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COMPARATIVE ANALYSIS OF TOPSIS AND FUZZY TOPSIS FOR THE EVALUATION OF TRAVEL WEBSITE SERVICE QUALITY

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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 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, and most criteria have some degree of interdependent or interactive characteristics. In the face of the strong competition 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 multiple-attribute decision making (MADM) approaches for the evaluation of TWSQ. A comparative analysis of Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Fuzzy TOPSIS methods are illustrated through a practical application from the websites of five travel agencies. Empirical results showed that the proposed methods are viable approaches in solving the evaluation problem of TWSQ.*

Keywords: *Fuzzy set theory; MADM; TOPSIS; TWSQ*

1. INTRODUCTION

Internet has had a tremendous impact on today's travel and tourism business due to the rapidly growing online market over the past several years [41]. The Internet has become one of the most important channels for business (Teich et al., 2000; Le, 2005). Consumers used the Internet to find travel options, seek the best possible prices, and book reservations for airline tickets, hotel rooms, car rentals, cruises, and tours (Longhi, 2009; Gratzer et al., 2004). 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 & Fesenmaier, 2000).

A website offers a business not only a platform to promote products or services but also another avenue to generate revenue by attracting more customers. Website quality should be defined as how much the website helps the users to achieve their objectives and how well the website responds to user's requirement technically (Kim, 2006). 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 successful 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, 1988) were the first to introduce a formal service quality model. Service quality is measured along five fundamental quality dimensions: tangibles (appearance of physical facilities, equipment, personnel, and communication materials), reliability (the ability of the firm to perform the promised service dependably and accurately), responsiveness (willingness to help customers and provide prompt service), assurance (knowledge and courtesy of the employees and their ability to convey trust and confidence), and empathy (the caring and individualized attention provided to the customer). Zeithaml et al. (2000) developed 11 SERVQUAL-related dimensions based on focus group research. Zeithaml et al. (2000) suggest measuring user interface quality in three dimensions, namely accessibility, navigation and aesthetics. 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 (Chand, 2010) used the five dimensions of SERVQUAL instrument and the characteristics of Internet as a basis for developing the measurement dimensions that affect website service quality, but Rowley (2006) revealed that these studies have 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. Parasuraman et al. (2005) developed E-S-QUAL scale that effectively captured the nature of electronic service quality from the perspective of online shopping through a Website. The E-S-QUAL scale measures four dimensions of electronic service quality, namely Efficiency, System Availability, Fulfillment, and Privacy.

To explore the previous related studies, most of the conventional measurement methods for evaluating website service quality use statistical methods to analyze it. During recent years, different website evaluation approaches have been introduced. These deal, for example, with website usability and design (Palmer, 2002), content (Robbins & Stylianou, 2003), quality (Dominic et al., 2010), user acceptance (Shih, 2004), and user satisfaction (Szymanski & Hise, 2000) being the most common outcomes measured to evaluate websites. 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 was given to evaluating the consistency between web strategy and web presence, which can be considered as an internal evaluation, from the company's view point.

Multiple attribute or criteria decision making is one of the major tools for the evaluation of service quality in different field. MADM deals with the problem of choosing an option from a set of alternatives which are characterized in terms of their attributes (Hwang & Yoon, 1981). The decision maker may express or define a ranking for the attributes as importance/weights. The aim of the MADM is to obtain the optimum alternative that has the highest degree of satisfaction for all of the relevant attributes. Seven-point or five-point Likert scales is one of the major ways to collect the rating of different website service quality attributes (Yen & Lu, 2008; Chang et al., 2009). 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, the increasing numbers of studies have dealt with uncertain fuzzy problems by applying the fuzzy set theory extensively to help solving the service quality problems (Liou & Chen, 2006; Benitez et al., 2007; Shipley & Coy, 2009; Parameshwaran et al., 2009; Rahman & Qureshi, 2009; Büyüközkan, 2010). In the last few years, some fuzzy TOPSIS methods were developed in the different applied field. Lin et al. (2008) adopted fuzzy TOPSIS for order selection and pricing of manufacturer (supplier) with make-to-order basis when orders exceed production capacity. Wang & Chang (2007) applied fuzzy TOPSIS to help the Air Force Academy in Taiwan choose optimal initial training aircraft in a fuzzy environment. 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. Chen et al. (2006) applied fuzzy TOPSIS approach to deal with the supplier selection problem in supply chain system.

The main purpose of this research is to evaluate the major factors for travel agency websites quality from the viewpoint of users' perception and to develop a systematic multiple-attribute evaluation model including the comparison of both TOPSIS and Fuzzy TOPSIS, to find out the effective travel agency websites. Analytic Hierarchy Process (AHP) is applied to determine the weights of evaluation criteria and TOPSIS and fuzzy TOPSIS methods are utilized to rank the service quality of the travel agency websites. This research looks forward 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. The theories for the two MADM methods are discussed in detail sequentially in the next section. Section 3 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 Section 4. Finally, the last section contains some conclusions reached in this paper.

2. TOPSIS METHOD AND FUZZY TOPSIS METHOD

2.1 TOPSIS Method

TOPSIS is one of the useful Multi Attribute Decision Making techniques that are very simple and easy to implement, so that it is used when the user prefers a simpler weighting approach. On the other hand, the AHP approach provides a decision hierarchy and requires pairwise comparison among criteria (Lee et al., 2001). TOPSIS method was firstly proposed by Hwang & 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 & Chang, 2007; Wang & Elhag, 2006; Wang & 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 & Karakasoğlu, 2009).

