An Investigation and Ranking Public and Private Islamic Banks Using Dimension of Service Quality (SERVQUAL) Based on TOPSIS Fuzzy Technique

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Abstract

Purpose: This paper propose a conceptual approach to assess the perceived service quality Dimensions such as SERVQUAL gap a between two types of banks, namely Public and Private Islamic Banks in Iran and to rank these characteristics of each Private and public Islamic Bank service. It aims to introduce (Fuzzy TOPSIS) approach for this purpose. In this paper is to propose a fuzzy multi-criteria decision model to evaluate the service quality of state and private banks. This paper develops an evaluation model based on the Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy Technique for Order Performance by Similarity to Ideal Solution (FTOPSIS) and Fuzzy Simple Additive Weighting (FSAW) methods. Furthermore, the relative weights of the chosen evaluation indexes were calculated by Fuzzy Analytic Hierarchy
Process (FAHP). And the two MCDM analytical tools of FTOPSIS and FSAW were respectively adopted to rank the four banks as an empirical example.

Design/methodology/approach- The target population includes the customers of the four private and public Islamic banks. In order to meet the objectives of the study, Fuzzy TOPSIS approach was used. Required information was gathered through a questionnaire. The sample includes 192 customers of private Islamic banks and 192 customers of public Islamic banks.

Practical limitations/implications

Originality/value: This paper emphasizes the need Analysis Gap of service quality to SERVQUAL Model to private and public Islamic Banks and ranking characterizes Perspective Consumer Perception. This paper also provides guidelines for bank managers in private and public Islamic Banks on which dimensions of service quality. They should emphasize in order to retain their customers and attract new ones. The study is the first application of a fuzzy TOPSIS approach to examine Service Quality Dimensions of Islamic Banks.

Keywords: SERVQUAL- Service Quality- TOPSIS Fuzzy - Iran-private and public Bank

1. Introduction

In today’s changing environment to survive must adopt to change. Create the appropriate structure is company's main concerns. The present’s date, companies are Successful that in areas of activity to be one step ahead. Nowadays no organization can succeed unless it can attract and retain enough customers ( Mehran Nejati, 2008). Service quality has been recognized as a key strategic issue for organizations operating in service sectors (Xin Guo et al., 2008).

Service quality has become an increasingly important factor for success and survival in the banking industry. Because of this, the correct assessment of bank service quality will be an essential topic. It applies the Gap theory between customer perceptions and expectations of service quality to determine perceived service quality (Chen et al., 2007).

Since Gap theory and SERVQUAL measurements were proposed (Parasuraman et al., 1985, 1988, 1991), such concepts and methods have been widely accepted and applied in the domain of service quality measurement. Therefore, understanding the customers‘ expectation and perception of banks’ service quality dimensions is necessary and important for banks, special perspective customers from private and public banks’ service quality dimensions.

This study seeks to review the Bank service quality dimensions and introduces a fuzzy TOPSIS approach for prioritizing these dimensions according to customers’ expectations and perception.
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In this paper an instrument is developed to measure service quality in the private and public Islamic bank in Iran.

2. Explanation of SERVQUAL Model

As a concept, service quality has received much attention in the literature because of its sustainability as a source of competitive advantage (Nejati et al., 2008). The pioneer study of Parasuraman et al. (1985) has been a major driving force in developing an increased understanding of and knowledge about service quality (Gerrard and Cunningham, 2001).

Nowadays SERVQUAL is the best-known service quality measurement instrument, and has been widely used to measure service quality in various service industries. In recent research, these have included: tourism management (Juwaheer, 2004; Antony et al., 2004; Tsang and Qu, 2000); library services (Yu et al., 2008); the banking sector (Chi et al., 2003; Jabnoun and Ai-Tamimi, 2003); electronic commerce (Durvasula et al., 1999; Gounaris, 2005); retailing services (Kumar et al., 2008; Ma and Niehm, 2006); information systems (Jiang et al., 2000; Lee et al., 2009); and the health sector (Wicks and Chin, 2008; Bakar et al., 2008a; Mostafa, 2005). It applies the Gap theory between customer perceptions and expectations of service quality to determine perceived service quality (Chen et al., 2007), (Hsiu-Yuan Hu et al., 2009).

