Ranking Parameters on Quality of Online Shopping Websites Using Multi-Criteria Method

Mehrbakhsh Nilashi, Karamollah Bagherifard, Othman Ibrahim, Nasim Janahmadi and Leila Ebrahimi

Faculty of Computer Science and Information Systems, University Technology Malaysia, Johor, Malaysia
Department of Computer Engineering, Islamic Azad University, Yasooj branch, Yasooj, Iran
Department of Computer Engineering, Ahrar Institute of Technology and Higher Education, Rasht, Iran
Commercial and Social Science College, Payame Noor University, Qeshm Br, Iran

Abstract: The growing use of Internet in Malaysia provides a developing prospect of online shopping for international students. Also, international students are an outstanding group in online shopping in Malaysia. In view of this, in order to improve increase online shopping among international students and Malaysian online shopping, a research framework was proposed and a survey of international student was done. Proposed research framework considers three key dimensions service quality, information quality and system quality for online shopping website. To gather initial data, international students of UTM were asked. Data was collected from 300 international students of UTM. Using normal TOPSIS and fuzzy-TOPSIS approaches all parameters in hierarchy were ranked. Our findings demonstrated that using fuzzy-TOPSIS method trust, response time, reliability, responsiveness, empathy, timeliness, accuracy of information, navigation and accessibility are the nine first important parameters in online website quality.

Keywords: Fuzzy-TOPSIS, information quality, international students, online shopping, service quality, system, quality

INTRODUCTION

The amount of interest in online shopping has increased dramatically over recent years how it becomes progressive obvious that online shopping offers advantages for vendors and customers similarly. Demands and preferences of consumers are altering to the expance that online shopping is becoming the more suitable option for many consumers.

A study by International Data Corporation (IDC) Asia Pacific indicates that the future forecast for online shopping in Malaysia looks bright and promising (Louis and Leon, 1999). Malaysia moved towards advanced information, communications based on the growing trend of Internet users in the last three years and multimedia services.

Furthermore, because of a rapid rise in the number of PCs, PDA, mobile phone technology in Malaysia, as well as each year provides greater opportunities for Malaysians to conduct both business and shop online.

Moreover, the number of international students in Malaysia has increased from 30 thousand in the year 2003 to about 70 thousand in 2010 (MOHE, 2010). Principally, in many university of Malaysia most of the international students are studying from Southeast Asia, Middle Eastern countries, Middle Asia and African countries and a minimal number from Europe.

According to the latest statistics, there are more than 90,000 international students currently studying in the various institutions of higher learning in Malaysia. Immigration Department records shows, the number of foreigners holding student passes number 90,501 as of 31 December 2008. This is close to the target set by the Ministry of Higher Education, which are 100,000 by 2010. Statistics results by the Immigration Department shows that Indonesia and China constitute the highest number of international students in this country. And the numbers of Indonesia and China students were estimated 14, 359 and 11, 628, respectively. There are also a big number of students from Nigeria (6, 765), Iran (6, 514), Bangladesh (3, 820) and the Middle East countries.

International student of university have high knowledge background and by present have been one of
### Table 1: The criteria of course website quality

<table>
<thead>
<tr>
<th>Researcher</th>
<th>System quality</th>
<th>Information quality</th>
<th>Service quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiu et al. (2005)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cho et al. (2009)</td>
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<tr>
<td>Lee et al. (2005)</td>
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<tr>
<td>Lin (2007)</td>
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<tr>
<td>Marks et al. (2005)</td>
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<td>Ong et al. (2004)</td>
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<tr>
<td>Madu and Madu (2002a)</td>
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<tr>
<td>Loiacono et al. (2002)</td>
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<tr>
<td>Pituch and Lee (2006)</td>
<td></td>
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</tr>
<tr>
<td>Roca et al. (2006)</td>
<td></td>
<td></td>
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<tr>
<td>Saade and Bahli (2005)</td>
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<tr>
<td>Teo et al. (2003)</td>
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<tr>
<td>Tung and Chang (2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee (2006)</td>
<td></td>
<td></td>
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<tr>
<td>Wang (2003a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaynama and Black (2000)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hakman (2000)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tzeng et al. (2007)</td>
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<tr>
<td>Janda et al. (2002)</td>
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<tr>
<td>Kim and Lim (2001)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Katerattanakul (2002)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Madu and Madu (2002b)</td>
<td></td>
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</tr>
</tbody>
</table>

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According to Elliot and Fowell (2000), the quality of e-tail websites, particularly such attributes as responsiveness of customer service, ease of site navigation, implicitly of checkout process and security of transaction and personal information are factors that online shopper consider them in online shopping.

Many researchers have studied website quality widely (Marks et al., 2005; Chiu et al., 2005). Previous studies have been organized to detect effect on course website effectiveness or quality. Moreover, functionally-based website features have surveyed by some researchers in assisting the design of effective course websites through increasing interactivity and supporting learning (Cho et al., 2009; Roca et al., 2006).

Website quality is one of the most important consumer reactions in online shopping and its importance is reflected in the ability to intend buying in online shopping. As shown in Table 1, website quality has been conceptualized in a variety of ways.

For instance, some researchers focus on the impact of system quality on quality of websites based on consumer perceptions of website characteristics such as Learnability, Innovativeness, Navigability, Response time and Accessibility. Also several researchers considered the impact of service quality on quality of websites such as Reliability, Responsiveness, Trust and Empathy. Furthermore, information quality is on of another important entity that affect on website quality has been considered by researches such as Accuracy, Currency, Completeness, Complexity and Coherence.

Table 1 summarizes the criteria that affect on website quality from some researches.

Therefore, the objective of this research is to identify important parameters of online shopping.
Fig. 2: Hierarchical structure of online shopping website quality

websites and analyze key attributes on online shopping websites in Malaysia that these attributes affect online shopping intention of university international student.

**Research framework:** The key components of the research framework for online shopping website quality can be seen in Fig. 1. According to the previous researches, our framework suggested that online shopping website quality is based on information quality, system quality and service quality.

In the research framework, System quality refers to the detected ability of a website to provide suitable functions in relation to customer. Higher quality of a website depends on usefulness and more functionality (Chatterjee and Sambamurthy, 1999). System Accessibility, timeliness and Response time are examples of qualities valued by traditional IS (Bailey and Pearson, 1983).

In the context of Internet shopping, system quality the interaction between consumers and the website is considered largely such as information searching, downloading and doing e-commerce transactions (Javenpaa and Todd, 1997).

Information quality refers to the quality of the information provided by the online services. High-quality information presentation can effectively facilitate doing transaction in online website shopping. According to Turban and Gehrke (2000) research information quality is the content of the Web site that either attracts or repels online customers. Moreover, Szymanski and Hise (2000) uncovered that consumer satisfaction with online shopping is largely determined by the quality of a site’s product information.

In the follows, the quality of service also plays an important role in enhancing website quality. Typical dimensions of service quality include reliability, responsiveness, trust and empathy (Pitt, Watson and Kavan, 1995). These dimensions are likely to meet customer expectations and support online users in each step of the transaction process. Indeed, the study of online service quality with dimensions of SERVQUAL was conducted by Gefen (2002).

Furthermore, Zeithmal and Parasuraman (2002) offered that higher service quality is vital to encourage repeat purchases and build customer loyalty.

**Hierarchy framework:** In this research according to reviewing the literature on website quality in Table 1, a proposed hierarchical structure of the research problem was defined that has been shown in Fig. 2. The goal is to rank the sub-criteria in this hierarchical structure.

As seen in Fig. 2, there are 14 sub-criteria in hierarchical structure.