A MADM problem with m alternatives (A_1, A_2,…., A_m) that are evaluated by n attributes (C_1, C_2,…., C_n) can be viewed as a geometric system with m points in n-dimensional space. An element x_{ij} of the matrix indicates the performance rating of the ith alternative, A_i, with respect to the jth attribute, C_j, as shown in Eqs. (1).

The terms used in the present study are briefly defined as follows:

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.

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccccc} C_1 & C_2 & C_3 & . & . & . & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & . & . & . & x_{1n} \\ x_{21} & x_{22} & x_{23} & . & . & . & x_{2n} \\ x_{31} & x_{32} & x_{33} & . & . & . & x_{3n} \\ . & . & . & . & . & . & . \\ x_{m1} & x_{m2} & x_{m3} & . & . & . & x_{mn} \end{bmatrix} \end{array} \quad (1)$$

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 (w_j) represent the relative importance of each attribute to the others. $W = \{w_j | j = 1, 2, …., n\}$.

Normalization: Normalization seeks to obtain comparable scales, which allows attribute comparison. The vector normalization approach divides the rating of each attribute by its norm to calculate the normalized value of x_{ij} as defined in Eqs. (2):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad i = 1, 2, …., m; \; j = 1, 2, …., n \qquad (2)$$

Given the above terms, the formal TOPSIS procedure is defined as follows:

Step 1: Construct normalized decision matrix. This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria.

Step 2: Construct the weighted normalized decision matrix. Assume a set of weights for each criteria w_j for $j = 1,…,n$. Multiply each column of the normalized decision matrix by its associated weight. An element of the new matrix is:

$v_{ij} = w_j r_{ij}$, for i = 1, 2,…, m; j = 1, 2,…, n (3)

Step 3: Determine the positive ideal (A^*) and negative ideal (A^-) solutions. The A^* and A^- are defined in terms of the weighted normalized values, as shown in Eqs. (4) and (5), respectively:

Positive Ideal solution:

$$A^* = \{ v_1^*, …, v_n^* \}, \text{ where } v_j^* = \{ \max (v_{ij}) \text{ if } j \in J ; \; \min (v_{ij}) \text{ if } j \in J' \} \qquad (4)$$

Negative ideal solution:

$$A^- = \{ v_1^-, …, v_n^- \}, \text{ where } v' = \{ \min (v_{ij}) \text{ if } j \in J ; \; \max (v_{ij}) \text{ if } j \in J' \} \qquad (5)$$

Where J is a set of benefit attributes (larger-the-better type) and J' is a set of cost attributes (smaller-the-better type).

Step 4: Calculate the separation measures for each alternative.

The separation of each alternative from the positive ideal alternative is:

$$S_i^* = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^*)^2}, \qquad i = 1,…, m \quad (6)$$

Similarly, the separation of each alternative from the negative ideal alternative is:

$$S_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}, \quad i = 1,…, m \quad (7)$$

Step 5: Calculate the relative closeness to the ideal solution or similarities to ideal solution CC_i^*

$$C_i^* = S_i^- / (S_i^* + S_i^-), \; 0 < C_i^* < 1 \qquad (8)$$

Note that $0 \le C_i^* \le 1$, where $C_i^* = 0$ when $A_i = A^-$, and $C_i^* = 0$, when $A_i = A^*$

Step 6: By comparing C_i^* values, the ranking of alternatives are determined. Choose an alternative with maximum C_i^* or rank alternatives according to C_i^* in descending order.

2.2 Fuzzy TOPSIS Model

It is often difficult for a decision-maker to assign a precise performance rating to an alternative for the attributes under consideration. The merit of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of precise numbers. This section extends the TOPSIS to the fuzzy environment (Yang & Hung, 2007). This method is particularly suitable for solving the group decision-making problem under fuzzy environment. The rationale of fuzzy theory has been reviewed before the development of fuzzy TOPSIS. The mathematics concept borrowed from Ashtiani et al. (2009), Buyukozkan et al. (2007) and Wang & Chang (2007), Kabir et al. (2011); Bahram and Asghari, 2011; Kalpande *et al.*, 2010; Tadic *et al.*, 2010):

Definition 1: A fuzzy set $\tilde{M}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{M}}(x)$ which associates with each element x in X, a real number in the interval [0, 1]. The function value $\mu_{\tilde{M}}(x)$ is termed the grade of membership of x in $\tilde{M}$. The present study uses triangular fuzzy numbers. A triangular fuzzy number $\tilde{a}$ can be defined by a triplet (a_1, b_1, c_1). Its conceptual schema and mathematical form are shown by Eqs. (9):

$$\mu(x \backslash \tilde{M}) = \begin{cases} 0, & x \le a_1, \\ (x-a_1)/(b_1-a_1), & a_1 < x \le b_1, \\ (c_1-x)/(b_1-c_1), & b_1 < x \le c_1, \\ 0, & x > c_1, \end{cases} \quad (9)$$

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

$$d(\tilde{M}_1, \tilde{M}_2) = \left[\frac{1}{3}\{(a_1-a_2)^2 + (b_1-b_2)^2 + (c_1-c_2)^2\}\right]^{1/2} \quad (10)$$

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

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

$\tilde{M}_1 \oplus \tilde{M}_2 = a_1 + a_2, b_1 + b_2, c_1 + c_2$ (11)

$\tilde{M}_1 \Theta \tilde{M}_2 = a_1 - a_2, b_1 - b_2, c_1 - c_2$ (12)

$\tilde{M}_1 \otimes \tilde{M}_2 = a_1a_2, b_1b_2, c_1c_2$ (13)

The fuzzy MADM can be concisely expressed in matrix format as Eqs. (14) and (15).

