EVALUATION OF TRAVEL WEBSITE SERVICE QUALITY USING FUZZY TOPSIS

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Abstract

The Internet revolution has led to significant changes in the way travel agencies interact with customers. Travel websites provide customers with diverse services including travel information and products through the Internet. In practical environments, Internet users face a variety of travel website service quality (TWSQ) that is vague from human beings' subjective judgments. In the face of the strong competitive environment, in order to profit by making customers proceed with transactions on the websites, travel websites should pay more attention to improve their service quality. This study discusses the major factors for travel agency websites' quality from the viewpoint of users' perception, and explores the use of Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) for the evaluation of TWSQ. Fuzzy TOPSIS is a preferred solution method when the performance ratings are vague and imprecise. The proposed methodology is illustrated through a practical application.

Keywords: Fuzzy set theory, multiple-attribute decision making, TOPSIS, TWSQ

Introduction

The Internet has had a tremendous impact on today's travel and tourism businesses due to the rapidly growing online market over the past several years (Telfer and Sharpley, 2008). The Internet has become one of the most important channels for business (Le, 2005). Consumers use it to find travel options, seek the best possible prices, and book reservations for airline tickets, hotel rooms, car rentals, cruises, and tours (Gratzer *et al.*, 2004; Longhi, 2009). Prior studies have pointed out that online travel booking and associated travel services are one of the most successful B2C e-commerce practices (Burns, 2006). Furthermore, many travel service/product suppliers have grasped these potential advantages by establishing their own websites to help their business grow more rapidly (Pan and Fesenmaier, 2000).

A website offers a business not only a platform to promote products or services but also another avenue to generate revenue by

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attracting more customers. Unfortunately, not all websites successfully turn visitors into customers. The effective evaluation of websites has therefore become a point of concern for practitioners and researchers (Yen, 2005). As the number of online customers increases day by day, travel-related website providers should consider how to capture customer preferences explicitly (Shen *et al.*, 2009). Researchers indicated that service quality can help create differentiation strategies between providers (Clemons *et al.*, 2002) and may be is one of the critical success factors of any Internet business (Zeithaml *et al.*, 2002). Moreover, excellent online service will result in desirable behaviors such as word of mouth promotion, willingness to pay a price premium and repurchasing (Reichheld *et al.*, 2000). Thus, for travel agencies desiring to survive and thrive on the Internet, and willing to invest in online services, it is critical to understand precisely in advance how online customers will evaluate their full service offer and which service quality dimensions are valued most (Jeong *et al.*, 2003).

Parasuraman *et al.* (1985) developed a five-gap model and indicated that service quality is a perception result when customers compare their expectations with their perceptions of the service received. Subsequently, SERVQUAL instrument (Parasuraman *et al.*, 1988) has been widely used by academics and practitioners to measure service quality. Santos (2003) indicated that service quality is a key determinant in differentiating service offers and building competitive advantages, since the costs of comparing alternatives are relatively low in online environments. A number of researchers (e.g. Chand, 2010) used the five dimensions of SERVQUAL instrument and the characteristics of the Internet as basis for developing the measurement dimensions that affect website service quality, but Rowley (2006) revealed that these studies had shown that some of service quality dimensions were different from the five dimensions described by the original SERVQUAL researchers. To better understand the dimensions that affect the online consumer's TWSQ in virtual context, this study attempts to derive the instrument dimensions of website service quality through modifying moderately the e-SERVQUAL scale developed by Zeithaml *et al.* (2002) and considering the travel and tourism contexts from the online customers' perspectives to suit the travel website context.

To explore the past related studies, most of the conventional measurement methods for evaluating website service quality use statistical methods for the analysis. During recent years, different website evaluation approaches have been introduced. These deal with website usability and design (Palmer, 2002), content (Robbins and Stylianou, 2003), quality (Dominic *et al.*, 2010), user acceptance (Shih, 2004), and user satisfaction (Szymanski and Hise, 2000). From a tactical viewpoint, these approaches were good by assessing user attitude towards the website and could be considered as an external user's view. From a strategic viewpoint, however, little attention has been given to evaluating the consistency between web strategy and web presence, which can be considered as an internal evaluation, from the company's viewpoint.

Multiple criteria decision making (MCDM) is one of the major tools for the evaluation of service quality in different fields. MCDM deals with the problem of choosing an option from a set of alternatives which are characterized in terms of their attributes (Hwang and Yoon, 1981). The decision maker may express or define a ranking for the attributes as importance/ weights. The aim of the MCDM is to obtain the optimum alternative that has the highest degree of satisfaction for all of the relevant criteria. Seven-point or five-point Likert scales is one of the major way to collect the rating of different website service quality attributes (Yen and Lu, 2008; Chang *et al.*, 2009). Mustafa *et al.* (2005) applied Analytic Hierarchy Process (AHP) to determine the service quality of airlines and compared the service quality of various airlines. They evaluated the service quality of seven airlines servicing the Penang International Airport on the basis of four criteria tangibility, reliability, responsiveness and assurance.

Moreover, measuring website service quality is characterized by uncertainty, subjectivity, imprecision, and vagueness with perception of response. After Zadeh (1965) proposed the fuzzy set theory, an increasing number of studies have dealt with uncertain fuzzy problems by applying the fuzzy set theory extensively to help solve the service quality problems. Liou and Chen (2006) proposed a conceptual model to assess the perceived service quality properly using fuzzy set theory. The fuzzy perceived quality score is calculated by combining the fuzzy numbers of criteria with the corresponding weights. The fuzzy scores are then transformed to linguistic terms to reflect the customer's satisfaction level of overall service quality as interpreted by the reviewer. Benitez *et al.* (2007) presented a fuzzy TOPSIS approach for evaluating dynamically the service quality of three hotels of an important corporation in Gran Canaria Island via surveys. Lai *et al.* (2007) exploreed the effects of travel website service quality on the customers' relational benefits, and the relationships among customers' relational benefits, e-satisfaction, and e-loyalty. They investigated on-line customers who have had transactions with travel websites within one year and used LISREL software to test the hypotheses. Oliveira (2007) employed structural equation modeling to examine the link between website service quality and customer loyalty. His research found a strong and significant link between the two constructs, suggesting that this relationship also holds in e-service settings.