**METHODOLOGY**

In this research, the primary data were collected through questionnaires that have been distributed to the
Find out as many as possible different key attributes that affect on quality of online shopping websites
To design a suitable questionnaire to find out the importance of factors
To distribute questionnaire for gather the information from international students
Using TOPSIS in order to rank the website key attributes
Using fuzzy TOPSIS in order to rank the website key attributes
A comparison between the outcome of normal TOPSIS and fuzzy TOPSIS method

Table 2: The respondents’ demographic profile

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Frequency</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>male</td>
<td>225</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Age</td>
<td>23-25</td>
<td>90</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>26-30</td>
<td>120</td>
<td>40</td>
</tr>
<tr>
<td>Degree of studying</td>
<td>Master</td>
<td>189</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>P.HD</td>
<td>111</td>
<td>37</td>
</tr>
<tr>
<td>Country</td>
<td>Nigeria</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Pakistan</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Indonesia</td>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Iran</td>
<td>180</td>
<td>60</td>
</tr>
</tbody>
</table>

international student of UTM who are online users. For this study, a number of respondents are 300 students.

The structured questionnaire is used in collecting the data for the study. The questionnaires were designed properly in order to get the maximum accuracy of information and the maximum understanding to the respondents. The question is designed into six sections, where every section has been tested using the reliability analysis except for the demographic question. The first section comprise of information on respondent demographic profile, four sections on the independent variable namely, trust, website quality, internet knowledge and internet advertising and one section on online shopping. It had also five options (index) ranked by 1-5 for the raised questions could be found as follows:

1 = Not important, 2 = low important, 3 = average, 4 = Important, 5 = very important

Figure 3 shows the schematic form of research methodology of this research.

Table 2 provides the respondents’ demographic profile. About 75% of them were male and 25% were female. Fifty four percent were Malay and 46% were Chinese. The mean age of the respondents was about 25 years old. About 37% were P.HD student, while 63% were master student.

Research objectives and outcome: The objective of this research is to identify important parameters of online shopping websites and analyze key attributes on online shopping websites in Malaysia that these attributes affect online shopping intention of university international student.

TOPSIS and fuzzy-TOPSIS: TOPSIS, one of the known classical MCDM methods, was first developed by Hwang and Yoon (1981) that can be used with both normal numbers and fuzzy numbers.

In addition, TOPSIS is attractive in that limited subjective input is needed from decision makers. The only subjective input needed is weights.

Since the preferred ratings usually refer to the subjective uncertainty, it is natural to extend TOPSIS to consider the situation of fuzzy numbers. Fuzzy TOPSIS can be intuitively extended by using the fuzzy arithmetic operations as follows (Hwang and Yoon, 1981; Gwo-Hshiung and Jen-Jia, 1997; Opricovic and Tzeng, 2004):

Given a set of alternatives, \( A = \{A_i | i = 1, \cdots, n\} \), and a set of criteria, \( C = \{C_j | j = 1, \cdots, m\} \), where, \( \bar{X} = \{\bar{x}_{ij} | i = 1, \cdots, n; j = 1, \cdots, m\} \) denotes the set of fuzzy ratings and \( \bar{W} = \{\bar{w}_j | j = 1, \cdots, m\} \) is the set of fuzzy weights.

The first step of TOPSIS is to calculate normalized ratings by:

\[
\tilde{r}_{ij}(x) = \frac{\bar{x}_{ij}}{\sqrt{\sum_{i=1}^{n} \bar{x}_{ij}^2}}, \quad i = 1, \cdots, n; \quad j = 1, \cdots, m
\] (1)

And then to calculate the weighted normalized ratings by:

\[
\tilde{v}_{ij}(x) = \bar{w}_j \tilde{r}_{ij}(x), \quad i = 1, \cdots, n; \quad j = 1, \cdots, m.
\] (2)

Next the positive ideal point (PIS) and the negative ideal point (NIS) are derived as:

\[ PIS = \bar{A}^+ = \{ \bar{v}_i^+(x), \bar{v}_2^+(x), \ldots, \bar{v}_n^+(x) \} = \{(\max_i \bar{v}_i(x)) | j \in J_1), (\min_i \bar{v}_i(x)) | j \in J_2) | i = 1, \ldots, n \} \] (3)

\[ PIS = \bar{A}^- = \{ \bar{v}_i^-(x), \bar{v}_2^-(x), \ldots, \bar{v}_n^-(x) \} = \{(\min_i \bar{v}_i(x)) | j \in J_1), (\max_i \bar{v}_i(x)) | j \in J_2) | i = 1, \ldots, n \} \] (4)

where, \( J_1 \) and \( J_2 \) are the benefit and the cost attributes, respectively.

Similar to the crisp situation, the following step is to calculate the separation from the PIS and the NIS between the alternatives. The separation values can also be measured using the Euclidean distance given as:

\[ \bar{S}_i^+ = \sum_{j=1}^{n} \left( \bar{v}_j(x) - \bar{v}_j^+(x) \right)^2, i = 1, \ldots, n \] (5)

and

\[ \bar{S}_i^- = \sum_{j=1}^{n} \left( \bar{v}_j(x) - \bar{v}_j^-(x) \right)^2, i = 1, \ldots, n \] (6)

where,

\[ \max \{ \bar{v}_j(x) \} - \bar{v}_j^+(x) = \min \{ \bar{v}_j(x) \} - \bar{v}_j^-(x) = 0. \] (7)

Then, the defuzzified separation values should be derived using one of defuzzified methods, such as CoA to calculate the similarities to the PIS.

Next, the similarities to the PIS is given as:

\[ C_i^* = \frac{D(S_i^+)}{[D(S_i^+) + D(S_i^-)]}, i = 1, \ldots, n \] (8)

where, \( C_i^* \in [0,1] \) \( \forall i = 1, \ldots, n \)

Finally, the preferred orders are ranked according to \( C_i^* \) in descending order to choose the best alternatives.

**Applying TOPSIS method:** In this research TOPSIS was used for ranking effective parameters on online website shopping. Based on 14 parameters in hierarchy structure in previous section, a questionnaire was developed for gathering data from 300 international students. Afterward, TOPSIS was applied for ranking. Table 3 show results of respondents’ responses categorized by their importance. TOPSIS method has been described in this section.

**First Step:**

\[ n_j = r_{ij} / \left( \sum_{i=1}^{m} (r_{ij})^2 \right)^{1/2} \] (9)

Table 4 shows divide of each cell of Table 5 on square of related column. For example in the first cell of Table 5, 10 divides to \((25.57 \times 3.91)\).

Afterward, by using entropy method, objective weights were calculated. The following equation calculates entropy measure of every index.

\[ E_j = -K \sum_{i=1}^{m} \left[ n_{ij} \ln(n_{ij}) \right] \Rightarrow \left\{ \forall j = 1,2,\ldots,n \right\} K = \frac{1}{\ln(m)} \] (10)

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Table 5: Multiply each cell by itself result of Table 1

| Question no. | Not important | Low important | Moderate | Important | Very important |
|--------------|---------------|---------------|----------|-----------|===============|
| 1            | 1.00          | 2.00          | 3.00     | 4.00      | 5.00          |
| 2            | 1.00          | 169.00        | 2116.00  | 6400.00   | 25600.00      |
| 3            | 16.00         | 441.00        | 1156.00  | 9801.00   | 20164.00      |
| 4            | 100.00        | 256.00        | 3025.00  | 16900.00  | 7921.00       |
| 5            | 64.00         | 529.00        | 6400.00  | 8100.00   | 9801.00       |
| 6            | 4.00          | 400.00        | 1354.00  | 6724.00   |               |
| 7            | 64.00         | 256.00        | 8100.00  | 14400.00  |               |
| 8            | 144.00        | 6400.00       | 19600.00 | 202898.00 |               |
| 9            | 16.00         | 256.00        | 6400.00  | 14400.00  |               |
| 10           | 144.00        | 6400.00       | 20164.00 | 202898.00 |               |
| SUM          | 654.00        | 10230.00      | 51692.00 | 161326.00 | 202898.00     |

Table 6: Max row of matrix V

<table>
<thead>
<tr>
<th>Max Vi1</th>
<th>Max Vi2</th>
<th>Max Vi3</th>
<th>Max Vi4</th>
<th>Max Vi5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.050879</td>
<td>5.722108</td>
<td>8.429407</td>
<td>16.86465</td>
<td>23.30857</td>
</tr>
</tbody>
</table>

