Dubois and Prade (1978) those numbers that can satisfy these three requirements will then be called fuzzy numbers, and the following is the explanation for the features and calculation of the triangular fuzzy number.

In this paper, a triangular fuzzy numbers *A* are parameterized by a triplet (a_1, a_2, a_3). The membership function $\mu_A(x)$ is defined below.

$$\mu_A(x) = \begin{cases} \dfrac{x - a_1}{a_2 - a_1} & , a_1 \le x \le a_2 \\ \dfrac{x - a_3}{a_2 - a_3} & , a_1 \le x \le a_2 \\ 0 & , otherwise \end{cases}$$

Each linguistic term was characterized by a triangular fuzzy number for representing its approximate value range between 0 and 2.5, and donated as (a_1, a_2, a_3), where $0 \le a_1 \le a_2 \le a_3 \le 2.5$. Value of a_2 is the most likely value of the linguistic term, and a_1 and a_3 are the lower and upper bound used, respectively, to reflect the fuzziness of the term. The set of fuzzy number for the linguistic terms are defined and presented in Table 1.

TABLE 1 - TRIANGULAR FUZZY NUMBERS (TFN)

Linguistic terms	Symbols	TFN
Very Poor	VP	(0.00, 0.00, 0.75)
Poor	P	(0.00,0.75, 1.25)
Fair	F	(0.75,1.25, 1.75)
Good	G	(1.25,1.75, 2.50)
Very Good	VG	(2.25, 2.50, 2.50)

Step 2: Compute overall evaluation of the fuzzy judgement

The overall evaluation of the fuzzy judgement copes with the fact that every evaluator perceives differently toward every criterion. The subsequent valuation of the linguistic variable certainly varies among individuals. The overall fuzzy judgement can be integrated by the equation

$$A_{ij}=(1/m)\odot(A_{ij}^1\oplus A_{ij}^2, \ldots, \oplus A_{ij}^m) \quad (1)$$

where $\odot$ is the multiplication of fuzzy numbers, $\oplus$ is the add operation of fuzzy numbers, A_{ij} the overall average performance valuation of ferry i under criterion j over m assessors.

Step 3: Obtain end point of fuzzy numbers, A_{ij}

A_{ij} as a fuzzy number can be represented by triangular membership function as the equation

$$A_{ij}=(LA_{ij}, MA_{ij}, UA_{ij}) \quad (2)$$

where LA_{ij}, UA_{ij} are the ends points of fuzzy numbers and MA_{ij} is the middle point of fuzzy numbers.

Step 4: Defuzzification

To justify whether a ferry service criteria is at the level of 'good' or 'poor', defuzzification of the information is needed. The result of fuzzy synthetic decision of each alternative is a fuzzy number. Therefore, it is necessary that the nonfuzzy ranking method for fuzzy numbers be employed during service quality comparison for each alternative. In other words, Defuzzification is a technique to convert the fuzzy number into crisp real numbers, the procedure of defuzzification is to locate the Best Nonfuzzy Performance (BNP) value. In other words, defuzzification is a technique to convert the fuzzy number into crisp real numbers. The procedure of defuzzification is locating the Best Nonfuzzy Performance (BNP) value. In this paper, the formula to get the Best Nonfuzzy Performance that is define as

$$BNP_{ij}=[(UA_{ij}-LA_{ij})+(MA_{ij}-LA_{ij})]/3+LA_{ij} \quad \forall i, j \quad (3)$$

for the triplet (a_1, a_2, a_3) of a tringular fuzzy number Ã.

Step 5: Ranking the performance criteria

Criteria are ranked based on the magnitude of BNP.

2.2. Level and degree of Satisfaction

Besides ranking of the criteria, satisfaction level for each criterion is equally important. It gives specific satisfaction level out of five defined linguistic levels perceived by customer. Level of satisfaction and its degree can be obtained using the following steps.