At the heart of the SERVQUAL model is an understanding of the nature and determinants of customer expectations and perceptions of service quality. Consumers’ expectations and perceptions are measured to identify any shortfall in service levels, better known as the disconfirmation paradigm in the services marketing literature. A customer will perceive quality in a positive way only when the service provider meets or exceeds his/her expectations (Nejati et al., 2008).

The model is mainly to explain the reason that the service quality of the service industry cannot meet the customer demands, and considers that in order to meet the customer demands, it is necessary to break through the five service quality gaps in the model (Hsiu-Yuan Hu et al., 2009). SERVQUAL (Parasuraman et al., 1988, 1991) consists of the five dimensions explained below:

1. Reliability. This dimension refers to the ability to perform the service dependably and accurately.
2. Responsiveness. This dimension refers to the willingness to help customers and provide prompt service.
3. Tangibles. This dimension refers to the physical facilities, equipment, and appearance of personnel.
4. Assurance. This dimension refers to employees’ knowledge, courtesy and ability to convey trust and confidence.
Empathy. This dimension refers to the level of caring and individual attention provided to customers.

Paramusun (1988) defined service quality as the gap between customers’ expectation of service and their perception of the service experience. The various gaps visualised in the model are:

1. Gap 1: Difference between consumers’ expectation and management’s perceptions of those expectations, i.e. not knowing what consumers expect.
2. Gap 2: Difference between management’s perceptions of consumers’ expectations and service quality specifications, i.e. improper service-quality standards.
3. Gap 3: Difference between service quality specifications and service actually delivered, i.e. the service performance gap.
4. Gap 4: Difference between service delivery and the communications to consumers about service delivery, i.e. whether promises match delivery.
5. Gap 5: Difference between consumers’ expectation and perceived service.

This gap depends on size and direction of the four gaps associated with the delivery of service quality on the marketer’s side (Kumar et al., 2009).

Parasuraman et al. (1985) thinks that Gap 5 is the function of Gap 1 to Gap 4, which is $5 = f(Gap\ 1, \ Gap\ 2, \ Gap\ 3, \ Gap\ 4)$, among which Gap 1, Gap 2, Gap 3, and Gap 4 Gap are from the service provider, which originated from the internal organization, and Gap 5 is decided by the customer, which originated from the difference between customer expectation and actual perceptions (Hsiu-Yuan Hu et al., 2009).

In the current study the original five dimensions, namely tangibility, reliability, responsiveness, assurance, and empathy, consisted of 22 statements taken from the SERVQUAL model due to Parasuraman et al. (1985). An additional dimension, compliance, consisting of four statements, is added. The compliance is one of major concern for the bank customers, particularly in Iran Islamic bank. The perception of service “compliance” may affect customers’ overall evaluation of the Islamic service.

Othman and Owen (2001) reviewed the suitability of the original SERVQUAL items in Islamic banking and conducted a study to develop an instrument to measure customer service quality in Kuwait by taking account of a “Compliance with Islamic law” factor in Islamic beliefs. Surveying 360 retail banking customers in Kuwait, he produced an inventory called CARTER which consists of 34 items across six factors:

1. Assurance;
2. Reliability;
3. Tangibles;
4. Empathy; and
5. Responsiveness (figure 1).
3. Measurement of service quality with Questionnaire:

In order to prioritize the bank service quality in an Iranian context, the service quality factors were driven from the SERVQUAL model. The required data were gathered in the form of a questionnaire asking the respondents to choose the importance of the mentioned service quality factors based on measure, with rankings of: 0 definitely low; 1 Extra low; 2 very low; 3 low; 4 Slightly low; 5 middle; 6 Slightly high; 7 high 8 very high; 9 extra high; 10 Definitely high. Prioritizing the factors was done using the Fuzzy TOPSIS.

4. Evaluation of service quality framework and analytical methods

The analytical structure of this research is illustrated in Fig. 2. A service quality analysis is conducted based on the selected evaluation criteria. First the FAHP approach is employed to calculate the relative weights of the service quality evaluation indexes. Then, according to these weights the two MCDM analytical tools of TOPSIS and SAW are used to rank the banking service quality and determine the best choice.
The concepts of the fuzzy set theory and details of the analytical methods are explained in the following subsections.