Table 7: Min row of matrix V

<table>
<thead>
<tr>
<th>Min Vi1</th>
<th>Min Vi2</th>
<th>Min Vi3</th>
<th>Min Vi4</th>
<th>Min Vi5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.000894</td>
<td>0.121383</td>
<td>5.234924</td>
<td>3.100281</td>
</tr>
</tbody>
</table>

The degree of divergence $d_j$ of the intrinsic information of each criterion $C_j$ ($j = 1, 2, ..., n$) may be calculated as:

$$d_j = 1 - E_j$$  \hspace{1cm} (11)

The value $d_j$ represents the inherent contrast intensity of $c_j$. The higher the $d_j$ is, the more important the criterion $c_j$ is for the problem. The objective weight for each criterion can be obtained. Accordingly, the normalized weights of indexes may be calculated as:

$$w_j = \frac{d_j}{\sum_{k=1}^{n} d_k}$$  \hspace{1cm} (12)

$$E_i = -\frac{1}{k} \sum_{i=1}^{k} (n_i \ln(n_i)) = \frac{1}{k} (\ln(0.12677 - 0.29336 + 5.3334 + 2.296349 - 0.2902 + 2.296349 - 0.29336 + 9.73362 - 0.29336 + 1.246386 + 0.481641 + 9.73362)) = -12.0532$$

$$E_4 = -\frac{1}{k} \sum_{i=1}^{k} (n_i \ln(n_i)) = \frac{1}{k} (\ln(8.429407 + 5.722108 + 8.429407 + 16.86465 + 23.30857)) = -77.95556 + 157.3443 + 60.58187 + 117.6449 + 64.23065 + 44.11359 + + 80.03882 + 157.3443 + 128.3291 + 189.7149 + 41.16847) = -423.813$$

$$E_5 = -\frac{1}{k} \sum_{i=1}^{k} (n_i \ln(n_i)) = \frac{1}{k} (\ln(164.1772 + 229.6136 + 68.82416 + 170.1714 + 50.41712 + 67.01719 + 40.35256 + 266.9915 + + 110.76437.70647158.303225.9638418.29701229.6136)) = -445.461$$

$$w_i = \frac{-11.0532}{-1223.43} = 0.009035$$

$$w_j = \frac{-110.631}{-1223.43} = 0.090427$$

$$w_i = \frac{-234.472}{-1223.43} = 0.191651$$

$$w_j = \frac{-422.813}{-1223.43} = 0.345596$$

$$w_j = \frac{-444.461}{-1223.43} = 0.363291$$

$$\sum w_j = 1 \Rightarrow w_1 + w_2 + w_3 + w_4 + w_5 = 0.009035 + 0.090427 + 0.191651 + 0.345596 + 0.363291 = 1$$

Therefore, matrix $w$ can be defined as:

$$w = \begin{bmatrix} 0.009035 & 0 & 0 & 0 & 0 \\ 0.090427 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.191651 & 0 & 0 \\ 0 & 0 & 0 & 0.345596 & 0 \\ 0 & 0 & 0 & 0 & 0.345596 \end{bmatrix}$$
To specify positive ideal and negative ideal:

Positive Ideal = \( A^+ = \{ (\max \ V_{ij}), (\max \ V_{ij}), i = 1, 2, \ldots, m \} = \{ V1^+ , V2^+ , \ldots , Vn^+ \} \) \hspace{1cm} (13)

Negative Ideal = \( A^- = \{ (\min x V_{ij}), (\min x V_{ij}), i = 1, 2, \ldots, m \} = \{ V1^- , V2^-, \ldots , Vn^- \} \) \hspace{1cm} (14)

Positive ideal and negative ideal of \( V \) has been shown in Table 6 and 7. These tables show the maximum and the minimum of each column of matrix \( V \) in two rows. \( A^+ \) is all the maximum numbers and \( A^- \) is all the minimum numbers.

To calculated the distance the following equation used for positive and negative ideal.

Distance \( i \) from positive Ideal = \( \sum_{j=1}^{n} (V_{ij} - V_{ij'} )^2 \frac{1}{\sqrt{2}} \) \hspace{1cm} (15)

Table 8 shows the sum and square of five \( (V_{ij} , V_{ij'} )^2 \) and \( (V_{ij} , V_{ij'} )^2 \) that were in the Table 9 and 10. Square is shown as \( d_{i} \) or distance \( i \) from positive ideal and \( d_{i} \) or distance \( i \) from negative Ideal. Also, in last column sum of the \( d_{i} \), \( d_{i} \) has been calculated. The results of distance between \( Ai \) and ideal solution are shown in Table 11.

Applying fuzzy TOPSIS method: Fuzzy-TOPSIS method is another type of fuzzification for the TOPSIS method in fuzzy environment that is defined and investigated by credibility measure. In this method, trapezoid-fuzzy numbers are used for ranking all sub-criteria of website quality. Therefore, using fuzzy
Table 11: The distance between Ai and ideal solution for final ranking

<table>
<thead>
<tr>
<th>cl</th>
<th>$d_1^i$</th>
<th>$d_1^i + d_1^i$</th>
<th>Ranking</th>
<th>Sub Criteria No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>cl1</td>
<td>0.481696</td>
<td>0.276130</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>cl2</td>
<td>0.548071</td>
<td>0.303943</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>cl3</td>
<td>0.376109</td>
<td>0.307400</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>cl4</td>
<td>0.486924</td>
<td>0.320035</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>cl5</td>
<td>0.350034</td>
<td>0.350034</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>cl6</td>
<td>0.276130</td>
<td>0.364535</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>cl7</td>
<td>0.303943</td>
<td>0.372327</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>cl8</td>
<td>0.595828</td>
<td>0.376109</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>cl9</td>
<td>0.364535</td>
<td>0.481696</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>cl10</td>
<td>0.307400</td>
<td>0.48924</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>cl11</td>
<td>0.544555</td>
<td>0.536635</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>cl12</td>
<td>0.320035</td>
<td>0.544555</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>cl13</td>
<td>0.372327</td>
<td>0.548071</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>cl14</td>
<td>0.536635</td>
<td>0.595828</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

The distance between ranking $d^-_1 / d^-_1 + d^-_1$, $0.481696$, $0.548071$, $0.376109$, $0.486924$, $0.350034$, $0.276130$, $0.303943$, $0.364535$, $0.372327$, $0.595828$, $0.364535$, $0.376109$, $0.481696$, $0.307400$, $0.48924$.

Table 12: Fuzzy trapezoid number for fuzzy TOPSIS method

<table>
<thead>
<tr>
<th>Linguistic variable</th>
<th>Range of fuzzy trapezoid number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non important</td>
<td>(0.6, 0.8, 1.6, 1.8)</td>
</tr>
<tr>
<td>Low important</td>
<td>(1.4, 1.6, 2.5, 2.7)</td>
</tr>
<tr>
<td>Moderate</td>
<td>(2.3, 2.5, 3.8, 4)</td>
</tr>
<tr>
<td>Important</td>
<td>(3.6, 3.8, 4.6, 4.8)</td>
</tr>
<tr>
<td>Very important</td>
<td>(4.4, 4.6, 5.2, 5.4)</td>
</tr>
</tbody>
</table>

Trapezoid numbers enabled us to change normal TOPSIS into fuzzy TOPSIS which is more precisely as the result shows in the next paragraph.

One of the characteristic of fuzzy numbers is fuzzy sets with special consideration for easy calculations. Trapezoid Fuzzy Numbers Let $\tilde{A} = (a, b, c, d)$, $a<b<c<d$, be a fuzzy set on $\mathbb{R} = (-\infty, \infty)$. It is called a trapezoid fuzzy number, if its membership function is:

$$\mu_{T}(x) = \begin{cases} 
\frac{x-a}{b-a}, & \text{if } a \leq x \leq b \\
1, & \text{if } b \leq x \leq c \\
\frac{d-x}{d-c}, & \text{if } c \leq x \leq d \\
0, & \text{otherwise}
\end{cases}$$  \hspace{1cm} (18)

Figure 4 shows the shape of a fuzzy trapezoid number.