Step 1: Define a linguistic level of service based on responses from questionnaire

According to Zadeh (1965), it is very difficult for conventional quantification to express reasonably those situations that are obviously complex or hard to define; thus, notion of a linguistic variable is necessary in such situations. A linguistic variable is a variable with linguistic words or sentences in a natural language (Zimmerman, 1996). One example for the linguistic variable is 'ferry service quality'. It means the service quality that customer experiences during ferry service. The possible values for this variable could be: 'very poor', 'poor' , 'fair', 'good', and 'very good'. In this study, there were five linguistic variables with 5-point Likert-scale. Membership functions for linguistic variables are defined by as follow:

Very poor,	{1/1	0.75/2	0.5/3	0/4	0/5}
Poor,	{0.5/1	1/2	0.75/3	0.25/4	0/5}
Average,	{0/1	0.5/2	1/3	0.5/4	0/5}
Good,	{0/1	0.25/2	0.75/3	1/4	0.5/5}
Very Good,	{0/1	0/2	0.5/3	0.75/4	1/5}

Step 2: Obtain weight for each respondent

Weight for each respondent, *w* is a proportion of the response's linguistic value, *v* to the total of linguistic value for all respondents, $\sum v$.

$$w_i = \frac{v_i}{\sum_{i=1}^{n} v_i} \tag{4}$$

Step 3: Obtain the overall value of membership function

The value of membership function for all level satisfaction of the evaluators can be determined by using a distance formula. Faratin et al. (1998) propose a formal model of service-oriented negotiation between autonomous agents. They introduce a multi-attribute representation and evaluation model that uses evaluation functions, defined as weighted sums of score function values.

$$\mu_i(x) = \sum_{i=1}^{n} w_i \, x_i \tag{5}$$

where x_i represents the *i*-th linguistic level of respondents, w_i is the weight of repondents.

Step 4: Obtain level and degree satisfaction

Turksen and Willson (1994), proposed a formula for calculating degree of similarity which involved the calculation of Euclidean distance between fuzzy sets given as:

$$SIM(B^{'}(y,m), B(yi,m)) = \frac{1}{1+\sqrt{\sum \mu_{B'}(yj,m) - \mu_B(yj,m)^2}} \tag{6}$$

where μ_B is the fuzzy set defined for linguistic rating and $\mu_{B'}$ is the calculated overall value of membership functions. The distance formula reflects degree and level of satisfaction for criteria. Details on calculation of the Euclidean distance formula can be retrieved from Lazim et al., (2004) and Lazim (2009).

3. RESEARCH STRUCTURE

The empirical study of ferry service quality is conducted according to the following research structure in order to meet the research objectives.

3.1. Design of questionnaire

The questionnaire of this study is designed based on related studies with some modifications based on the research structure and purpose of the research. The evaluators are selected from the customers who are using the ferry's service. The final version of the questionnaire is completed after amending or modifying words and sentences that are not clear in meaning. Linguistic variables 'very poor'(1) to 'very good'(5) are used in this paper to determine the satisfaction levels of ferry service criteria. The customers have to answer the questionnaire given in scale 1 to 5.

3.2. Evaluation aspects and Criteria

The variables of the questionnaire are on-board comfort, ferry employees, handling of abnormal conditions and reliability of services. We used these criteria category in the questionnaire. The criteria in Fig. 1 are used for service quality evaluation of a ferry company. The criteria below are a modified version from Chang and Yeh (2002).