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccccc} C_1 & C_2 & C_3 & . & . & . & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \tilde{x}_{13} & . & . & . & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{23} & . & . & . & \tilde{x}_{2n} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \tilde{x}_{m3} & . & . & . & \tilde{x}_{mn} \end{bmatrix} \end{array}$$

$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n]$ (15)

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

The normalized fuzzy decision matrix denoted by $\tilde{R}$ is shown as Eqs. (16):

$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}$ (16)

The weighted fuzzy normalized decision matrix is shown as Eqs. (17):

$$\tilde{V} = \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & . & \tilde{v}_{1j} & . & . & \tilde{v}_{1n} \\ \tilde{v}_{21} & \tilde{v}_{22} & . & \tilde{v}_{2j} & . & . & \tilde{v}_{2n} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ \tilde{v}_{i1} & \tilde{v}_{i2} & . & \tilde{v}_{ij} & . & . & \tilde{v}_{in} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ \tilde{v}_{m1} & \tilde{v}_{m2} & . & \tilde{v}_{mj} & . & . & \tilde{v}_{mn} \end{bmatrix} = \begin{bmatrix} \tilde{w}_1\tilde{r}_{11} & \tilde{w}_2\tilde{r}_{12} & . & \tilde{w}_j\tilde{r}_{1j} & . & . & \tilde{w}_n\tilde{r}_{1n} \\ \tilde{w}_1\tilde{r}_{21} & \tilde{w}_2\tilde{r}_{22} & . & \tilde{w}_j\tilde{r}_{2j} & . & . & \tilde{w}_n\tilde{r}_{2n} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ \tilde{w}_1\tilde{r}_{i1} & \tilde{w}_2\tilde{r}_{i2} & . & \tilde{w}_j\tilde{r}_{ij} & . & . & \tilde{w}_n\tilde{r}_{in} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ \tilde{w}_1\tilde{r}_{m1} & \tilde{w}_2\tilde{r}_{m2} & . & \tilde{w}_j\tilde{r}_{mj} & . & . & \tilde{w}_n\tilde{r}_{mn} \end{bmatrix} \quad (17)$$

Given the above fuzzy theory, the proposed fuzzy TOPSIS procedure is then defined as follows:

Step 1: Choose the linguistic ratings ($\tilde{x}_{ij}$, $i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, n$) for alternatives with respect to criteria and the appropriate linguistic variables ($\tilde{w}_j$, $j = 1, 2, \ldots, n$) for the weight of the criteria.

The fuzzy linguistic rating ($\tilde{r}_{ij}$) preserves the property that the ranges of normalized triangular fuzzy numbers belong to [0, 1]; thus, there is no need for a normalization procedure. For this instance, the $\tilde{D}$ defined by Eqs. (15) is equivalent to the $\tilde{R}$ defined by Eqs. (17).

Step 2: Construct the weighted normalized fuzzy decision matrix. The weighted normalized value $\tilde{V}$ is calculated by Eqs. (18).

Step 3: Identify positive ideal (A^*) and negative ideal (A^-) solutions. The fuzzy positive-ideal solution (FPIS, A^*) and the fuzzy negative-ideal solution (FNIS, A^-) are shown as Eqs. (18) and (19):

Positive Ideal solution:

$$A^* = \{ \tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^* \}, \text{ where } \tilde{v}_j^* = \{(\max \tilde{v}_{ij} \mid i = 1,2,\ldots,m), j = 1,2,\ldots,n\} \quad (18)$$

Negative ideal solution:

$$A^- = \{ \tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^- \}, \text{ where } \tilde{v}_j^- = \{(\max \tilde{v}_{ij} \mid i = 1,2,\ldots,m), j = 1,2,\ldots,n\} \quad (19)$$

Step 4: Calculate separation measures. The distance of each alternative from A^* and A^- can be currently calculated using Eqs. (20) and (21).

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*) \quad i = 1, 2, \ldots, m \quad (20)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-) \quad i = 1, 2, \ldots, m \quad (21)$$

Step 5: Calculate similarities to ideal solution. This step solves the similarities to an ideal solution by Eqs. (22):

$$CC_i^* = d_i^- / (d_i^* + d_i^-) \quad (22)$$

Step 6: Rank preference order. Choose an alternative with maximum CC_i^* or rank alternatives according to CC_i^* in descending order. The proposed fuzzy TOPSIS is then applied to the case study as shown in the next section.

3. AN EMPIRICAL STUDY

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 consumer survey was conducted towards meeting the objectives of the present study. A structured undisguised questionnaire was developed containing 37 closed questions and 5 open questions. The questionnaire was sent by e-mail to a random and convenience sample of the travel service providers, customers, academic experts and professional executives of about 412 contacts on April 10th 2010, with the invitation to complete the questionnaire for at least one travel website and 253 respondents completed the questionnaire, a response rate of 61.4%.

For the actual survey, individuals from the sample were invited by e-mail to participate in the Web survey. The e-mail invitation letter described the purpose of the study and assured the confidentiality of information provided by respondents. The participants were asked to continue the survey only if they have taken services from any travel service providers. Then, the participants were directed to a Web site by clicking on a URL in the e-mail to reach the survey webpage. About a week later, a second reminder e-mail was sent to the people who did not respond to the Web survey. Two weeks after, a third reminder e-mail was sent to the people who did not respond to the Web survey.