All process of fuzzy TOPSIS will be calculated upon three of trapezoid numbers that average numbers of experts are shown in Table 12:

A calculation between two fuzzy trapezoid numbers can be defined as:

$$D_1 = (a_1, b_1, c_1, d_1)$$
$$D_2 = (a_2, b_2, c_2, d_2)$$
$$\Rightarrow D_1 + D_2 = (a_1 + a_2, b_1 + b_2, c_1 + c_2, d_1 + d_2)$$  \hspace{1cm} (19)
Table 13: The sum of four trapezoid numbers in Table 12

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum</td>
<td>1098.8</td>
<td>1158.8</td>
<td>1405.9</td>
<td>1465.9</td>
</tr>
<tr>
<td></td>
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<td>1176.6</td>
<td>1408.9</td>
<td>1468.9</td>
</tr>
<tr>
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<td>1042.0</td>
<td>1102.0</td>
<td>1345.0</td>
<td>1405.0</td>
</tr>
<tr>
<td></td>
<td>1091.2</td>
<td>1151.2</td>
<td>1381.9</td>
<td>1441.9</td>
</tr>
<tr>
<td></td>
<td>1014.5</td>
<td>1074.5</td>
<td>1325.8</td>
<td>1385.8</td>
</tr>
<tr>
<td></td>
<td>980.6</td>
<td>1040.6</td>
<td>1303.1</td>
<td>1363.1</td>
</tr>
<tr>
<td></td>
<td>991.6</td>
<td>1051.6</td>
<td>1317.2</td>
<td>1377.2</td>
</tr>
<tr>
<td></td>
<td>1141.3</td>
<td>1201.3</td>
<td>1417.1</td>
<td>1477.1</td>
</tr>
<tr>
<td></td>
<td>1024.8</td>
<td>1084.8</td>
<td>1342.4</td>
<td>1402.4</td>
</tr>
<tr>
<td></td>
<td>960.4</td>
<td>1020.4</td>
<td>1295.2</td>
<td>1355.2</td>
</tr>
<tr>
<td></td>
<td>1135.7</td>
<td>1195.7</td>
<td>1419.3</td>
<td>1479.3</td>
</tr>
<tr>
<td></td>
<td>968.5</td>
<td>1029.5</td>
<td>1300.4</td>
<td>1360.4</td>
</tr>
<tr>
<td></td>
<td>920.0</td>
<td>980.0</td>
<td>1221.6</td>
<td>1281.6</td>
</tr>
<tr>
<td></td>
<td>1141.3</td>
<td>1195.7</td>
<td>1419.3</td>
<td>1479.3</td>
</tr>
<tr>
<td></td>
<td>968.5</td>
<td>1029.5</td>
<td>1300.4</td>
<td>1360.4</td>
</tr>
<tr>
<td></td>
<td>920.0</td>
<td>980.0</td>
<td>1221.6</td>
<td>1281.6</td>
</tr>
</tbody>
</table>

In the next step, each cell of Table 15 will be divided by 300 in order to make the 14 fuzzy numbers for starting fuzzy TOPSIS.

In the next step, 14 fuzzy numbers in Table 13 should be multiplied by itself and will come in Table 15.

Using (Buckley, 1985; Bailey and Pearson, 1983) method, a calculation between two fuzzy trapezoid numbers can be defined as:

\[
D1 = (a_1, b_1, c_1, d_1)
\]
\[
D2 = (a_2, b_2, c_2, d_2)
\]
\[
\Rightarrow M = D1 * D2 = D1 * D2 = (a(L_1, L_2), b, c, d(R_1, R_2)) \quad (20)
\]
\[
\Rightarrow M \sim \text{Fuzzy trapezoid number}
\]

Therefore, Table 13 was calculated from Table 14 by summing of four trapezoid numbers.

Table 14: Applying fuzzy number on questionnaire data

<table>
<thead>
<tr>
<th>Rij</th>
<th>Selected option</th>
<th>Fuzzy number 1</th>
<th>Selected option</th>
<th>Fuzzy number 2</th>
<th>Selected option</th>
<th>Fuzzy number 3</th>
<th>Selected option</th>
<th>Fuzzy number 4</th>
<th>Selected option</th>
<th>Fuzzy number 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q.No</td>
<td>1.0</td>
<td>0.6</td>
<td>0.8</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
<td>1.4</td>
<td>1.6</td>
<td>2.5</td>
<td>2.7</td>
</tr>
<tr>
<td>1</td>
<td>2.0</td>
<td>3.6</td>
<td>3.8</td>
<td>4.6</td>
<td>4.8</td>
<td>5.0</td>
<td>4.4</td>
<td>4.6</td>
<td>5.5</td>
<td>5.7</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>320.4</td>
<td>338.2</td>
<td>409.4</td>
<td>427.2</td>
<td>440.0</td>
<td>455.4</td>
<td>475.2</td>
<td>495.6</td>
<td>516.0</td>
</tr>
<tr>
<td>3</td>
<td>130</td>
<td>468</td>
<td>494</td>
<td>598</td>
<td>624</td>
<td>640</td>
<td>666</td>
<td>692</td>
<td>718</td>
<td>744</td>
</tr>
<tr>
<td>4</td>
<td>99</td>
<td>356.4</td>
<td>376.2</td>
<td>455.4</td>
<td>475.2</td>
<td>495.6</td>
<td>516.0</td>
<td>532.8</td>
<td>553.6</td>
<td>575.6</td>
</tr>
<tr>
<td>5</td>
<td>130</td>
<td>468</td>
<td>494</td>
<td>598</td>
<td>624</td>
<td>640</td>
<td>666</td>
<td>692</td>
<td>718</td>
<td>744</td>
</tr>
<tr>
<td>6</td>
<td>90</td>
<td>324</td>
<td>342</td>
<td>414</td>
<td>432</td>
<td>450</td>
<td>468</td>
<td>486</td>
<td>504</td>
<td>522</td>
</tr>
<tr>
<td>7</td>
<td>116</td>
<td>417.6</td>
<td>440.8</td>
<td>533.6</td>
<td>556.8</td>
<td>580</td>
<td>604</td>
<td>628</td>
<td>652</td>
<td>676</td>
</tr>
<tr>
<td>8</td>
<td>92</td>
<td>331.2</td>
<td>349.6</td>
<td>423.2</td>
<td>441.6</td>
<td>460</td>
<td>480</td>
<td>500</td>
<td>520</td>
<td>540</td>
</tr>
<tr>
<td>9</td>
<td>80</td>
<td>288</td>
<td>304</td>
<td>368</td>
<td>384</td>
<td>404</td>
<td>424</td>
<td>444</td>
<td>464</td>
<td>484</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>360</td>
<td>380</td>
<td>460</td>
<td>480</td>
<td>500</td>
<td>520</td>
<td>540</td>
<td>560</td>
<td>580</td>
</tr>
<tr>
<td>11</td>
<td>130</td>
<td>468</td>
<td>494</td>
<td>598</td>
<td>624</td>
<td>640</td>
<td>666</td>
<td>692</td>
<td>718</td>
<td>744</td>
</tr>
<tr>
<td>12</td>
<td>120</td>
<td>432</td>
<td>456</td>
<td>552</td>
<td>576</td>
<td>600</td>
<td>624</td>
<td>648</td>
<td>672</td>
<td>696</td>
</tr>
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<td>13</td>
<td>140</td>
<td>504</td>
<td>532</td>
<td>644</td>
<td>672</td>
<td>700</td>
<td>724</td>
<td>748</td>
<td>772</td>
<td>796</td>
</tr>
<tr>
<td>14</td>
<td>78</td>
<td>280.8</td>
<td>296.4</td>
<td>358.8</td>
<td>374.4</td>
<td>400</td>
<td>416</td>
<td>432</td>
<td>448</td>
<td>464</td>
</tr>
</tbody>
</table>

In the next step, each cell of Table 15 will be divided by 300 in order to make the 14 fuzzy numbers for starting fuzzy TOPSIS.