5. The Fuzzy set theory and fuzzy number

Fuzzy set theory has been introduced by Zadeh (1965) provides a strict mathematical framework in which vague conceptual phenomena can be precisely and rigorously studied (Zimmermann, 1991). These sets are extension of classical sets whose elements have degrees of membership. In classical set theory, the membership of elements in a set is assessed in binary terms according to a bivalent condition – an element either belongs or does not belong to the set (Liou, Yen, & Tzeng, 2007; Wu & Lee, 2007). Fuzzy set theory is an important method to provide measuring the ambiguity of concepts that are associated with human beings’ subjective judgments including linguistic terms, satisfaction degree and importance degree that are often vague. Linguistic variables are variables whose values are words or sentences in a natural or artificial language. In other words, they are variables with lingual expression as their values (Hsieh et al., 2004; Zadeh, 1975). Because linguistic terms generally include uncertainty and vagueness, membership functions are used to pertain to a set for eliminating it. In the classical set theory, an entity is the member of a set or not. Because of the uncertainty of an entity in a fuzzy set, membership function that is the cornerstone of the fuzzy sets needs to be defined for each entity in the set.
A fuzzy number is a special fuzzy set \( \tilde{A} = x \in \mathbb{R} | \mu_\tilde{A}(x) \) where \( x \) takes its values on the real line \( \mathbb{R} : -\infty < x < +\infty \) and its membership function \( \mu_\tilde{A}(x) \) is a continuous mapping from and to the close interval \([0,1]\). The most commonly used fuzzy numbers are triangular and trapezoidal fuzzy numbers. In this paper, trapezoidal fuzzy numbers (TrFNs) are used to represent the linguistic variables with following membership function Eq. (1):

\[
\begin{align*}
TrFN(x : a, b, c, d) = & \begin{cases} 
0 & , x < a \\
\frac{(x-a)}{(b-a)} & , a \leq x < b \\
\frac{(d-x)}{(d-c)} & , c \leq x < d \\
0 & , x > d
\end{cases}
\end{align*}
\]

Definition of trapezoidal is left 0 in Fig 3; b is left 1; c is right 1; a and d is right 0.

The main arithmetic operations for two trapezoidal fuzzy numbers \( \tilde{A} = (a_1, b_1, c_1, d_1) \) and \( \tilde{B} = (a_2, b_2, c_2, d_2) \) are displayed as following Eqs. (2) – (5):

\[
\begin{align*}
\tilde{A} + \tilde{B} &= (a_1 + a_2, b_1 + b_2, c_1 + c_2, d_1 + d_2) \quad (2) \\
\tilde{A} - \tilde{B} &= (a_1 - d_2, b_1 - c_2, c_1 - b_2, d_1 - a_2) \quad (3) \\
\tilde{A} \otimes \tilde{B} &= (a_1 \cdot a_2, b_1 \cdot b_2, c_1 \cdot c_2, d_1 \cdot d_2) \quad (4) \\
\tilde{A} \oslash \tilde{B} &= (ra_1, rb_1, rc_1, rd_1) \quad (5)
\end{align*}
\]
6. Linguistic variable

Linguistic variables are variables whose values are words or sentences in a natural or artificial language. In other words, they are variables with lingual expression as their values. Possible values for these variables could be: “Definitely low”, “Extra low”, “Very low”, “Low”, “Slightly low”, “Middle”, “Slightly high”, “High”, “Very high”, “Extra high” and “Definitely high”. The evaluators are asked to conduct their judgments, and each linguistic variable can be indicated by a trapezoidal fuzzy number (TrFN) within the scale range of 0–1. The trapezoidal fuzzy conversion scale is presented in Table 1. For instance, the linguistic variable “Slightly low” can be represented as (0.3, 0.4, 0.4, 0.5).

<table>
<thead>
<tr>
<th>Eleven ranks of criteria rating of flexibility</th>
<th>Fuzzy number</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_0$: Definitely low</td>
<td>(0.001,0.001,0.001,0.1)</td>
</tr>
<tr>
<td>$V_1$: Extra low</td>
<td>(0.001,0.1,0.1,0.2)</td>
</tr>
<tr>
<td>$V_2$: Very low</td>
<td>(0.1,0.2,0.2,0.3)</td>
</tr>
<tr>
<td>$V_3$: Low</td>
<td>(0.2,0.3,0.3,0.4)</td>
</tr>
<tr>
<td>$V_4$: Slightly low</td>
<td>(0.3,0.4,0.4,0.5)</td>
</tr>
<tr>
<td>$V_5$: Middle</td>
<td>(0.4,0.5,0.5,0.6)</td>
</tr>
<tr>
<td>$V_6$: Slightly high</td>
<td>(0.5,0.6,0.6,0.7)</td>
</tr>
<tr>
<td>$V_7$: High</td>
<td>(0.6,0.7,0.7,0.8)</td>
</tr>
<tr>
<td>$V_8$: Very high</td>
<td>(0.7,0.8,0.8,0.9)</td>
</tr>
<tr>
<td>$V_9$: Extra high</td>
<td>(0.8,0.9,0.9,1.0)</td>
</tr>
<tr>
<td>$V_{10}$: Definitely high</td>
<td>(0.9, 1.0, 1.0, 1.0)</td>
</tr>
</tbody>
</table>