Parameshwaran *et al.* (2009) used fuzzy Analytic Hierarchy Process (FAHP) for the measurement of service quality of automobile repair shops. The Service Quality Measure (SQM) from fuzzy AHP, the cost dimensions (generated revenue and operating cost) and the time dimension (productive service time) were provided to the Data Envelopment Analysis (DEA) model to measure the efficiency of automobile repair shops. Fuzzy Multi-Attribute Decision-Making (FMADM) approach was also used to measure of service quality of healthcare (Rahman and Qureshi, 2009). They also proposed a Technique for Order Performance by Similarity to Ideal Solution (TOPSIS)-based Performance Index (PI) for the performance evaluation of hospital services. Yang *et al.* (2009) used four dimensions of SERVQUAL, which include reliability, responsiveness, assurance, and empathy, to measure the users' cognition of SERVQUAL in online channel. Sun and Lin (2009) proposed a conceptual framework for evaluating the competitive advantages of shopping websites using fuzzy TOPSIS. According to their research, the security and trust are the most important factors for improving the competitive advantage of shopping website. Lee *et al.* (2009) evaluated the of travel website service quality by Fuzzy Analytic Hierarchy Process (FAHP). FAHP method was employed to determine the fuzzy weights between each aspect from subjective judgment and a non-additive integral technique was applied to integrate the performance ratings of criteria in each aspect. Shipley and Coy (2009) developed an operational performance model with direct applicability to the post-9/11 US airline industry using fuzzy logic. A database of numerical scores was transformed into a fuzzy database, and then fuzzy probabilities were used to assess the belief that the scores fall within the desired range for each criterion. Büyüközkan (2010) presented a MCDM framework for evaluating the performance of Turkish government websites. The subjectivity and vagueness in multidimensional characteristics of website quality were dealt with fuzzy logic. Abdolvand and Taghipouryan (2011) evaluated service quality of Iran's service organizations by using Fuzzy MCDM approach. At first, they applied Entropy method for calculating the criteria weights. Then, for evaluation of Service Quality they used fuzzy numbers on the basis of five dimensions of service quality in SERVQUAL model. Finally, they conducted Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to achieve the final ranking results.

The main purpose of this study is to evaluate the major factors for travel agency websites quality from the viewpoint of users' perception and propose a systematic evaluation model that considers the uncertainties or vagueness of decision making or judgments to find out the ideal solution using fuzzy TOPSIS. In classical TOPSIS, the rating and weight of the criteria are known precisely. However, under many real situations, crisp data are inadequate to model real life situation since human judgments are vague and cannot be estimated with exact numeric values (Kabir and Hasin, 2012). To resolve the ambiguity frequently arising in information from human judgments, fuzzy set theory has been incorporated in many MCDM methods including TOPSIS. The merit of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of precise numbers. Fuzzy TOPSIS is used to determine the weights of evaluation criterion and rank the service quality of the five websites. This research also tries to provide some empirical tactics in order to enhance management performance for the evaluation of website service quality.

The remainder of this paper is organized as follows. In the next section, the proposed methodology will be described with a brief note on fuzzy set theory and fuzzy TOPSIS method. The following section provides the background information for the case study problem and the justification of the proposed model. The discussion that summarizes the empirical results is given in next section. Finally, the last section presents the conclusion and discusses the limitations and scope for future research.

Fuzzy TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the useful MCDM techniques that are very simple and easy to implement, so that it is used when the user prefers a simpler weighting approach. TOPSIS method was first proposed by Hwang and Yoon (1981). According to this technique, the best alternative would be the one that is nearest to the positive ideal solution and farthest from the negative ideal solution (Benitez *et al.*, 2007). The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria (Wang and Elhag, 2006; Wang and Chang, 2007; Wang and Lee, 2007; Lin *et al.*, 2008). In other words, the positive ideal solution is composed of all best values attainable of criteria, whereas the negative ideal solution consists of all worst values attainable of criteria (Ertuğrul and Karakasoğ lu, 2009).

This section extends the TOPSIS to the fuzzy environment (Yang and Hung, 2007). This method is particularly suitable for solving the group decision-making problem under fuzzy environment. The rationale of fuzzy theory were reviewed before the development of fuzzy TOPSIS. The mathematics concept was borrowed from Ashtiani *et al.* (2009); Buyukozkan *et al.* (2007) and Wang and Chang (2007):

Definition 1: A fuzzy set $\widetilde{M}$ in a universe of discourse X is characterized by a membership function $\mu_{\widetilde{M}}(x)$ which associates with each element x in X, a real number in the interval [0, 1]. The function value $\mu_{\widetilde{M}}(x)$ is termed the grade of membership of x in $\widetilde{M}$. The present study uses triangular fuzzy numbers. A triangular fuzzy number ã can be defined by a triplet (a_1, b_1, c_1). Its conceptual schema and mathematical form are shown by Equation (1):

$$\mu(x\backslash\widetilde{M}) = \begin{cases} 0, & x \le a_1, \\ (x-a_1)/(b_1-a_1), & a_1 < x \le b_1, \\ (c_1-x)/(b_1-c_1), & b_1 < x \le c_1, \\ 0, & x > c_1, \end{cases} \tag{1}$$

Definition 2: Let $\widetilde{M}_1 = (a_1, b_1, c_1)$ and $\widetilde{M}_2 = (a_2, b_2, c_2)$ are two triangular fuzzy numbers, then the vertex method is defined to calculate the distance between them.

$$d(\widetilde{M}_1, \widetilde{M}_2) = [\tfrac{1}{3}\{(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2\}]^{1/2} \quad (2)$$

Property 1: Assuming that both $\widetilde{M}_1 = (a_1, b_1, c_1)$ and $\widetilde{M}_2 = (a_2, b_2, c_2)$ are real numbers, then the distance measurement d $(\widetilde{M}_1, \widetilde{M}_2)$ is identical to the Euclidian distance.