In the next step, 14 fuzzy numbers in Table 13 should be multiplied by itself and will come in Table 15.

Using (Buckley, 1985; Bailey and Pearson, 1983) method, a calculation between two fuzzy trapezoid numbers can be defined as:

\[
D1 = (a_1, b_1, c_1, d_1)
\]
\[
D2 = (a_2, b_2, c_2, d_2)
\]
\[
\Rightarrow M = D1 * D2 = D1 * D2 = (a(L_1, L_2), b, c, d(R_1, R_2)) \quad (20)
\]
\[
\Rightarrow M \sim \text{Fuzzy trapezoid number}
\]
Table 15: Fourteen fuzzy numbers generated by dividing Table 13 by 300

<table>
<thead>
<tr>
<th>Rij = Σn/n</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.662667</td>
<td>3.862667</td>
<td>4.686333</td>
<td>4.886333</td>
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</tr>
<tr>
<td>3.722000</td>
<td>3.922000</td>
<td>4.696333</td>
<td>4.896333</td>
<td></td>
</tr>
<tr>
<td>3.473333</td>
<td>3.673333</td>
<td>4.483333</td>
<td>4.683333</td>
<td></td>
</tr>
<tr>
<td>3.637333</td>
<td>3.837333</td>
<td>4.606333</td>
<td>4.806333</td>
<td></td>
</tr>
<tr>
<td>3.381667</td>
<td>3.581667</td>
<td>4.419333</td>
<td>4.619333</td>
<td></td>
</tr>
<tr>
<td>3.268667</td>
<td>3.468667</td>
<td>4.326667</td>
<td>4.526667</td>
<td></td>
</tr>
<tr>
<td>3.416000</td>
<td>3.616000</td>
<td>4.474667</td>
<td>4.674667</td>
<td></td>
</tr>
<tr>
<td>3.201333</td>
<td>3.401333</td>
<td>4.317333</td>
<td>4.517333</td>
<td></td>
</tr>
<tr>
<td>3.804333</td>
<td>4.004333</td>
<td>4.723667</td>
<td>4.923667</td>
<td></td>
</tr>
<tr>
<td>3.416000</td>
<td>3.616000</td>
<td>4.474667</td>
<td>4.674667</td>
<td></td>
</tr>
<tr>
<td>3.201333</td>
<td>3.401333</td>
<td>4.317333</td>
<td>4.517333</td>
<td></td>
</tr>
<tr>
<td>3.804333</td>
<td>4.004333</td>
<td>4.723667</td>
<td>4.923667</td>
<td></td>
</tr>
</tbody>
</table>

Table 16: The μM(x) for non-trapezoid fuzzy number

\[
\mu_{M(x)} = \begin{cases} 
0 & \text{if } x \leq a \\
0 & \text{if } \geq d \\
1 & \text{if } b \leq x \leq c \\
\alpha & \text{if } a \leq x \leq b, \alpha \in [0,1] \\
\alpha & \text{if } c \leq x \leq d, \alpha \in [0,1]
\end{cases}
\]

\[
a = a_1 \times a_2 \quad \Rightarrow \quad L_1 = (b_1 - a_1) \times (b_2 - a_2)
\]

\[
b = b_1 \times b_2 \quad \Rightarrow \quad L_2 = a_2 \times (b_1 - a_1) + a_1 \times (b_2 - a_2)
\]

Table 17: 14 Fuzzy non trapezoid numbers generated from multiplying Rij by itself

<table>
<thead>
<tr>
<th>Q. No</th>
<th>a</th>
<th>L1</th>
<th>c</th>
<th>L2</th>
<th>R1</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.41513</td>
<td>0.040000</td>
<td>1.465067</td>
<td>14.92019</td>
<td>21.96172</td>
<td>23.87625</td>
</tr>
<tr>
<td>2</td>
<td>13.85328</td>
<td>0.040000</td>
<td>1.488800</td>
<td>15.38208</td>
<td>22.05555</td>
<td>23.97408</td>
</tr>
<tr>
<td>3</td>
<td>12.06404</td>
<td>0.040000</td>
<td>1.389333</td>
<td>13.49338</td>
<td>20.10028</td>
<td>21.93361</td>
</tr>
<tr>
<td>4</td>
<td>13.23019</td>
<td>0.040000</td>
<td>1.454933</td>
<td>14.72513</td>
<td>21.21831</td>
<td>23.10084</td>
</tr>
<tr>
<td>5</td>
<td>11.43567</td>
<td>0.040000</td>
<td>1.352667</td>
<td>12.82834</td>
<td>19.53051</td>
<td>21.33824</td>
</tr>
<tr>
<td>6</td>
<td>10.68418</td>
<td>0.040000</td>
<td>1.327467</td>
<td>12.03165</td>
<td>18.86744</td>
<td>20.64491</td>
</tr>
<tr>
<td>7</td>
<td>14.47295</td>
<td>0.040000</td>
<td>1.521733</td>
<td>16.03469</td>
<td>22.31303</td>
<td>24.24249</td>
</tr>
<tr>
<td>8</td>
<td>11.66906</td>
<td>0.040000</td>
<td>1.366400</td>
<td>13.07546</td>
<td>20.02264</td>
<td>21.85251</td>
</tr>
<tr>
<td>9</td>
<td>10.24854</td>
<td>0.040000</td>
<td>1.280533</td>
<td>11.56907</td>
<td>18.63937</td>
<td>20.40630</td>
</tr>
<tr>
<td>10</td>
<td>14.33127</td>
<td>0.040000</td>
<td>1.514267</td>
<td>15.88554</td>
<td>22.38236</td>
<td>24.31476</td>
</tr>
<tr>
<td>11</td>
<td>10.42214</td>
<td>0.040000</td>
<td>1.291333</td>
<td>11.73547</td>
<td>18.78934</td>
<td>20.56320</td>
</tr>
<tr>
<td>12</td>
<td>9.404444</td>
<td>0.040000</td>
<td>1.226667</td>
<td>10.67111</td>
<td>16.58118</td>
<td>18.24998</td>
</tr>
<tr>
<td>13</td>
<td>13.17690</td>
<td>0.040000</td>
<td>1.452000</td>
<td>14.6689</td>
<td>20.9764</td>
<td>22.8484</td>
</tr>
<tr>
<td>Sum</td>
<td>169.33300</td>
<td>0.050000</td>
<td>19.43333</td>
<td>189.3264</td>
<td>282.7161</td>
<td>308.4198</td>
</tr>
<tr>
<td>SQRT</td>
<td>13.02180</td>
<td>0.074331</td>
<td>4.408325</td>
<td>13.75959</td>
<td>16.81416</td>
<td>17.56188</td>
</tr>
<tr>
<td>1/SQR</td>
<td>0.076847</td>
<td>1.336306</td>
<td>0.226844</td>
<td>0.072677</td>
<td>0.059474</td>
<td>0.056941</td>
</tr>
</tbody>
</table>
Table 18: The 14 fuzzy trapezoid numbers for fuzzy TOPSIS processes