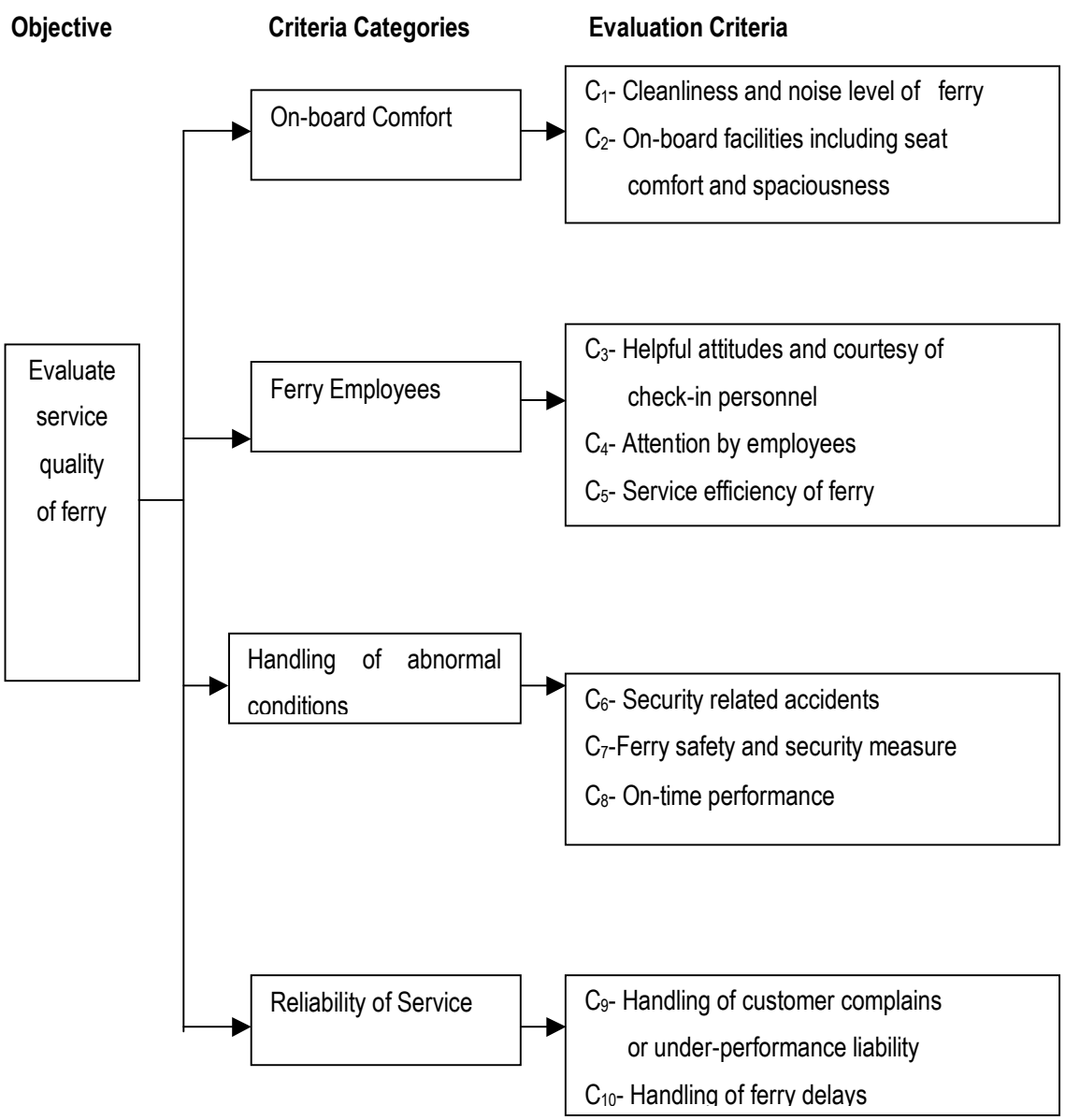

FIGURE 1 - CRITERIA OF SERVICE QUALITY

3.3. Survey

The sample of this research was a group of ferry passengers that used a ferry service from mainland of Peninsula Malaysia to a tourist spot island and vice-versa. The questionnaires were distributed to the customers who were using the ferry services. Hundred twenty six questionnaires were given out to the customers and eighty seven of questionnaires were completely filled. The results were evaluated from the answers given by customers or passengers. The questionnaire was structured into two sections. Section A contains personal data's of customers such as genders, ages, races, occupations and nationalities. Section B contains customer's perception about quality of ferry services. Customers have to fill the questionnaire given in the scale of 5, 4, 3, 2, 1 to represent very good, good, average, poor, very poor respectively.

3.4. Evaluation Framework

In accordance with the objectives described above, the evaluation procedure of this study consists of two parts. In the first part, the rank of performance for criteria by applying Average Fuzzy Judgment and BNP method are calculated. The criteria of service quality that customers consider the most important are identified. In the second part, degree of similarity between overall value of membership and linguistic rating are utilized to obtain the degree and satisfaction levels. The framework of two parts procedures are shown in Fig. 2.