Property 2: Assuming that $\widetilde{M}_1 = (a_1, b_1, c_1)$ and $\widetilde{M}_2 = (a_2, b_2, c_2)$ are two TFNs, then their operational laws can be expressed as follows:

$$\widetilde{M}_1 \oplus \widetilde{M}_2 = a_1 + a_2, b_1 + b_2, c_1 + c_2 \quad (3)$$

$$\widetilde{M}_1 \Theta \widetilde{M}_2 = a_1 - a_2, b_1 - b_2, c_1 - c_2 \quad (4)$$

$$\widetilde{M}_1 \otimes \widetilde{M}_2 = a_1 a_2, b_1 b_2, c_1 c_2 \quad (5)$$

Attributes: Attributes (C_j, j = 1, 2,..., n) should provide a means of evaluating the levels of an objective. Each alternative can be characterized by a number of attributes.

Alternatives: These are synonymous with ‘options’ or ‘candidates’. Alternatives (A_i, i = 1, 2, ..., m) are mutually exclusive of each other.

Attribute weights: Weight values ($\widetilde{w}_j$) represent the relative importance of each attribute to the others. $\widetilde{W} = \{\widetilde{w}_j \mid j = 1, 2,..., n\}$.

Fuzzy Membership Function

The decision makers use the linguistic variables to evaluate the importance of criteria, sub-criteria and the ratings of alternatives with respect to various criteria. The present study has only precise values for the performance ratings and for the criteria weights. In order to illustrate the idea of fuzzy MCDM, the existing precise values have been transformed into seven-levels, fuzzy linguistic variables -Very Low (VL), Low (L), Medium Low (ML), Medium (M), Medium High (MH), High (H) and Very High (VH).

Among the commonly used fuzzy numbers, triangular and trapezoidal fuzzy numbers are likely to be the most adoptive ones due to their simplicity in modeling and interpretation. Both triangular and trapezoidal fuzzy numbers are applicable to the present study. As triangular fuzzy number can adequately represent the seven-level fuzzy linguistic variables, it is used for the analysis hereafter. A transformation can be found in Table 1 and Figure 1. For example, the fuzzy variable - Medium High (MH) has its associated triangular fuzzy number with minimum of 0.5, mode of 0.7 and maximum of 0.9. The same definition is then applied to the other fuzzy variables.

The linguistic ratings ($\widetilde{x}_{ij}$, i = 1, 2,..., m, j = 1, 2,..., n) for alternatives with respect to criteria and the appropriate linguistic variables ($\widetilde{w}_j$, j = 1, 2,..., n) for the weight of the criteria can be concisely expressed in matrix format as Equations (6) and (7).

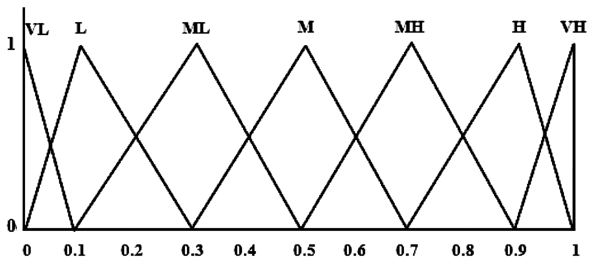

Figure 1. Fuzzy triangular membership functions

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & \cdots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \tilde{x}_{13} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{23} & \cdots & \tilde{x}_{2n} \\ \tilde{x}_{31} & \tilde{x}_{32} & \tilde{x}_{33} & \cdots & \tilde{x}_{3n} \\ \vdots & \vdots & \vdots & & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \tilde{x}_{m3} & \cdots & \tilde{x}_{mn} \end{bmatrix} \end{array} \tag{6}$$

$$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n] \tag{7}$$

where $\tilde{x}_{ij}$, $i = 1, 2, ..., m$, $j = 1, 2, ..., n$ and $\tilde{x}_j$, $j = 1, 2, ..., n$ are linguistic triangular fuzzy numbers, $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $\tilde{x}_j = (w_{j1}, w_{j2}, w_{j3})$. Note that $\tilde{x}_{ij}$ is the performance rating of the ith alternative, A_i, with respect to the jth attribute, C_j and w_j represents the weight of the jth attribute, C_j.

The normalized fuzzy decision matrix denoted by $\tilde{R}$ is shown as Equation (8):

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times} \tag{8}$$

The weighted fuzzy normalized decision matrix is shown as Equation (9):

$$\tilde{V} = \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & \tilde{v}_{1j} & \cdots & \tilde{v}_{1n} \\ \tilde{v}_{21} & \tilde{v}_{22} & \tilde{v}_{2j} & \cdots & \tilde{v}_{2n} \\ \vdots & \vdots & \vdots & & \vdots \\ \tilde{v}_{i1} & \tilde{v}_{i2} & \tilde{v}_{ij} & \cdots & \tilde{v}_{in} \\ \vdots & \vdots & \vdots & & \vdots \\ \tilde{v}_{m1} & \tilde{v}_{m2} & \tilde{v}_{mj} & \cdots & \tilde{v}_{mn} \end{bmatrix} = \begin{bmatrix} \tilde{w}_1\tilde{r}_{11} & \tilde{w}_2\tilde{r}_{12} & \cdot & \tilde{w}_j\tilde{r}_{1j} & \cdots & \tilde{w}_n\tilde{r}_{1n} \\ \tilde{w}_1\tilde{r}_{21} & \tilde{w}_2\tilde{r}_{22} & \cdot & \tilde{w}_j\tilde{r}_{2j} & \cdots & \tilde{w}_n\tilde{r}_{2n} \\ \vdots & \vdots & & \vdots & & \vdots \\ \tilde{w}_1\tilde{r}_{i1} & \tilde{w}_2\tilde{r}_{i2} & \cdot & \tilde{w}_j\tilde{r}_{ij} & \cdots & \tilde{w}_n\tilde{r}_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ \tilde{w}_1\tilde{r}_{m1} & \tilde{w}_2\tilde{r}_{m2} & \cdot & \tilde{w}_j\tilde{r}_{mj} & \cdots & \tilde{w}_n\tilde{r}_{mn} \end{bmatrix} \tag{9}$$