<table>
<thead>
<tr>
<th>Q.No</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.763877</td>
<td>0.887359</td>
<td>1.596103</td>
<td>1.834828</td>
</tr>
<tr>
<td>2</td>
<td>0.788827</td>
<td>0.914829</td>
<td>1.602922</td>
<td>1.842346</td>
</tr>
<tr>
<td>3</td>
<td>0.686945</td>
<td>0.802501</td>
<td>1.460819</td>
<td>1.685541</td>
</tr>
<tr>
<td>4</td>
<td>0.753347</td>
<td>0.87577</td>
<td>1.542074</td>
<td>1.775239</td>
</tr>
<tr>
<td>5</td>
<td>0.651164</td>
<td>0.762948</td>
<td>1.41941</td>
<td>1.639788</td>
</tr>
<tr>
<td>6</td>
<td>0.608373</td>
<td>0.751566</td>
<td>1.371221</td>
<td>1.586507</td>
</tr>
<tr>
<td>7</td>
<td>0.622099</td>
<td>0.730775</td>
<td>1.401056</td>
<td>1.619499</td>
</tr>
<tr>
<td>8</td>
<td>0.824112</td>
<td>0.953642</td>
<td>1.621634</td>
<td>1.862973</td>
</tr>
<tr>
<td>9</td>
<td>0.664454</td>
<td>0.777645</td>
<td>1.455177</td>
<td>1.679308</td>
</tr>
<tr>
<td>10</td>
<td>0.583567</td>
<td>0.688055</td>
<td>1.354645</td>
<td>1.568171</td>
</tr>
<tr>
<td>11</td>
<td>0.816044</td>
<td>0.944771</td>
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<td>1.868526</td>
</tr>
<tr>
<td>12</td>
<td>0.593452</td>
<td>0.699022</td>
<td>1.365545</td>
<td>1.580229</td>
</tr>
<tr>
<td>13</td>
<td>0.535503</td>
<td>0.63466</td>
<td>1.205064</td>
<td>1.402464</td>
</tr>
<tr>
<td>14</td>
<td>0.750312</td>
<td>0.872413</td>
<td>1.524493</td>
<td>1.758840</td>
</tr>
</tbody>
</table>

Table 19: Maximum and minimum of fuzzy trapezoid numbers for A+ and A-

<table>
<thead>
<tr>
<th>Max Vi</th>
<th>No. 10</th>
<th>A+</th>
<th>0.787573</th>
<th>0.840805</th>
<th>1.108558</th>
<th>1.161955</th>
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</thead>
<tbody>
<tr>
<td>Min Vi</td>
<td>No. 8</td>
<td>A-</td>
<td>1.112209</td>
<td>1.165353</td>
<td>1.327045</td>
<td>1.380392</td>
</tr>
</tbody>
</table>

Table 20: Minimum and maximum trapezoid numbers with their membership functions

Afterward, each cell in Table 16 should be multiplied by (0.056941, 0.0059474, 0.072677, 0.076847) that is transpired. Table 18 demonstrates result of this multiplication.

In this step for finding minimum and maximum fuzzy trapezoid number for A+ and A-, was tried to calculate the area under each of the curve. Each curve forms a trapezoid shape. Table 19 shows minimum and maximum trapezoid numbers with their membership functions.

Therefore, the maximum and minimum vectors are for question number 1 and 13, respectively. Table 20 shows minimum and maximum trapezoid numbers with their membership functions.

After calculating reverse sum matrix (Table 23, 24), it is time now to multiply this matrix with matrix in Table 21 and 22.

In this case, two matrixes are with fuzzy number and result of multiplication of them is also fuzzy but not trapezoid number. Therefore, 14 none trapezoid numbers has been demonstrated in Table 25. Each8 parts in a row make a curve. Therefore, totally 14 curves was generated (Table 26, 27).

For ranking all parameters, area under any curve should be calculated. Therefore, according to the Adamo (1980).

In the Table 28, from first 9 important parameters, eight of them were repeated both in TOPSIS and fuzzyTOPSIS and it means that the outcomes of two methods are close to each other that can say approximately the results are the same however, in the fuzzy TOPSIS due to fuzzy numbers that are more accurate than normal numbers, it is obvious that the results are more exact than the results with normal numbers.

Therefore, the maximum and minimum vectors are for question number 1 and 13, respectively. Table 20 shows minimum and maximum trapezoid numbers with their membership functions.

After calculating reverse sum matrix (Table 23, 24), it is time now to multiply this matrix with matrix in Table 21 and 22.

In this case, two matrixes are with fuzzy number and result of multiplication of them is also fuzzy but not trapezoid number. Therefore, 14 none trapezoid numbers has been demonstrated in Table 25. Each8 parts in a row make a curve. Therefore, totally 14 curves was generated (Table 26, 27).

For ranking all parameters, area under any curve should be calculated. Therefore, according to the Adamo (1980).

In the Table 28, from first 9 important parameters, eight of them were repeated both in TOPSIS and fuzzyTOPSIS and it means that the outcomes of two methods are close to each other that can say approximately the results are the same however, in the fuzzy TOPSIS due to fuzzy numbers that are more accurate than normal numbers, it is obvious that the results are more exact than the results with normal numbers.
Table 23: The square distance between minimum and maximum for di+ and di-

<table>
<thead>
<tr>
<th></th>
<th>di+</th>
<th>di−</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>0.000622</td>
<td>0.000755</td>
<td>0.000477</td>
</tr>
<tr>
<td>0.005919</td>
<td>0.007201</td>
<td>0.018302</td>
</tr>
<tr>
<td>0.00111</td>
<td>0.00135</td>
<td>0.002919</td>
</tr>
<tr>
<td>0.012704</td>
<td>0.015478</td>
<td>0.031220</td>
</tr>
<tr>
<td>0.024182</td>
<td>0.029513</td>
<td>0.050572</td>
</tr>
<tr>
<td>0.020101</td>
<td>0.024518</td>
<td>0.038403</td>
</tr>
<tr>
<td>0.003628</td>
<td>0.004393</td>
<td>0.000652</td>
</tr>
<tr>
<td>0.012704</td>
<td>0.015478</td>
<td>0.031220</td>
</tr>
</tbody>
</table>

Table 24: Reverse sum of A+ and A−

<table>
<thead>
<tr>
<th>Reverse Sum</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.349344</td>
<td>6.539720</td>
<td>15.65882</td>
<td>19.17362</td>
<td></td>
</tr>
<tr>
<td>5.166547</td>
<td>6.315614</td>
<td>12.61753</td>
<td>15.43329</td>
<td></td>
</tr>
<tr>
<td>9.763784</td>
<td>11.945656</td>
<td>28.26876</td>
<td>34.65724</td>
<td></td>
</tr>
<tr>
<td>7.016943</td>
<td>8.584056</td>
<td>17.16234</td>
<td>21.02298</td>
<td></td>
</tr>
<tr>
<td>10.597333</td>
<td>12.959306</td>
<td>31.31031</td>
<td>38.34209</td>
<td></td>
</tr>
<tr>
<td>10.467346</td>
<td>12.790995</td>
<td>27.73148</td>
<td>33.9075</td>
<td></td>
</tr>
<tr>
<td>10.698542</td>
<td>13.079388</td>
<td>29.62222</td>
<td>36.23188</td>
<td></td>
</tr>
<tr>
<td>9.917976</td>
<td>12.134646</td>
<td>30.7838</td>
<td>37.71735</td>
<td></td>
</tr>
<tr>
<td>0.145609</td>
<td>12.395205</td>
<td>23.48849</td>
<td>28.71748</td>
<td></td>
</tr>
<tr>
<td>4.579813</td>
<td>5.596316</td>
<td>10.03517</td>
<td>12.28139</td>
<td></td>
</tr>
<tr>
<td>10.371174</td>
<td>12.672493</td>
<td>25.24331</td>
<td>30.86134</td>
<td></td>
</tr>
<tr>
<td>5.349350</td>
<td>6.539743</td>
<td>15.65884</td>
<td>19.17362</td>
<td></td>
</tr>
<tr>
<td>7.626959</td>
<td>9.331577</td>
<td>17.61974</td>
<td>21.58568</td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION

This study utilized normal TOPSIS and fuzzy TOPSIS method to rank the parameters that affect on website quality in online shopping based on Malaysian International student' perceptions.

The problem in this research is to identify parameters of website quality of online shopping websites in Malaysia. All parameters was identified from previous researches of several researchers.

This research makes a significant innovation, which is to analyze that “which parameters of online shopping website quality are important for international students”.