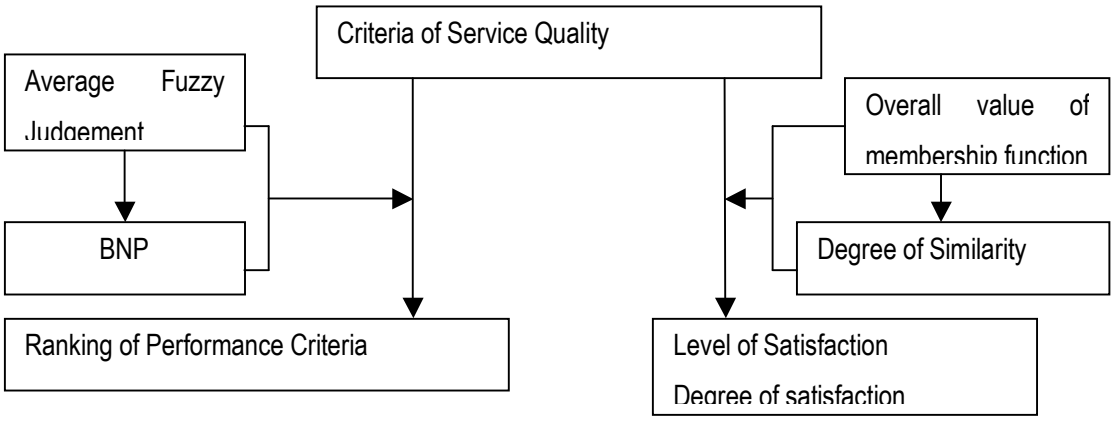

FIGURE 2 - EVALUATION FRAMEWORK

4. ANALYSIS AND RESULTS

A fuzzy MCDM analysis approach as prescribed in previous section is utilised in this evaluation. For the purpose of clarity, examples of obtaining performance criteria and degree of satisfaction are given prior tabling full results.

4.1. Performance Criteria

Assuming that we take 10 customers to evaluate of C_1 (Cleanliness and noise level of the ferry).

Set of customers, $X = \{X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_8, X_{10}\}$

Set of the level of the service = {5, 4, 2, 3, 1, 3, 1, 4, 3, 1}

The average of fuzzy result (Equation (1)),

$A_i\ (a_1, a_2, a_3)$ = 1/10(2.25 + 1.25+...+0.00, 2.5 +1.75+…+0.00, 2.5 +2.25+…+ 0.75)

= (0.70, 1.05, 1.58).

Equations (2) are used to obtain end points of fuzzy numbers.

The next step is defuzzification which meant to convert fuzzy number to the crisp real number for find the BNP value.

Using Equation (3), then $BNP_i = 1.16$.

Thus, the performance for criterion C_1 is 1.16

The same fashions of calculations are executed for all criteria after considering score from all respondents. The performance and ranking for the all criteria are presented in Table 1.

TABLE 1 - RANKING OF THE PERFORMANCE OF THE CRITERIA

Criteria	Defuzzification	Ranking
C_1	4.17	4
C_2	4.00	8
C_3	4.33	2
C_4	4.25	3
C_5	4.35	1
C_6	4.01	7
C_7	3.98	9
C_8	4.08	5
C_9	4.03	6
C_{10}	3.76	10

It is clearly seen that criterion C_5 scores the highest value. Service efficiency of ferry personnel received the highest thumbs up from the customers. The criterion of C_{10} handling of ferry delay was ranked as the least defuzzification score.

4.2. Level of Satisfaction and Degree of Satisfaction

Example below explains the calculation steps to obtain level of satisfaction and degree of satisfaction.

Assuming that we take 10 customers for evaluate of C_1 (Cleanliness and noise level of the ferry).

Set of customer, $X = \{X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_8, X_{10}\}$

Set of the level of the service = {5, 4, 2, 3, 1, 3, 1, 4, 3, 1}.

Using equation (4),

Value of weight, $w_i = \{\frac{5}{27}, \frac{4}{27}, ..., ..., ..., ..., \frac{1}{27}\}$

We used sum of weighted for the membership function to evaluate the service (Equation (5)). Membership value for customer X_i

$$\mu_{X_1} = \frac{5}{27}\{0/1 \quad 0/2 \quad 0.5/3 \quad 0.75/4 \quad 1/5\}$$

$$= \{ \quad 0/1 \quad 0/2 \quad 0.09259/3 \quad 0.13889/4 \quad 0.18529/5\}$$

$$\mu_{X_2} = \frac{4}{27}\{0/1 \quad 0.25/2 \quad 0.75/3 \quad 1/4 \quad 0.5/5\}$$

Membership values for ten customers are executed and results are given in Table 2.

TABLE 2 - VALUE OF MEMBERSHIP FUNCTION FOR TEN EVALUATORS

Evaluators	Membership Value
X_1	{ 0 0 0.09259 0.13889 0.18529 }
X_2	{ 0 0.037404 0.11111 0.14815 0.07407 }
X_3	{ 0.037404 0.07407 0.5556 0.01852 0 }
X_4	{ 0 0.5556 0.11111 0.5556 0 }
X_5	{ 0.037404 0.02778 0.01852 0 0 }
X_6	{ 0 0.5556 0.11111 0.5556 0 }
X_7	{ 0.037404 0.02778 0.01852 0 0 }
X_8	{ 0 0.037404 0.11111 0.14815 0.07407 }
X_9	{ 0 0.5556 0.11111 0.5556 0 }
X_{10}	{ 0.037404 0.02778 0.01852 0 0 }

The overall value of membership function for the criterion C_1 given by ten customers is:

$$\mu_x(X) = \{0.14816/1 \quad 0.39817/2 \quad 0.75926/3 \quad 0.62039/4 \quad 0.33343/5\}$$

Degree of satisfaction can be calculated using Equation (6).