Table 1. Linguistic variable and the fuzzy triangular membership functions

Linguistic variable	Membership function	Domain	Triangular fuzzy scale
Very Low (VL	$\mu_{\tilde{M}}(x) = (0.1-x) / (0.1-0)$	$0 \le x \le 0.1$	0,0,0.1
Low (L)	$\mu_{\tilde{M}}(x) = (x-0) / (0.1-0)$	$0 \le x \le 0.1$	0,0.1,0.3
	$\mu_{\tilde{M}}(x) = (0.3-x) / (0.3-0.1)$	$0.1 \le x \le 0.3$	
Medium Low (ML)	$\mu_{\tilde{M}}(x) = (x-0.1) / (0.3-0.1)$	$0.1 \le x \le 0.3$	0.1,0.3,0.5
	$\mu_{\tilde{M}}(x) = (0.5-x) / (0.5-0.3)$	$0.3 \le x \le 0.5$	
Medium (M)	$\mu_{\tilde{M}}(x) = (x-0.3) / (0.5-0.3)$	$0.3 \le x \le 0.5$	0.3,0.5,0.7
	$\mu_{\tilde{M}}(x) = (0.7-x) / (0.7-0.5)$	$0.5 \le x \le 0.7$	
Medium High (MH)	$\mu_{\tilde{M}}(x) = (x-0.5) / (0.7-0.5)$	$0.5 \le x \le 0.7$	0.5,0.7,0.9
	$\mu_{\tilde{M}}(x) = (0.9-x) / (0.9-0.7)$	$0.7 \le x \le 0.9$	
High (H)	$\mu_{\tilde{M}}(x) = (x-0.7) / (0.9-0.7)$	$0.7 \le x \le 0.9$	0.7,0.9,1
	$\mu_{\tilde{M}}(x) = (1-x) / (1-0.9)$	$0.9 \le x \le 1$	
Very High (VH)	$\mu_{\tilde{M}}(x) = (x-0.9) / (1-0.9)$	$0.9 \le x \le 1$	0.9,1,1

The fuzzy positive-ideal solution (FPIS) A^* and the fuzzy negative-ideal solution (FNIS) A^- are calculated as Equations (10) and (11):

Positive Ideal solution:

$$A^* = \{ \tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^* \}, \text{ where } \tilde{v}_j^* = \{ (\max \tilde{v}_{ij} \mid i = 1,2,\ldots,m), j = 1,2,\ldots,n \} \quad (10)$$

Negative ideal solution:

$$A^- = \{ \tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^- \}, \text{ where } \tilde{v}_j^- = \{ (\max \tilde{v}_{ij} \mid i = 1,2,\ldots,m), j = 1,2,\ldots,n \} \quad (11)$$

The distance of each alternative from FPIS and FNIS can be calculated using Equations (12) and (13).

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}), \; i = 1, 2, \ldots, m \quad (12)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \; i = 1, 2, \ldots, m \quad (13)$$

Then, similarities to ideal solution are calculated. This step solves the similarities to an ideal solution by Equation (14):

$$CC_i^* = d_i^- / (d_i^* + d_i^-) \quad (14)$$

The CC_i^* is defined to determine the ranking order of all alternatives. Choose an alternative with maximum CC_i^* or rank alternatives according to CC_i^* in descending order.

Empirical Evidence

A comparison of five existing travel websites in Bangladesh serves to validate the model by testing the propositions that were developed. To preserve confidentiality, the five travel websites are referenced as WA_1, WA_2, WA_3, WA_4 and WA_5. A structured undisguised questionnaire was developed containing 37 closed questions and 5 open questions. The questionnaire was sent by e-mail to a convenience sample of about 346 contacts on April 10th 2011, with the invitation to complete the questionnaire for at least one travel website. One hundred and forty one respondents completed the questionnaire, 39 respondents for WA_1, 25 respondents for WA_2, 21 respondents for WA_3, 31 respondents for WA_4, and 25 respondents for WA_5.

The main goal of the questionnaire is to identify the major factors for travel agency websites quality from the viewpoint of users' perception. The hierarchy structure adopted in this study as a means of dealing with assessing the service quality of travel websites is shown in Figure 2.

The evaluation of the service website quality is conducted by a committee of experts consisting of five professionals from practice and two from the academia. The performance ratings or fuzzy pairwise comparison of sub-criteria with respect to the five alternatives and their weights using linguistic variables provided by committee of experts are given in Table 2. The fuzzy linguistic variable is then transformed into a fuzzy triangular membership function as shown in Table 3 using Table 1 and Figure 1.

Using Equation (9) and fuzzy multiplication Equation (5), fuzzy weighted decision matrix is calculated which is shown in Table 4.

Table 5 shows that the elements $\tilde{v}_{ij}$ are normalized positive triangular fuzzy numbers and their ranges belong to the closed interval [0,1]. Thus, fuzzy positive-ideal solution (FPIS) A^* and the fuzzy negative-ideal solution (FNIS) A^- can be defined as: $\tilde{v}_{j^*} = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$. Then, the distance of each alternative from A^* and A^- is calculated using Equations (10) and (11). After that, the similarities to an ideal solution are determined using Equation (14). The resulting fuzzy TOPSIS analyses are summarized in Table 5.