7. The fuzzy AHP method

Analytic hierarchy process (AHP) is one of the most widely-used multi-attribute decision-making (MADM) methods based on an additive weighting process, in which
several relevant attributes are represented through their relative importance. This method is a powerful method to solve complex decision problems. Any complex problem can be decomposed into several sub-problems using AHP in terms of hierarchical levels where each level represents a set of criteria or attributes relative to each sub-problem. Although, the classical AHP has some shortcomings. Pure AHP includes the opinions of experts and it is not capable of reflecting human’s vague thoughts. As well evaluation, improvement and selection based on preference of decision-makers have great influence on the AHP results. To overcome such problems, Buckley (1985) incorporated the fuzzy theory into the AHP, called the Fuzzy Analytic Hierarchy Process (FAHP). Experts may prefer intermediate judgments rather than certain judgments. Thus the fuzzy set theory makes the comparison process more flexible and capable to explain experts’ preferences (Kahraman, Cebeci, & Ulukan, 2003). The procedure of Buckley’s FAHP for determining the evaluation weights are explained as follows:

Step 1: Via consulting experts obtain the pair-wise comparison matrices of dimensions $(\tilde{A})$ whose elements are $(\tilde{a}_{ij})$, where all $i$ and $j$ are trapezoidal fuzzy numbers. Compute the elements of synthetic pair-wise comparison matrix by using the geometric mean method suggested by Buckley (1985).

There are 12 experts giving advice about relative importance of attributes. Applying fuzzy numbers defined in Table 1, we transfer the linguistic scales obtained by experts to the corresponding fuzzy numbers in Table 2 (also Appendix A). Then the elements of synthetic pair-wise comparison matrix are calculated as follow [1]:

$$\tilde{A} = \begin{pmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{pmatrix} = \begin{pmatrix} 1 & \tilde{t}_{12} & \cdots & \tilde{t}_{1n} \\ \tilde{t}_{21} & 1 & \cdots & \tilde{t}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{t}_{n1} & \tilde{t}_{n2} & \cdots & 1 \end{pmatrix}$$

Where:

$$\tilde{t}_{ij} = (\tilde{t}_{ij}^1 \otimes \tilde{t}_{ij}^2 \otimes \cdots \otimes \tilde{t}_{ij}^{12})^{1/12}$$

It can be obtained the all matrix elements by this procedure, therefore, the synthetic pair wise comparison matrices will be constructed as follows Table 2 and also Appendix A:
Table 2. Assign linguistic terms to the pair wise comparisons by asking

<table>
<thead>
<tr>
<th>Evaluation of service quality of state and private banks</th>
<th>Tangible (_{D_1})</th>
<th>Reliability (_{D_2})</th>
<th>Responsibility (_{D_3})</th>
<th>Assurance (_{D_4})</th>
<th>Empathy (_{D_5})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible (_{D_1})</td>
<td>1</td>
<td>(\nu_5)</td>
<td>(\nu_8)</td>
<td>(\nu_7)</td>
<td>(\nu_9)</td>
</tr>
<tr>
<td>Reliability (_{D_2})</td>
<td>(\nu_5^{-1})</td>
<td>1</td>
<td>(\nu_6)</td>
<td>(\nu_6)</td>
<td>(\nu_7)</td>
</tr>
<tr>
<td>Responsibility (_{D_3})</td>
<td>(\nu_8^{-1})</td>
<td>(\nu_6^{-1})</td>
<td>1</td>
<td>(\nu_7)</td>
<td>(\nu_6)</td>
</tr>
<tr>
<td>Assurance (_{D_4})</td>
<td>(\nu_9^{-1})</td>
<td>(\nu_6^{-1})</td>
<td>(\nu_7^{-1})</td>
<td>1</td>
<td>(\nu_8)</td>
</tr>
<tr>
<td>Empathy (_{D_5})</td>
<td>(\nu_9^{-1})</td>
<td>(\nu_7^{-1})</td>
<td>(\nu_6^{-1})</td>
<td>(\nu_8^{-1})</td>
<td>1</td>
</tr>
</tbody>
</table>