The numerical results are

$SIM\ (X, Very\ Poor)$ = 0.47782

$SIM\ (X, Poor)$ = 0.48969

$SIM\ (X, Average)$ = 0.50130

$SIM\ (X, Good)$ = 0.51845

$SIM\ (X, Very\ Good)$ = 0.51615

The consensus for ten customers is 'good' in rating the level of satisfaction for C_1 with 0.51845 degree of satisfaction.

The evaluation procedures for other criteria and customers are executed with the similar fashion. In summary, values of membership functions for all level of satisfaction in accordance to criteria are presented in Table 3.

TABLE 3 - VALUES OF MEMBERSHIP FUNCTIONS BASED ON LEVEL OF SATISFACTIONS

Criteria	Value of membership function for all level of satisfactions				
C_1	0.054216/1	0.369723/2	0.795168/3	0.69276/4	0.355416/5
C_2	0.05625/1	0.392991/2	0.828129/3	0.704709/4	0.19688/5
C_3	0.03468/1	0.344633/2	0.794827/3	0.728332/4	0.375712/5
C_4	0.041174/1	0.345153/2	0.798568/3	0.697813/4	0.361756/5
C_5	0.031614/1	0.343389/2	0.795998/3	0.720527/4	0.376435/5
C_6	0.065415/1	0.395643/2	0.806869/3	0.659664/4	0.32088/5
C_7	0.072335/1	0.419814/2	0.816043/3	0.665095/4	0.295587/5
C_8	0.064407/1	0.391084/2	0.799049/3	0.667174/4	0.337419/5
C_9	0.052802/1	0.394397/2	0.824547/3	0.655255/4	0.298133/5
C_{10}	0.083050/1	0.462610/2	0.863797/3	0.65197/4	0.222603/5

It can be seen that membership functions are greater that 0.5 for level of satisfaction 'average' and 'good' for all criteria. The consensus of all membership functions is needed to obtain degree of satisfaction.

The degree of satisfaction and level of satisfaction according to the criteria are presented in Table 4.

TABLE 4 - DEGREE OF SATISFACTION AND LEVEL OF SATISFACTION ON BOARD COMFORT

CRITERIA	DEGREE OF SATISFACTION	LEVEL OF SATISFACTION
C_1: Cleanliness and noise level of ferry	0.561459	VERY GOOD
C_2: On-board facilities including seat comfort and spaciousness	0.863388	GOOD
C_3: Helpful attitudes and courtesy of check-in personnel	0.659324	VERY GOOD
C_4: Attention by employees	0.563578	VERY GOOD
C_5: Service efficiency of ferry personnel	0.670189	VERY GOOD
C_6: Security-related accidents	0.596082	GOOD
C_7: Ferry safety and security measures	0.783580	GOOD
C_8: On-time performance	0.685633	VERY GOOD
C_9: Handling of customer's complaints or under-performance liability	0.725451	GOOD
C_{10}: Handling of ferry delays	0.827914	GOOD

Table 4 shows the results obtained from analysing the satisfaction of customers for on board comforts criteria. The results show that the customers are happy with the service following the level of satisfaction at 'very good' and 'good'. The identification of customers' perceptions of service quality in ferry is essential to tailor marketing efforts in ensuring customer satisfactions are met.

5. CONCLUDING REMARKS

In an attempt to promote the island as a tourist holiday destination through its ferry operation activities, ferry management should make concerted efforts for improving their customer's satisfaction. In this paper, customers evaluated the service of ferry according to the ten criteria. Fuzzy numbers and membership function have been used as an adequate methodology to overcome the uncertainty of concepts that are associated with human beings' subjective judgments. The defuzzification method has identified the best criteria and eventually the ranking for all criteria is established. The distance formula is also employed to determine level of satisfaction and its respective degrees. The fuzzy decision making approach gives the different in technique to estimate the perception of customer's satisfactions rather than using statistical method. Service efficiency of ferry personnel was ranked as the best criteria. The level of satisfaction 'good' and 'very good' were given thumbs up from customers to all criteria. This study makes empirical contributions to hospitality and tourism marketing literature especially in the way the ferry service can be upgraded. The results obtained via the definition of fuzzy number and linguistic level together with their membership functions as methods to measure service quality. The results also help the ferry company to better understand how the customers view their services.

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