Based on the Table 5, the order of ranking the alternatives using fuzzy TOPSIS method results as follows:

$$WA_2 > WA_1 > WA_3 > WA_4 > WA_5$$

Discussions

Fuzzy TOPSIS is a preferred choice for the instance of imprecise or vague performance ratings in solving the proposed service quality problem. Based on the fuzzy TOPSIS analysis, a conclusion can be drawn from the viewpoint of users' perception that the website quality of WA_2 provides the best information and service. Due to the MCDM nature of the proposed problem, an optimal solution may not exist; however, the systematic evaluation of the MCDM problem can reduce the risk of

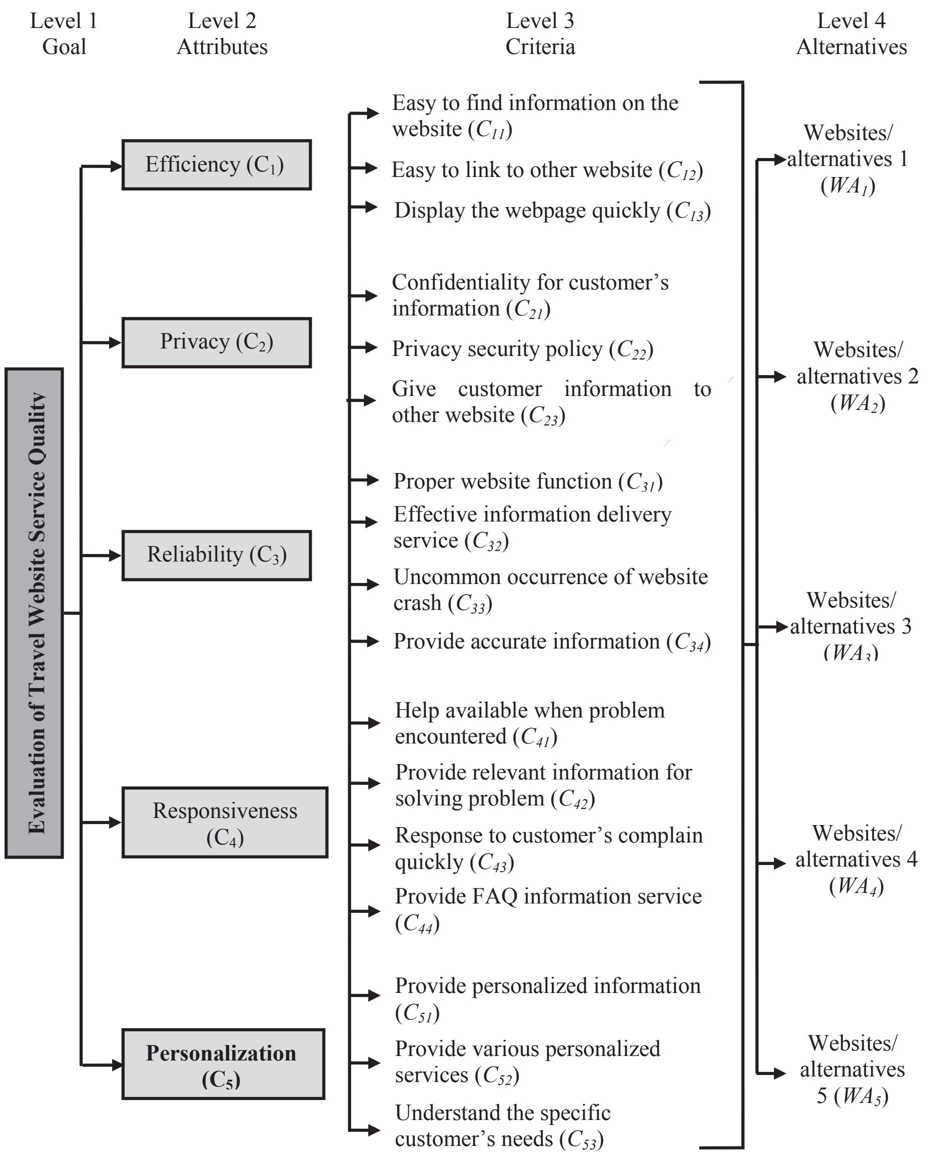

Figure 2. The objective hierarchy for evaluation of travel website service

a poor service quality selection.

Finally, there are some limitations to the fuzzy TOPSIS approach. The membership function of natural-language expression depends on the managerial perspective of the decision-maker. The decision maker must be at a strategic level in the company in order to evaluate the importance and trends of all aspects, such as strategy, marketing, and technology to evaluate travel website service quality.

Conclusions

As a result of the rapid development of information and communication technologies, customers have gained access to a wide range of new services on the Internet. To help travel service providers better understand how the online customers view their services relative to their competitors, a customer-driven model of TWSQ is a crucial management tool for the travel managers. Through establishing a proper and effective evaluation model for assessing the TWSQ, it can identify criteria and find the relative importance of criteria. The proposed methodology provides a systematic approach to narrow down the number of alternatives and to facilitate the decision making process. The proposed models can provide a guideline for the travel managers to provide appropriate levels of service quality in response to customers' needs.

As a future direction, other decision-making methods can be included in the methodology to ensure more integrated and/or comparative study. As another direction, TWSQ evaluation criteria number can be increased, and a user friendly interface can be prepared to speed up and simplify the calculations. For further research, the results of the study can be compared with those of

Table 2. Aggregated fuzzy comparison matrix of the attributes with respect to the overall objective

	WA_1	WA_2	WA_3	WA_4	WA_5	*Weights*
C_{11}	VH	M	M	VL	VH	M
C_{12}	ML	VH	MH	VL	MH	ML
C_{13}	VH	MH	ML	ML	VL	L
C_{21}	MH	VL	VH	MH	VL	M
C_{22}	VH	VL	ML	MH	ML	ML
C_{23}	M	VH	VL	VL	M	L
C_{31}	VL	ML	VH	VH	VL	M
C_{32}	VH	VL	VH	VH	M	L
C_{33}	VH	M	VH	M	VL	ML
C_{34}	VL	ML	VH	VL	MH	L
C_{41}	ML	ML	VH	VL	M	ML
C_{42}	VH	VL	MH	ML	MH	L
C_{43}	MH	VH	ML	VL	ML	ML
C_{44}	VH	M	MH	M	VL	L
C_{51}	VH	M	M	VH	VL	ML
C_{52}	VH	VH	ML	VL	VL	MH
C_{53}	VL	VL	VH	M	M	L