The majority of respondents aged between 17-25 and 43-62, while 39.7% of the respondents were female. The respondents of the study also indicated that they were employed in many different occupations. 38.7% of the respondents had a job related to the professional, technical, and related occupations, and about 21.5% had a job related to executive, administrative, and managerial occupations, as well as administrative support occupations. As far as the educational and economical level is concerned, most of the respondents (78.3%) were highly educated (hold university and master degrees) and financially sound.

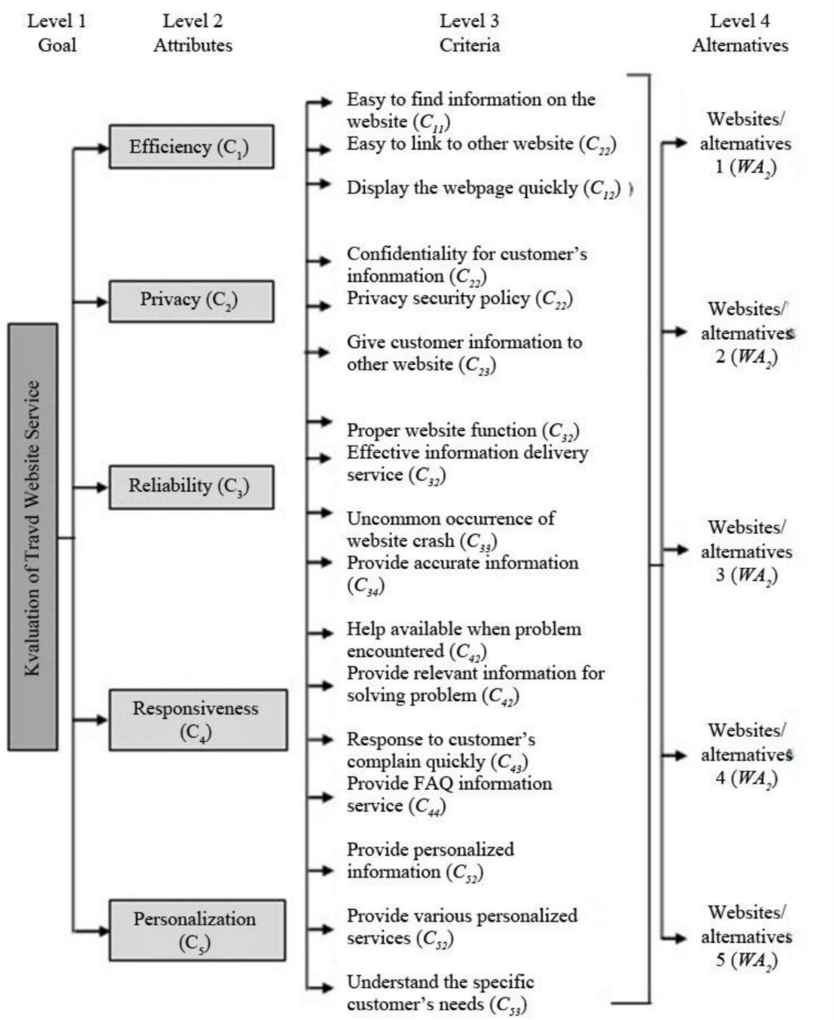

Figure 1: The objective hierarchy for evaluation of travel website service

The main goal of the questionnaire is to identify the factors for travel agency websites quality from the viewpoint of users' perception. The selection of the potential criteria and evaluation of the service website quality is conducted by a committee of experts that are comprised of seven professionals from practice and three from the academia. The committee of experts identifies effective and major criteria among all the attributes shown to the respondents in the survey. The hierarchy structure adopted in this study was developed by the committee of experts as a means of dealing with assessing the service quality of travel website is shown in Figure 1: the objective hierarchy for evaluation of travel website service.

The performance ratings given by the committee of experts for the 17 criteria from 5 attributes with respect to the five alternatives are summarized in Table 1 decision matrix. The decision matrix from Table 1 is used for the TOPSIS analysis and fuzzy TOPSIS analysis.

3.1 Empirical illustrations for TOPSIS method

Based on the first step of the TOPSIS procedure, each element is normalized by Eqs. (2). The resulting normalized decision matrix for the TOPSIS analysis is shown as Table 2.

Table 1: Decision matrix

	(WA_1)	(WA_2)	(WA_3)	(WA_4)	(WA_5)
(C_{11})	8	7	7	6	8
(C_{12})	6	8	7	5	7
(C_{13})	8	7	6	6	5
(C_{21})	7	5	8	7	5
(C_{22})	8	5	6	7	6
(C_{23})	4	3	5	5	4
(C_{31})	5	6	8	8	5
(C_{32})	7	5	7	7	6
(C_{33})	4	5	4	5	6
(C_{34})	6	7	9	6	8
(C_{41})	6	6	9	5	7
(C_{42})	8	5	7	6	7
(C_{43})	7	8	6	5	6
(C_{44})	9	7	8	7	5
(C_{51})	8	7	7	8	6
(C_{52})	9	9	7	6	6
(C_{53})	6	6	8	7	7