After collecting information through the literature Review, hierarchical structure of online shopping website quality was organize that shows parameters that affect on online shopping website quality. Then in the second step, based on the hierarchical structure a questionnaire was prepared just to gather information from international students in Malaysia. Afterward, all the collected data processed and ranked with the normal TOPSIS methods.

In the next step, using fuzzy TOPSIS with trapezoid numbers all parameters were ranked to compare with normal TOPSIS.

Accordingly the results of both fuzzy TOPSIS and TOPSIS compared with each other that have been shown in the Table 29. Findings show fuzzy TOPSIS due to fuzzy numbers that are more accurate than normal numbers. Therefore, 8 parameters that had been
<table>
<thead>
<tr>
<th>x</th>
<th>Mu(x)</th>
<th>Membership Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>x ≤ 0.278995</td>
<td>0</td>
<td>U1 = 0.013935 α^2 + 0.124708 α + 0.278995</td>
</tr>
<tr>
<td>x ≤ 3.584293</td>
<td>0</td>
<td>U2 = 0.119598 α^2 - 1.309473 α + 3.584293</td>
</tr>
<tr>
<td>0.417639 ≤ x ≤ 2.394418</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.278995 ≤ x ≤ 0.417638</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>2.394418 ≤ x ≤ 3.584293</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.331553</td>
<td>0</td>
<td>U3 = 0.016463 α^2 + 0.147761 α + 0.331553</td>
</tr>
<tr>
<td>x ≥ 2.986285</td>
<td>0</td>
<td>U4 = 0.099129 α^2 - 1.088170α + 2.986285</td>
</tr>
<tr>
<td>0.495777 ≤ x ≤ 1.997245</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.331553 ≤ x ≤ 0.495777</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.997245 ≤ x ≤ 2.986285</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.223932</td>
<td>0</td>
<td>U5 = 0.011431 α^2 + 0.101193 α + 0.223932</td>
</tr>
<tr>
<td>x ≥ 2.777179</td>
<td>0</td>
<td>U6 = 0.094051 α^2 - 1.022147α + 2.777179</td>
</tr>
<tr>
<td>0.336556 ≤ x ≤ 1.849082</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.223932 ≤ x ≤ 0.336556</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.849082 ≤ x ≤ 2.777179</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.3232996</td>
<td>0</td>
<td>U7 = 0.016731 α^2 + 0.149285α + 0.332996</td>
</tr>
<tr>
<td>x ≥ 2.921383</td>
<td>0</td>
<td>U8 = 0.0981004 α^2 - 1.070156α + 2.921382</td>
</tr>
<tr>
<td>0.499013 ≤ x ≤ 1.949229</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.3232996 ≤ x ≤ 0.499013</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.94229 ≤ x ≤ 2.921282</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.141761</td>
<td>0</td>
<td>U9 = 0.007283 α^2 + 0.064271α + 0.141761</td>
</tr>
<tr>
<td>x ≥ 2.159533</td>
<td>0</td>
<td>U10 = 0.072979 α^2 - 0.793980α + 2.159533</td>
</tr>
<tr>
<td>0.213315 ≤ x ≤ 1.438532</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.141761 ≤ x ≤ 0.213315</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.438532 ≤ x ≤ 2.159533</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.055582</td>
<td>0</td>
<td>U11 = 0.002875 α^2 + 0.025291α + 0.055582</td>
</tr>
<tr>
<td>x ≥ 1.148512</td>
<td>0</td>
<td>U12 = 0.038684 α^2 - 0.421579α + 1.148512</td>
</tr>
<tr>
<td>0.083747 ≤ x ≤ 0.765618</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.055582 ≤ x ≤ 0.083747</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>0.765618 ≤ x ≤ 1.148512</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.080228</td>
<td>0</td>
<td>U13 = 0.004145 α^2 + 0.036480α + 0.080228</td>
</tr>
<tr>
<td>x ≥ 1.706677</td>
<td>0</td>
<td>U14 = 0.057447 α^2 - 0.626246α + 1.706677</td>
</tr>
<tr>
<td>0.120853 ≤ x ≤ 1.137878</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.080228 ≤ x ≤ 0.120853</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.137878 ≤ x ≤ 1.706677</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.391312</td>
<td>0</td>
<td>U15 = 0.0119258 α^2 + 0.173620α + 0.391312</td>
</tr>
<tr>
<td>x ≥ 2.439731</td>
<td>0</td>
<td>U16 = 0.080303 α^2 - 0.885253α + 2.439731</td>
</tr>
<tr>
<td>0.54819 ≤ x ≤ 1.634781</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.391312 ≤ x ≤ 0.54819</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.634781 ≤ x ≤ 2.439731</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.164913</td>
<td>0</td>
<td>U17 = 0.008463 α^2 + 0.074724α + 0.164913</td>
</tr>
<tr>
<td>x ≥ 2.89076</td>
<td>0</td>
<td>U18 = 0.097666 α^2 - 1.062694α + 2.89076</td>
</tr>
<tr>
<td>0.248099 ≤ x ≤ 1.925732</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.164913 ≤ x ≤ 0.248099</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.925732 ≤ x ≤ 2.89076</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.023436</td>
<td>0</td>
<td>U19 = 0.001219 α^2 + 0.010696α + 0.023436</td>
</tr>
<tr>
<td>x ≥ 0.78855</td>
<td>0</td>
<td>U20 = 0.026586 α^2 - 0.289591α + 0.78855</td>
</tr>
<tr>
<td>0.035352 ≤ x ≤ 0.525545</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.023436 ≤ x ≤ 0.035352</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>0.525545 ≤ x ≤ 0.78855</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.360445</td>
<td>0</td>
<td>U21 = 0.017760 α^2 + 0.160020α + 0.360445</td>
</tr>
<tr>
<td>x ≥ 2.667689999</td>
<td>0</td>
<td>U22 = 0.087925 α^2 - 0.968619α + 0.360445</td>
</tr>
<tr>
<td>0.538225 ≤ x ≤ 1.786996</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.360445 ≤ x ≤ 0.538225</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>1.786996 ≤ x ≤ 2.667689999</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>x ≤ 0.034826</td>
<td>0</td>
<td>U23 = 0.001808 α^2 + 0.015877α + 0.034826</td>
</tr>
<tr>
<td>x ≥ 0.975232927</td>
<td>0</td>
<td>U24 = 0.032844 α^2 - 0.357954α + 0.975233</td>
</tr>
<tr>
<td>0.052511 ≤ x ≤ 0.650123</td>
<td>1</td>
<td>α ∈ [0, 1]</td>
</tr>
<tr>
<td>0.034826 ≤ x ≤ 0.052511</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
<tr>
<td>0.650123 ≤ x ≤ 0.975232927</td>
<td>α ∈ [0, 1]</td>
<td></td>
</tr>
</tbody>
</table>
Table 26: (Continued)

<table>
<thead>
<tr>
<th>Condition</th>
<th>( x )</th>
<th>( r_a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x \leq 0 )</td>
<td>0</td>
<td>U25 = 0</td>
</tr>
<tr>
<td>( x \geq 0 )</td>
<td>0</td>
<td>U26 = 0</td>
</tr>
<tr>
<td>( 0.6234 \leq x \leq 0 )</td>
<td>1</td>
<td>( \alpha \in [0, 1] )</td>
</tr>
<tr>
<td>( 0.7638 \leq x \leq 0 )</td>
<td>( \alpha \in [0, 1] )</td>
<td></td>
</tr>
<tr>
<td>( 0.351931 \leq x \leq 0.351931 )</td>
<td>0</td>
<td>U27 = ( 0.017708a^2 + 157886a + 0.351931 )</td>
</tr>
<tr>
<td>( 0.527525 \leq x \leq 1.797831 )</td>
<td>0</td>
<td>U28 = ( 0.090581a^2 - 0.988257a + 2.695507 )</td>
</tr>
<tr>
<td>( 1.0 \leq x \leq 1.797831 )</td>
<td>1</td>
<td>( \alpha \in [0, 1] )</td>
</tr>
<tr>
<td>( 2.0643 \leq x \leq 2.6234 )</td>
<td>( \alpha \in [0, 1] )</td>
<td></td>
</tr>
</tbody>
</table>