Table 3. Fuzzy decision matrix and fuzzy attribute weights

	WA_1	WA_2	WA_3	WA_4	WA_5	*Weights*
C_{11}	0.9,1,1	0.3,0.5,0.7	0.3,0.5,0.7	0,0,0.1	0.9,1,1	0.3,0.5,0.7
C_{12}	0.1,0.3,0.5	0.9,1,1	0.5,0.7,0.9	0,0,0.1	0.5,0.7,0.9	0.1,0.3,0.5
C_{13}	0.9,1,1	0.5,0.7,0.9	0.1,0.3,0.5	0.1,0.3,0.5	0,0,0.1	0,0.1,0.3
C_{21}	0.5,0.7,0.9	0,0,0.1	0.9,1,1	0.5,0.7,0.9	0,0,0.1	0.3,0.5,0.7
C_{22}	0.9,1,1	0,0,0.1	0.1,0.3,0.5	0.5,0.7,0.9	0.1,0.3,0.5	0.1,0.3,0.5
C_{23}	0.3,0.5,0.7	0.9,1,1	0,0,0.1	0,0,0.1	0.3,0.5,0.7	0,0.1,0.3
C_{31}	0,0,0.1	0.1,0.3,0.5	0.9,1,1	0.9,1,1	0.0,0.1	0.3,0.5,0.7
C_{32}	0.9,1,1	0,0,0.1	0.9,1,1	0.9,1,1	0.3,0.5,0.7	0,0.1,0.3
C_{33}	0.9,1,1	0.3,0.5,0.7	0.9,1,1	0.3,0.5,0.7	0,0,0.1	0.1,0.3,0.5
C_{34}	0,0,0.1	0.1,0.3,0.5	0.9,1,1	0,0,0.1	0.5,0.7,0.9	0,0.1,0.3
C_{41}	0.1,0.3,0.5	0.1,0.3,0.5	0.9,1,1	0,0,0.1	0.3,0.5,0.7	0.1,0.3,0.5
C_{42}	0.9,1,1	0,0,0.1	0.5,0.7,0.9	0.1,0.3,0.5	0.5,0.7,0.9	0,0.1,0.3
C_{43}	0.5,0.7,0.9	0.9,1,1	0.1,0.3,0.5	0,0,0.1	0.1,0.3,0.5	0.1,0.3,0.5
C_{44}	0.9,1,1	0.3,0.5,0.7	0.5,0.7,0.9	0.3,0.5,0.7	0,0,0.1	0,0.1,0.3
C_{51}	0.9,1,1	0.3,0.5,0.7	0.3,0.5,0.7	0.9,1,1	0,0,0.1	0.1,0.3,0.5
C_{52}	0.9,1,1	0.9,1,1	0.1,0.3,0.5	0,0,0.1	0,0,0.1	0.5,0.7,0.9
C_{53}	0.0,0.1	0,0,0.1	0.9,1,1	0.3,0.5,0.7	0.3,0.5,0.7	0,0.1,0.3

Table 4. Fuzzy-weighted decision matrix

	WA_1	WA_2	WA_3	WA_4	WA_5	*Weights*
C_{11}	0.27,0.5,0.7	0.09,0.25,0.49	0.09,0.25,0.49	0,0,0.07	0.27,0.5,0.7	0.3,0.5,0.7
C_{12}	0.01,0.09,0.25	0.09,0.3,0.5	0.05,0.21,0.45	0,0,0.05	0.05,0.21,0.45	0.1,0.3,0.5
C_{13}	0,0.1,0.3	0,0.07,0.27	0,0.03,0.15	0,0.03,0.15	0,0,0.03	0,0.1,0.3
C_{21}	0.15,0.35,0.63	0,0,0.07	0.27,0.5,0.7	0.15,0.35,0.63	0,0,0.07	0.3,0.5,0.7
C_{22}	0.09,0.3,0.5	0,0,0.05	0.01,0.09,0.25	0.05,0.21,0.45	0.01,0.09,0.25	0.1,0.3,0.5
C_{23}	0,0.05,0.21	0,0.1,0.3	0,0,0.03	0,0,0.03	0,0.05,0.21	0,0.1,0.3
C_{31}	0,0,0.07	0.03,0.15,0.35	0.27,0.5,0.7	0.27,0.5,0.7	0,0,0.07	0.3,0.5,0.7
C_{32}	0,0.1,0.3	0,0,0.03	0,0.1,0.3	0,0.1,0.3	0,0.05,0.21	0,0.1,0.3
C_{33}	0.09,0.3,0.5	0.03,0.15,0.35	0.09,0.3,0.5	0.03,0.15,0.35	0,0,0.05	0.1,0.3,0.5
C_{34}	0,0,0.03	0,0.03,0.15	0,0.1,0.3	0,0,0.03	0,0.07,0.27	0,0.1,0.3
C_{41}	0.01,0.09,0.25	0.01,0.09,0.25	0.09,0.3,0.5	0,0,0.05	0.03,0.15,0.35	0.1,0.3,0.5
C_{42}	0,0.1,0.3	0,0,0.03	0,0.07,0.27	0,0.03,0.15	0,0.07,0.27	0,0.1,0.3
C_{43}	0.05,0.21,0.45	0.09,0.3,0.5	0.01,0.09,0.25	0,0,0.05	0.01,0.09,0.25	0.1,0.3,0.5
C_{44}	0,0.1,0.3	0,0.05,0.21	0,0.07,0.27	0,0.05,0.21	0,0,0.03	0,0.1,0.3
C_{51}	0.09,0.3,0.5	0.03,0.15,0.35	0.03,0.15,0.35	0.09,0.3,0.5	0,0,0.05	0.1,0.3,0.5
C_{52}	0.45,0.7,0.9	0.45,0.7,0.9	0.05,0.21,0.45	0,0,0.09	0,0,0.09	0.5,0.7,0.9
C_{53}	0,0,0.03	0,0,0.03	0,0.1,0.3	0,0.05,0.21	0.3,0.5,0.7	0,0.1,0.3