Table 2: Normalized decision matrix for TOPSIS analysis

	(WA_1)	(WA_2)	(WA_3)	(WA_4)	(WA_5)
(C_{11})	0.2777	0.2653	0.2386	0.2304	0.3123
(C_{12})	0.2083	0.3032	0.2386	0.192	0.2733
(C_{13})	0.2777	0.2653	0.2045	0.2304	0.1952
(C_{21})	0.243	0.1895	0.2726	0.2688	0.1952
(C_{22})	0.2777	0.1895	0.2045	0.2688	0.2343
(C_{23})	0.1388	0.1137	0.1704	0.192	0.1562
(C_{31})	0.1736	0.2274	0.2726	0.3072	0.1952
(C_{32})	0.243	0.1895	0.2386	0.2688	0.2343
(C_{33})	0.1388	0.1895	0.1363	0.192	0.2343
(C_{34})	0.2083	0.2653	0.3067	0.2304	0.3123
	(WA_1)	(WA_2)	(WA_3)	(WA_4)	(WA_5)
(C_{41})	0.2083	0.2274	0.3067	0.192	0.2733
(C_{42})	0.2777	0.1895	0.2386	0.2304	0.2733
(C_{43})	0.243	0.3032	0.2045	0.192	0.2343
(C_{44})	0.3124	0.2653	0.2726	0.2688	0.1952
(C_{51})	0.2777	0.2653	0.2386	0.3072	0.2343
(C_{52})	0.3124	0.3411	0.2386	0.2304	0.2343
(C_{53})	0.2083	0.2274	0.2726	0.2688	0.2733

The second step requires the attribute weight information to calculate the weighted normalized ratings. The relative importance of each criterion can be obtained from the AHP method. The corresponding definitions for the importance ratios are shown in Table 3.

Table 3: Linguistic definition for importance ratios of two selected items

Level of importance (a_{ij})	Linguistic definition for comparison of the i^{th} and the j^{th} items
1	The i^{th} item is equal important as the j^{th} item
3	The i^{th} item is slightly more important than the j^{th} item
5	The i^{th} item is more important than the j^{th} item
7	The i^{th} item is strongly more important than the j^{th} item
9	The i^{th} item is extremely more important than the j^{th} item
2,4,6,8	The intermediate values between two adjacent judgments
$1/a_{ij} = a_{ji}$	The inverse comparison between the i^{th} and the j^{th} items

For instance, the judgment matrix and the weights of four criteria under the third attribute i.e., responsiveness, given by the committee of experts can be figured out as Table 4.

The weights of the all evaluation objectives can be obtained in the same manner as shown in Table 5.

Then, weighted normalized matrix is formed by multiplying each value with their corresponding weights. Table 6 shows the normalized weighted decision matrix for each alternative with respect to the each criterion. Positive and negative ideal solutions are determined by taking the maximum and minimum values for each criterion using Eqs. (4) and (5). Then the distance of each alternative from PIS and NIS with respect to each criterion are calculated with the help of Eqs. (6) and (7). Table 6 shows the separation measure of each alternative form PIS and NIS. The closeness coefficient of each logistics service provider is calculated by using Eqs. (8) and the ranking of the alternatives are determined according to these values in Table 6.

Table 4: The pairwise comparison table of the relative importance

Criteria of Attribute (Reliability)	C_{31}	C_{32}	C_{33}	C_{34}	Weights
Proper website function (C_{31})	1	5	3	7	0.56
Privacy security policy (C_{32})	1/5	1	1/3	3	0.12
Uncommon occurrence of website crash (C_{33})	1/3	3	1	5	0.26
Provide accurate information (C_{34})	1/7	1/3	1/5	1	0.06

Table 5: The weight of all evaluation objectives

Criteria	Attributes	Weight	Criteria	Attributes	Weight
(C_1)		0.23		(C_{33})	0.26
	(C_{11})	0.43		(C_{34})	0.06
	(C_{12})	0.38	(C_4)		0.18
	(C_{13})	0.19		(C_{41})	0.33
(C_2)		0.12		(C_{42})	0.19
	(C_{21})	0.51		(C_{43})	0.39
	(C_{22})	0.30		(C_{44})	0.09
	(C_{23})	0.19	(C_5)		0.11
(C_3)		0.36		(C_{51})	0.28
	(C_{31})	0.56		(C_{52})	0.61
	(C_{32})	0.12		(C_{53})	0.11

Finally, the sixth step ranks the alternatives according to Table 6. The order of ranking the alternatives using TOPSIS method results as follows:
$WA_2 > WA_3 > WA_4 > WA_1 > WA_5$

According to the final scores, it can be concluded that the website quality of WA_2 provides the best information and service from the viewpoint of users' perception.

Table 6: TOPSIS analysis results

	(WA_1)	(WA_2)	(WA_3)	(WA_4)	(WA_5)	v_j*	v_j^-
(C_{11})	0.1194	0.1141	0.1026	0.0991	0.1343	0.1343	0.0991
(C_{12})	0.0792	0.1152	0.0907	0.073	0.1039	0.1152	0.073
(C_{13})	0.0528	0.0504	0.0389	0.0438	0.0371	0.0528	0.0371
(C_{21})	0.1239	0.0966	0.139	0.1371	0.0996	0.139	0.0966
(C_{22})	0.0833	0.0569	0.0614	0.0806	0.0703	0.0833	0.0569
(C_{23})	0.0264	0.0216	0.0324	0.0365	0.0297	0.0216	0.0365
(C_{31})	0.0972	0.1273	0.1527	0.172	0.1093	0.172	0.0972
(C_{32})	0.0292	0.0227	0.0286	0.0323	0.0281	0.0323	0.0227
(C_{33})	0.0361	0.0493	0.0354	0.0499	0.0609	0.0354	0.0609
(C_{34})	0.0125	0.0159	0.0184	0.0138	0.0187	0.0187	0.0125
(C_{41})	0.0687	0.075	0.1012	0.0634	0.0902	0.1012	0.0634
(C_{42})	0.0528	0.036	0.0453	0.0438	0.0519	0.0528	0.036
(C_{43})	0.0948	0.1182	0.0798	0.0749	0.0914	0.1182	0.0749
(C_{44})	0.0281	0.0239	0.0245	0.0242	0.0176	0.0281	0.0176
(C_{51})	0.0778	0.0743	0.0668	0.086	0.0656	0.086	0.0656
(C_{52})	0.1906	0.2081	0.1455	0.1405	0.1429	0.2081	0.1405
(C_{53})	0.0229	0.025	0.03	0.0296	0.0301	0.0301	0.0229
S_i*	0.09717	0.07968	0.09280	0.10742	0.11126		
S_i^-	0.07599	0.09959	0.08447	0.09159	0.06410		
C_i*	0.43884	0.55553	0.4765	0.46023	0.36553		