Table 27: Figure of curves for row 1 and row 9 of Table 25

<table>
<thead>
<tr>
<th>Function createfigure(KL, YL, XL)</th>
<th>Function createfigure(KL, YL, XL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>figure1 = figure;</td>
<td>figure1 = figure;</td>
</tr>
<tr>
<td>hold(axe1,'all');</td>
<td>hold(axe1,'all');</td>
</tr>
<tr>
<td>plot(XL, YL, 'Parent', axe1,...</td>
<td>plot(XL, YL, 'Parent', axe1,...</td>
</tr>
<tr>
<td>'DisplayName', 'U17=0.013989<em>x^2+0.124708</em>x+0.276699526'</td>
<td>'DisplayName', 'U17=0.013989<em>x^2+0.124708</em>x+0.276699526'</td>
</tr>
<tr>
<td>'DisplayName', 'U18=0.110568<em>x^2+0.004229</em>x^2+19.31'</td>
<td>'DisplayName', 'U18=0.110568<em>x^2+0.004229</em>x^2+19.31'</td>
</tr>
<tr>
<td>'DisplayName', 'U19=0.076810<em>x^2+1.3076977</em>x+0.3842903'</td>
<td>'DisplayName', 'U19=0.076810<em>x^2+1.3076977</em>x+0.3842903'</td>
</tr>
<tr>
<td>'DisplayName', 'U20=0.006667<em>x^2+0.677235</em>x+4.10113'</td>
<td>'DisplayName', 'U20=0.006667<em>x^2+0.677235</em>x+4.10113'</td>
</tr>
<tr>
<td>'DisplayName', 'U21=0.090581*x^2-0.988257x+2.695507'</td>
<td>'DisplayName', 'U21=0.090581*x^2-0.988257x+2.695507'</td>
</tr>
</tbody>
</table>

Table 28: A compression between normal TOPSIS and Fuzzy TOPSIS for ranking parameters

<table>
<thead>
<tr>
<th>Parameters ranking by fuzzy TOPSIS</th>
<th>Parameters ranking by normal TOPSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6234</td>
<td>0.276130</td>
</tr>
<tr>
<td>0.7638</td>
<td>13</td>
</tr>
<tr>
<td>0.9073</td>
<td>10</td>
</tr>
<tr>
<td>1.3129</td>
<td>6</td>
</tr>
<tr>
<td>1.5394</td>
<td>12</td>
</tr>
<tr>
<td>1.6106</td>
<td>5</td>
</tr>
<tr>
<td>1.7663</td>
<td>3</td>
</tr>
<tr>
<td>1.7948</td>
<td>9</td>
</tr>
<tr>
<td>2.0058</td>
<td>4</td>
</tr>
<tr>
<td>2.0192</td>
<td>3</td>
</tr>
<tr>
<td>2.0643</td>
<td>2</td>
</tr>
<tr>
<td>2.1869</td>
<td>9</td>
</tr>
<tr>
<td>2.6234</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4393
<table>
<thead>
<tr>
<th>$U_i$</th>
<th>Area</th>
<th>$S(U_i)$</th>
<th>$S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_1 = 0.013935a^2 + 0.124708a + 0.278995$</td>
<td>$\alpha$</td>
<td>$2 + 0.124708\alpha + 0.278995$</td>
<td>$S(U_1) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_2 = 0.119598a^2 - 1.309473a + 3.584293$</td>
<td>$\alpha$</td>
<td>$-1.309473\alpha + 3.584293$</td>
<td>$S(U_2) = 0.4109 \rightarrow S = 2.0643$</td>
</tr>
<tr>
<td>$U_3 = 0.016463a^2 + 0.147761a + 0.331553$</td>
<td>$\alpha$</td>
<td>$0.147761\alpha + 0.331553$</td>
<td>$S(U_3) = 0.3283 \rightarrow S = 2.0192$</td>
</tr>
<tr>
<td>$U_4 = 0.099129a^2 - 1.088170a + 2.986285$</td>
<td>$\alpha$</td>
<td>$-1.088170\alpha + 2.986285$</td>
<td>$S(U_4) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_5 = 0.016731a^2 + 0.149285a + 0.332996$</td>
<td>$\alpha$</td>
<td>$0.149285\alpha + 0.332996$</td>
<td>$S(U_5) = 0.3283 \rightarrow S = 2.0192$</td>
</tr>
<tr>
<td>$U_6 = 0.098004a^2 - 1.07156a + 2.91382$</td>
<td>$\alpha$</td>
<td>$-1.07156\alpha + 2.91382$</td>
<td>$S(U_6) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_7 = 0.00728a^2 + 0.064271a + 0.141761$</td>
<td>$\alpha$</td>
<td>$0.064271\alpha + 0.141761$</td>
<td>$S(U_7) = 0.3283 \rightarrow S = 2.0192$</td>
</tr>
<tr>
<td>$U_8 = 0.072979a^2 - 0.793980a + 2.159533$</td>
<td>$\alpha$</td>
<td>$-0.793980\alpha + 2.159533$</td>
<td>$S(U_8) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_9 = 0.002875a^2 + 0.02591a + 0.055582$</td>
<td>$\alpha$</td>
<td>$0.02591\alpha + 0.055582$</td>
<td>$S(U_9) = 0.3283 \rightarrow S = 2.0192$</td>
</tr>
<tr>
<td>$U_{10} = 0.038684a^2 - 0.421579a + 1.148512$</td>
<td>$\alpha$</td>
<td>$-0.421579\alpha + 1.148512$</td>
<td>$S(U_{10}) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_{11} = 0.019258a^2 + 0.173620a + 0.391312$</td>
<td>$\alpha$</td>
<td>$0.173620\alpha + 0.391312$</td>
<td>$S(U_{11}) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_{12} = 0.080303a^2 - 0.885253a + 2.439731$</td>
<td>$\alpha$</td>
<td>$-0.885253\alpha + 2.439731$</td>
<td>$S(U_{12}) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_{13} = 0.080303a^2 - 0.885253a + 2.439731$</td>
<td>$\alpha$</td>
<td>$-0.885253\alpha + 2.439731$</td>
<td>$S(U_{13}) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_{14} = 0.038684a^2 - 0.421579a + 1.148512$</td>
<td>$\alpha$</td>
<td>$-0.421579\alpha + 1.148512$</td>
<td>$S(U_{14}) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
<tr>
<td>$U_{15} = 0.019258a^2 + 0.173620a + 0.391312$</td>
<td>$\alpha$</td>
<td>$0.173620\alpha + 0.391312$</td>
<td>$S(U_{15}) = 0.3460 \rightarrow S = 2.6234$</td>
</tr>
</tbody>
</table>

Fig. 5: The most important nine criteria that ranked with fuzzy-TOPSIS method

repeated in two methods of ranking were selected. In addition, based on ranking this is understood that parameters in service quality are very important than two other groups. Finally, according to the ranking, first rank goes to trust that means to be able to providing to customer the trust facilities in online shopping website. The second rank is response time that means ability to perform the promised service faithfully and precisely. The third rank goes to reliability that means to be able to respond to customer desires. The rank four belongs to responsiveness that refers to providing the service on time and as ordered online. The rank five belongs to empathy that means to provide a personalized service through customized contents, personal greetings and individualized e-mail. The rank six belongs to the timeliness that refers to whether the information provided on the website is up-to-dated. The rank seven belongs to accuracy of information is concerned with the reliability of website content. In follows rank eight belongs to navigation that deals with the sequencing of pages, the organization of layout and consistency of navigation tools and finally the rank nine goes to accessibility that refers to the speed of access and information downloading and the availability of the
websites at all times. Figure 5: demonstrates the most important nine criteria that ranked with fuzzy-TOPSIS method.

REFERENCES