Table 5. Fuzzy TOPSIS analysis

	$\widetilde{v}_{j1}$	$\widetilde{v}_{j2}$	$\widetilde{v}_{j3}$	$\widetilde{v}_{j4}$	$\widetilde{v}_{j5}$	A^*	A^-
C_{11}	0.27,0.5,0.7	0.09,0.25,0.49	0.09,0.25,0.49	0,0,0.07	0.27,0.5,0.7	1,1,1	0,0,0
C_{12}	0.01,0.09,0.25	0.09,0.3,0.5	0.05,0.21,0.45	0,0,0.05	0.05,0.21,0.45	1,1,1	0,0,0
C_{13}	0,0.1,0.3	0,0.07,0.27	0,0.03,0.15	0,0.03,0.15	0,0,0.03	1,1,1	0,0,0
C_{21}	0.15,0.35,0.63	0,0,0.07	0.27,0.5,0.7	0.15,0.35,0.63	0,0,0.07	1,1,1	0,0,0
C_{22}	0.09,0.3,0.5	0,0,0.05	0.01,0.09,0.25	0.05,0.21,0.45	0.01,0.09,0.25	1,1,1	0,0,0
C_{23}	0,0.05,0.21	0,0.1,0.3	0,0,0.03	0,0,0.03	0,0.05,0.21	1,1,1	0,0,0
C_{31}	0,0,0.07	0.03,0.15,0.35	0.27,0.5,0.7	0.27,0.5,0.7	0,0,0.07	1,1,1	0,0,0
C_{32}	0,0.1,0.3	0,0,0.03	0,0.1,0.3	0,0.1,0.3	0,0.05,0.21	1,1,1	0,0,0
C_{33}	0.09,0.3,0.5	0.03,0.15,0.35	0.09,0.3,0.5	0.03,0.15,0.35	0,0,0.05	1,1,1	0,0,0
C_{34}	0,0,0.03	0,0.03,0.15	0,0.1,0.3	0,0,0.03	0,0.07,0.27	1,1,1	0,0,0
C_{41}	0.01,0.09,0.25	0.01,0.09,0.25	0.09,0.3,0.5	0,0,0.05	0.03,0.15,0.35	1,1,1	0,0,0
C_{42}	0,0.1,0.3	0,0,0.03	0,0.07,0.27	0,0.03,0.15	0,0.07,0.27	1,1,1	0,0,0
C_{43}	0.05,0.21,0.45	0.09,0.3,0.5	0.01,0.09,0.25	0,0,0.05	0.01,0.09,0.25	1,1,1	0,0,0
C_{44}	0,0.1,0.3	0,0.05,0.21	0,0.07,0.27	0,0.05,0.21	0,0,0.03	1,1,1	0,0,0
C_{51}	0.09,0.3,0.5	0.03,0.15,0.35	0.03,0.15,0.35	0.09,0.3,0.5	0,0,0.05	1,1,1	0,0,0
C_{52}	0.45,0.7,0.9	0.45,0.7,0.9	0.05,0.21,0.45	0,0,0.09	0,0,0.09	1,1,1	0,0,0
C_{53}	0,0,0.03	0,0,0.03	0,0.1,0.3	0,0.05,0.21	0,0.05,0.21	1,1,1	0,0,0
d_i^+	13.6642	13.2785	13.7867	15.0051	15.3456		
d_i^-	4.1507	4.0976	4.1228	2.61662	2.4222		
CC_i^*	0.2330	0.2358	0.2302	0.1485	0.1363		

other fuzzy multi-criteria techniques such as fuzzy ELECTRE, fuzzy PROMETHEE, or fuzzy VIKOR.

References

Abdolvand, M.A., and Taghipouryan, M.J. (2011). Evaluation of Customs Service Quality by Using Fuzzy SERVQUAL and Fuzzy MCDM. American Journal of Scientific Research, 35:89-103.

Ashtiani, B., Haghighirad, F., Makui, A., and Montazer, G.A. (2009). Extension of fuzzy TOPSIS method based on interval-valued fuzzy sets. Applied Soft Computing, 9(2):457-461.

Benitez, J.M., Martin, J.C., and Roman, C. (2007). Using fuzzy number for measuring quality of service in the hotel industry. Tourism Management, 28(2):544-555.

Burns, E. (2006). Online Retail Revenues to Reach $200 Billion. ClickZ. com, 5 June.

Büyüközkan, G. (2010). A MCDM Tool to Evaluate Government Websites in a Fuzzy Environment. Multiple Criteria Decision Making for Sustainable Energy and Transportation Systems, 634(2): 201-210.

Chand, M. (2010).Measuring the service quality of Indian tourism destinations: an application of SERVQUAL model. International Journal of Services Technology and Management, 13(3/4): 218-233.

Chang, H.H., Wang, Y.H., and Yang, W.Y. (2009). The impact of e-service quality, customer satisfaction and loyalty on e-marketing: Moderating effect of perceived value. Total Quality Management & Business Excellence, 20(4):423-443.

Clemons, E.K., Hann, I.H., and Hitt, L.M. (2002). Price dispersion and differentiation in online travel: an empirical investigation. Management

Science, 48(4):534-549.

Dominic, P.D.D., Jati, H., and Kannabiran, G. (2010). Performance evaluation on quality of Asian e-government websites-an AHP approach. International Journal of Business Information Systems, 6(2):219-239.

Ertuğrul, Đ., and Karakasoğlu, N. (2009). Performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods. Expert Systems with Applications, 36(1):702-715

Gratzer, M., Werthner, H., and Winiwarter, W. (2004). Electronic business in tourism.International Journal of Electronic Business, 2(5): 450-459

Hwang, C.L., and Yoon, K. (1981). Multiple attributes decision making methods and applications. Springer, Berlin.

Jeong, M., Oh, H., and Gregoire, M. (2003). Conceptualizing web site quality and its consequences in the lodging industry. International Journal of Hospitality Management, 22(2):161-175.