3.2 Empirical illustrations for Fuzzy TOPSIS method

Numeric performance ratings of Table 1 are adopted again for the Fuzzy TOPSIS analysis. In order to transform the performance ratings to fuzzy linguistic variables as discussed in the previous section, the performance ratings in Table 1 are normalized into the range of [0,1] by Eqs. (23) and (24) (Cheng, 1999):

(i) The larger the better type:

$$r_{ij} = [x_{ij} - \min\{x_{ij}\}] / [\max\{x_{ij}\} - \min\{x_{ij}\}] \quad (23)$$

(ii) The smaller the better type:

$$r_{ij} = [\max\{x_{ij}\} - x_{ij}] / [\max\{x_{ij}\} - \min\{x_{ij}\}] \quad (24)$$

For the present study, C_{23} and C_{33} are the smaller-the better type, the others belong to the larger-the-better type. Table 7 shows the Normalized decision matrix for fuzzy TOPSIS analysis transformed from Table 1.

3.2.1 Fuzzy membership function

The decision makers use the linguistic variables to evaluate the importance of attributes and the ratings of alternatives with respect to various attributes. The present study has only precise values for the performance ratings and for the attribute weights. In order to illustrate the idea of fuzzy MADM, the existing precise values has 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). The purpose of the transformation process has two folds as: (i) to illustrate the proposed fuzzy TOPSIS method and (ii) to benchmark the empirical results with other precise value methods in the later analysis.

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 easy of 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 and thus, is used for the analysis hereafter. A transformation table can be found as shown in Table 8. For example, the fuzzy variable - Very Low has its associated triangular fuzzy number with minimum of 0.00, mode of 0 and maximum of 0.1. The same definition is then applied to the other fuzzy variables Low, Medium Low, Medium, Medium High, High and Very High. Figure 2 illustrates the fuzzy membership functions.

The next step uses the fuzzy membership function to transform Table 7 into Table 9 as explained by the following example. If the numeric rating is 0.67, then its fuzzy linguistic variable is ‘‘MH’’. This transformation is also applied to the attributes respectively. Then, the resulting fuzzy linguistic variables are show as Table 9.

Table 7: Normalized decision matrix for fuzzy TOPSIS analysis

	(WA_1)	(WA_2)	(WA_3)	(WA_4)	(WA_5)
(C_{11})	1	0.5	0.5	0	1
(C_{12})	0.33	1	0.67	0	0.67
(C_{13})	1	0.67	0.33	0.33	0
(C_{21})	0.67	0	1	0.67	0
(C_{22})	1	0	0.33	0.67	0.33
(C_{23})	0.5	1	0	0	0.5
(C_{31})	0	0.33	1	1	0
(C_{32})	1	0	1	1	0.5
(C_{33})	1	0.5	1	0.5	0
(C_{34})	0	0.33	1	0	0.67
(C_{41})	0.25	0.25	1	0	0.5
(C_{42})	1	0	0.67	0.33	0.67
(C_{43})	0.67	1	0.33	0	0.33
(C_{44})	1	0.5	0.75	0.5	0
(C_{51})	1	0.5	0.5	1	0
(C_{52})	1	1	0.33	0	0
(C_{53})	0	0	1	0.5	0.5

Table 8: Linguistic variable and the fuzzy triangular membership functions

Linguistic variable	Triangular fuzzy number
Very Low (VL)	0,0,0.1
Low (L)	0,0.1,0.30
Medium Low (ML)	0.1,0.3,0.5
Medium (M)	0.3,0.5,0.7
Medium High (MH)	0.5,0.7,0.9
High (H)	0.7,0.9,1
Very High (VH)	0.9,1,1

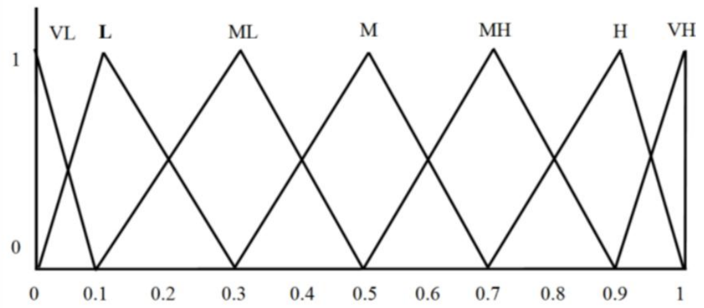

Figure 2: Fuzzy triangular membership functions

Table 9: Decision matrix using fuzzy linguistic variables

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

The fuzzy linguistic variable is then transformed into a fuzzy triangular membership function as shown in Table 10. This is the first step of the fuzzy TOPSIS analysis. The fuzzy attribute weight is also collected in Table 10.

The second step in the analysis is to find the weighted fuzzy decision matrix. Using Eqs. (17) and the fuzzy multiplication Eqs. (13), the resulting fuzzy weighted decision matrix is shown as Table 11.

For the fourth step, the distance of each alternative from A^* and A^- can be currently calculated using Eqs. (20) and (21). The fifth step solves the similarities to an ideal solution by Eqs. (22). The resulting fuzzy TOPSIS analyses are summarized in Table 12.

Based on the Table 12, the order of ranking the alternatives using fuzzy TOPSIS method results as follows:

$WA_2 > WA_1 > WA_3 > WA_4 > WA_5$

In this section, the existing precise values have been transformed to fuzzy linguistic variables in order to illustrate the concept of the proposed fuzzy-based method. 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. It is the aim of this section to illustrate the feasibility of the fuzzy-based method for the instance of fuzzy inputs, which is justified by the empirical results.

Table 10: Fuzzy decision matrix and fuzzy attribute weights

	(WA_1)	(WA_2)	(WA_3)	(WA_4)	(WA_5)	Weight
(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 11 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 $\tilde{v}_j^- = (0, 0, 0)$, $j = 1, 2,…., n$. This is the third step of the fuzzy TOPSIS analysis.

Table 11: Fuzzy-weighted decision matrix

	(WA_1)	(WA_2)	(WA_3)	(WA_4)	(WA_5)
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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
(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

4. DISCUSSIONS

According to the TOPSIS and fuzzy TOPSIS methods, the preference order of the alternatives is summarized in Table 13. It is evident that both methods lead to the choice of WA_2; hence, travel website of WA_2 shows the highest service quality. Other than WA_2, the preferences vary between methods. The fuzzy TOPSIS concludes with the order of ranking $WA_2 > WA_1 > WA_3 > WA_4 > WA_5$, whereas TOPSIS method concludes with the order of ranking $WA_2 > WA_3 > WA_4 > WA_1 > WA_5$. Due to the MADM nature of the proposed problem, an optimal solution may not exist; however, the systematic evaluation of the MADM problem can reduce the risk of a poor service quality selection.

When precise performance ratings are available, the TOPSIS method is considered to be a viable approach in solving a TWSQ problem. Fuzzy TOPSIS is a preferred choice for the instance of imprecise or vague performance ratings in solving the proposed service quality problem.

Table 12: Fuzzy TOPSIS analysis

	$\tilde{v}_{j1}$	$\tilde{v}_{j2}$	$\tilde{v}_{j3}$	$\tilde{v}_{j4}$	$\tilde{v}_{j5}$	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		

Table 13: The order of ranking of the alternatives for different methods

Preference Order	1	2	3	4	5
TOPSIS	WA_2	WA_3	WA_4	WA_1	WA_5
Fuzzy TOPSIS	WA_2	WA_1	WA_3	WA_4	WA_5

The aim of the proposed methodology is to recommend a systematic evaluation model to improve the TWSQ including the comparison of both TOPSIS and Fuzzy TOPSIS, to find out the effective travel agency websites. The proposed methodology provides a systematic approach to narrow down the number of alternatives and to facilitate the decision making process. 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 TWSQ.

5. 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 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 models can provide a guideline for the travel managers to provide appropriate levels of service quality in response to customers' needs.

The present study explored the use of TOPSIS and fuzzy TOPSIS in solving a TWSQ problem. The aim was to investigate the dimensions of online travel service quality, by adapting and extending the TOPSIS and fuzzy TOPSIS models. Moreover, the methods and experiences learned from the study can be valuable to the company's future strategic planning. Empirical results showed that the proposed methods are viable approaches in solving the proposed TWSQ problem. TOPSIS is a viable method for the proposed problem and is suitable for the use of precise performance ratings. When the performance ratings are vague and inaccurate, then the fuzzy TOPSIS is the preferred technique. In addition, there exists other worth investigating MADM methods for a travel website service quality problem. This becomes one of the future research opportunities in this classical yet important research area.

Sampling is a major limitation in this study. Since the survey was conducted based on a sample in Bangladesh, the prudent reader may need to interpret the results of the study with caution, particularly with respect to the generalization of research findings to Bangladesh travel service providers as a whole.

REFERENCES:

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

[2] Bahram, S.G.& Asghari, S. (2011), A new method for constructing confidence interval for Cpm based on fuzzy data. *International Journal for Quality Research*, 5(2), 67-73.

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

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

[5] Buyukozkan, G., Feyzioglu, O., & Nebol, E. (2008), Selection of the strategic alliance partner in logistics value chain. *International Journal of Production Economics*, 113, 148-158.

[6] 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.

[7] 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.

[8] Chang, H.H., Wang, Y.H., & 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.

[9] Chen, C.T., Lin, C.T., & Huang, S. F. (2006), A fuzzy approach for supplier evaluation and selection in supply chain management. *International Journal of Production Economics*, 102, 289-301.

[10] Cheng, C.H. (1999), Evaluating weapon systems using ranking fuzzy numbers. *Fuzzy Set Systems*, 107(1), 25-35.