Kabir, G. and Hasin, M.A.A. (2012). Framework for Benchmarking On-line Retailing Performance Using Fuzzy AHP and TOPSIS Method. International Journal of Industrial Engineering Computations, 3(4):561-576, 2012

Le, T.T. (2005). Business-to-business electronic marketplaces: evolving business models and competitive landscape. International Journal of Services Technology and Management, 6(1): 40-54.

Lai, C.S., Chen, C.S., and Lin, P.J. (2007). The effects of service quality on customer relational benefits in travel website. Management of Converging Technologies, Portland International Center for Management of Engineering and Technology (PICMET 2007), 5-9 August 2007:1133-1140.

Lee, C.C., Chiang, C., and Tzeng, G.H. (2009). The evaluation of travel website service quality by fuzzy MCDM.Proceedings of 17th Fuzzy Theory and Its Applications Symposium, Kaohsiung City, Taiwan, 18-19 December.

Lin, M.C., Wang, C.C., Chen, M.S., and Chang C. A. (2008). Using AHP and TOPSIS approaches in customer-driven product design process. Computers in Industry, 59(1):17-31.

Liou, T.S., and Chen, C.W. (2006).Subjective appraisal of service quality using fuzzy linguistic assessment. International Journal of Quality & Reliability Management, 23(8): 928-943.

Longhi, C. (2009). Internet and organisation of the industry in Tourism: a focus on the distribution of travel and tourism services. International Journal of Leisure and Tourism Marketing, 1(2):131-151.

Mustafa, A., Jia-Pei, F. Siaw-Peng, L., and Hamid, H.A. (2005).The evaluation of airline service quality using the Analytic Hierarchy Process (Ahp). Proceedings of International Conference on Tourism Development, Penang, Malaysia, 9-11 January.

Oliveira, R.C. (2007). Evidences from link between quality and loyalty in e-service: An empirical study. SISTEMAS & GESTÃO, 2(1):1-15.

Palmer, J.W. (2002). Website usability, design, and performance metrics. Information Systems Research, 13(2):151-167.

Pan, B., and Fesenmaier, D.R. (2000). A typology of tourism related web sites: its theoretical background and implications. Information Technology and Tourism, 3(3/4):155-176.

Parameshwaran, R., Srinivasan, P.S.S., Punniyamoorthy, M., Charunyanath, S.T., and Ashwin, C. (2009). Integrating fuzzy analytical hierarchy process and data envelopment analysis for performance management in automobile repair shops. European Journal of Industrial Engineering, 3(4):450-467.

Parasuraman, A., Zeithaml, V.A., and Berry, L.L. (1985). A conceptual model of service quality and its implications for future research.Journal of Marketing, 49(4):41-50.

Parasuraman, A., Zeithaml, V.A., and Berry, L.L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. Journal of Retailing, 64(1):12-40.

Rahman, Z., and Qureshi, M.N. (2009). Fuzzy approach to measuring healthcare service quality. International Journal of Behavioral and Healthcare Research, 1(2):105-124.

Reichheld, F.F., Markey Jr, R.G., and Hopton, C. (2000). E-customer loyalty-applying the traditional rules of business for online success. European Business Journal, 12(4):173-179.

Robbins, S.S., and Stylianou, A.C. (2003). Global corporate websites: an empirical investigation of content and design. Information and Management, 40(3):205-212.

Rowley, J. (2006). An analysis of the e-service literature: towards a research agenda. Internet Research, 16(3):339-359.

Santos, J. (2003). E-service quality: a model of virtual service quality dimensions. ManagingService Quality, 13(3):233-246.

Shen, H., Wei, J., and Zheng, L. (2009).An empirical study on the influential factors of travel agency websites quality based on the users' perception. International Journal of Services Technology and Management, 12(2):216-230.

Shih, H.P. (2004). An empirical study on predicting user acceptance of e-shopping on the Web. Information and Management, 41(3):351-368.

Shipley, M.F., and Coy, S.P. (2009).A fuzzy logic model for competitive assessment of airline service quality. International Journal of Productivity and Quality Management, 4(1): 84-102.

Sun, C.C., and Lin, G.T.R. (2009). Using fuzzy TOPSIS method for evaluating the competitive advantages of shopping websites. Expert Systems with Applications, 36(9):11764-11771.

Szymanski, D.M., and Hise, R.T. (2000). E-satisfaction: an initial examination. Journal of Retailing, 76(3):309-322.

Telfer, D.J., and Sharpley, R. (2008).Tourism and Development in the Developing World. Abingdon (Oxon) and New York, Routledge, 263.

Wang, T.C., and Chang, T.H. (2007). Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment. Expert Systems with Applications, 33(4):870-880.

Wang, Y.M., and Elhag, T.M.S. (2006). Fuzzy TOPSIS method based on alpha level sets with an application to bridge risk assessment. Expert Systems with Applications, 31(2):309-319.

Wang, Y.J., and Lee, H.S. (2007). Generalizing TOPSIS for fuzzy multiple-criteria group decision-making. Computers and Mathematics with Applications, 53(11):1762-1772.

Yang, T., and Hung, C.C. (2007). Multiple-attribute decision making methods for plant layout design problem. Robotics and Computer-Integrated Manufacturing, 23(1):126-137.

Yang, H.E., Wu, C.C., and Wang, K.C. (2009). An empirical analysis of online game service satisfaction and loyalty. Expert Systems with Applications, 36(2):1816-1825.

Yen, B.P.C. (2005). Analysis of evaluation models for websites. International Journal of Internet and Enterprise Management, 3(3):280-303.

Yen, C.H., and Lu, H.P. (2008). Effects of e-service quality on loyalty intention: an empirical study in online auction. Managing Service Quality, 18(2):127-146.

Zadeh, L.A. (1965). Fuzzy Sets. Information and Control, 8(2):338-353.

Zeithaml, V.A., Parasurman, A., and Malhotra, A. (2002). Service Quality Delivery through Web Site: A Critical Review of Extant Knowledge. Journal of the Academy of Marketing Science, 30(4):362-375.