[11] Clemons, E.K., Hann, I.H., & Hitt, L.M. (2002), Price dispersion and differentiation in online travel: an empirical investigation. *Management Science*, 48(4), 534-549.
[12] Dominic, P.D.D., Jati, H., & 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.
[13] Ertuğrul, Ð., & Karakasoğlu, N. (2009), Performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods. *Expert Systems with Applications: An International Journal*, 36(1), 702-715.
[14] Gratzer, M., Werthner, H., & Winiwarter, W. (2004), Electronic business in tourism. *International Journal of Electronic Business*, 2(5), 450-459.
[15] Hwang, C.L., & Yoon, K. (1981), *Multiple attributes decision making methods and applications*. Springer, Berlin.
[16] Jeong, M., Oh, H., & Gregoire, M. (2003), Conceptualizing web site quality and its consequences in the lodging industry. *International Journal of Hospitality Management*, 22(2), 161-175.
[17] Kalpande, S., Gupta, R.& Dandekar, M. (2010), Identification of strength and weaknesses of Indian manufacturing SMEs using AHP approach, *International Journal for Quality Research*, 4(4), pp. 263-269.
[18] Kabir, G., Mithy, S.N., & Hasin, M.A.A. (2011), Fuzzy Analysis for Higher Effectiveness of Control Chart. *International Journal of Quality and Innovation*, 1(4), 290-314.
[19] Kim, D. J., Kim, W. G., & Han, J. S. (2006), A perceptual mapping of online travel agencies and preference attributes. *Tourism Management*, 28(2), 591–603.
[20] 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.
[21] Lee, W.B., Lau, H., Liu, Z., & Tam, S. (2001), A fuzzy analytic hierarchy process approach in modular product design. *Expert Systems*, 18(1), 32–42.
[22] Lin, M.C., Wang, C.C., Chen, M.S., & Chang C. A. (2008), Using AHP and TOPSIS approaches in customer-driven product design process. *Computers in Industry*, 59(1), 17-31.
[23] Liou, T.S., & Chen, C.W. (2006), Subjective appraisal of service quality using fuzzy linguistic assessment. *International Journal of Quality & Reliability Management*, 23(8), 928-943.
[24] 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.
[25] Palmer, J.W. (2002), Website usability, design, and performance metrics. *Information Systems Research*, 13(2), 151-167.
[26] 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.
[27] Parameshwaran, R., Srinivasan, P.S.S., Punniyamoorthy, M., Charunyanath, S.T., & 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.
[28] Parasuraman, A., Zeithaml, V.A., & Berry, L.L. (1985), A conceptual model of service quality and its implications for future research. *Journal of Marketing*, 49(4), 41-50.
[29] Parasuraman, A., Zeithaml, V.A., & Berry, L.L. (1988), SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, 64(1), 12-40.
[30] Parasuraman, A., Zeithaml, V.A., & Malhotra, A. (2005), E-S-QUAL: A multiple-item scale for assessing electronic service quality. *Journal of Service Research*, 7(3), 213–233.
[31] Rahman, Z. & Qureshi, M.N. (2009), Fuzzy approach to measuring healthcare service quality. *International Journal of Behavioral and Healthcare Research*, 1(2), 105-124.
[32] Reichheld, F.F., Markey Jr, R.G., & Hopton, C. (2000), E-customer loyalty - applying the traditional rules of business for online success. *European Business Journal*, 12(4), 173-179.

[33] Robbins, S.S., & Stylianou, A.C. (2003), Global corporate websites: an empirical investigation of content and design. *Information and Management*, 40(3), 205-212.
[34] Rowley, J. (2006), An analysis of the e-service literature: towards a research agenda. *Internet Research*, 16(3), 339-359.
[35] Santos, J. (2003), E-service quality: a model of virtual service quality dimensions. *Managing Service Quality*, 13(3), 233-246.
[36] Shen, H., Wei, J., & 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.
[37] Shih, H.P. (2004), An empirical study on predicting user acceptance of e-shopping on the Web. *Information and Management*, 41(3), 351-368.
[38] Shipley, M.F., & 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.
[39] Szymanski, D.M., & Hise, R.T. (2000), E-satisfaction: an initial examination. *Journal of Retailing*, 76(3), 309-322.
[40] Tadić, D., Arsovski, S., Stefanović, M.& Aleksić, A. (2010), A fuzzy AHP and TOPSIS for ELV dismantling selection. *International Journal for Quality Research*, 4(2), 139-144.
[41] Telfer, D.J., & Sharpley, R. (2008), *Tourism and Development in the Developing World*. Abingdon (Oxon) and New York, Routledge, pp. 263.
[42] Teich, J., Wallenius, H., & Wallenius, J. (2000), World-Wide-Web technology in support of negotiation and communication. *International Journal of Services Technology and Management*, 1(1), 83-99.
[43] Wang, T.C., & Chang, T.H. (2007), Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment. *Expert Systems with Applications*, 33(4), 870-880.
[44] Wang, Y.M., & 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.
[45] 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.
[46] Yang, T., & Hung, C.C. (2007), Multiple-attribute decision making methods for plant layout design problem. *Robotics and Computer-Integrated Manufacturing*, 23(1), 126-137.
[47] Yen, B.P.C. (2005), Analysis of evaluation models for websites. *International Journal of Internet and Enterprise Management*, 3(3), 280-303.
[48] Yen, C.H., & 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.
[49] Zadeh, L.A. (1965). Fuzzy Sets. Information and Control, 8(2), 338-353.
[50] Zeithaml, V.A., Parasuraman, A., & Malhotra, A. (2000), *A conceptual framework for understanding e-service quality: Implications for future research and managerial practice*. Working paper report no. 00-115. Cambridge, MA: Marketing Service Institute.
[51] Zeithaml, V.A., Parasurman, A., & 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.