Step 2: The fuzzy weights \(\tilde{W}_i\) and geometric mean for each row can be calculated as follows:

\[
\tilde{z}_i = \left[ \prod_{j=1}^{n} \tilde{f}_{ij} \right]^{1/n}, \text{ for all } i \tag{8}
\]

\[
\tilde{w}_i = \tilde{z}_i \odot \left[ \sum_{j=1}^{n} \tilde{z}_j \right]^{-1}, \text{ for all } i \tag{9}
\]

Then, the weights for the dimensions can be found as shown in Table 3. Table 3 shows the relative weight of five dimensions of the evaluation of service quality of state and private banks, which obtained by AHP method.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible</td>
<td>(0.0818, 0.1234, 0.1234, 0.1665)</td>
</tr>
<tr>
<td>Reliability</td>
<td>(0.1078, 0.1528, 0.1528, 0.2093)</td>
</tr>
<tr>
<td>Responsibility</td>
<td>(0.1254, 0.1747, 0.1747, 0.2364)</td>
</tr>
<tr>
<td>Assurance</td>
<td>(0.1672, 0.2333, 0.2333, 0.3450)</td>
</tr>
<tr>
<td>Empathy</td>
<td>(0.2270, 0.3158, 0.3158, 0.4530)</td>
</tr>
</tbody>
</table>

8. The fuzzy TOPSIS method

In this study, we propose this method to evaluate the service quality of state and private banks. TOPSIS is one of the classical Multi-criteria decision making methods, was first developed by Hwang and Yoon (1981). There are two main differences between AHP and TOPSIS. (1) Pair-wise comparisons for attributes and alternatives are made in AHP, although there is no pair-wise comparison in TOPSIS. (2) AHP uses a hierarchy of attributes and alternatives, whereas TOPSIS does not. In this paper we
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use AHP for obtaining weight of attributes and then apply TOPSIS for ranking the alternatives.

The TOPSIS method is based on the concept that the chosen alternative should have the shortest distance from the positive-ideal solution (PIS) and the longest distance from the negative-ideal solution (NIS). Thus, the best alternative should not only be the shortest distance away from the positive ideal, but also should be the largest distance away from the negative ideal solution. It is often difficult for a decision-maker to assign a precise performance rating to an alternative for the attributes under consideration. The eligibility of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of precise numbers for conformity the real world in fuzzy environment. In the following the steps of TOPSIS are given:

Step 1: Determine the weighting of evaluation criteria. Fuzzy preference weights found in previous section by applying FAHP.

Step 2: Establish the fuzzy decision matrix. For This purpose, first 384 matrices are collected from customers (each bank = 96 matrices). Then appropriate linguistic variables for the alternatives with respect to attributes are assigned to each matrix. Ultimately, final decision matrix is calculated by arithmetic means of collected matrices as follows:

\[
\ddot{D} = \begin{bmatrix}
C_1 & C_2 & \ldots & C_n \\
A_1 & \ddot{x}_{11} & \ddot{x}_{12} & \ldots & \ddot{x}_{1n} \\
\vdots & \ddots & \ddots & \ddots & \ddots \\
A_m & \ddot{x}_{m1} & \ddot{x}_{m2} & \ldots & \ddot{x}_{mn} \\
\end{bmatrix}
\]

where \( \ddot{x}_{ij} \) is the performance rating of alternative \( A_i \) with respect to criterion \( C_j \) evaluated by \( k \)th expert, each element of decision matrix is shown with a trapezoidal number as follow:

\[
\ddot{x}_{ij} = \frac{1}{K} (\ddot{x}_{ij}^{1} \oplus \ldots \oplus \ddot{x}_{ij}^{K} \oplus \ldots \oplus \ddot{x}_{ij}^{n})
\]

We have shown the trapezoidal fuzzy number that defined as in Eq. 12 in Fig4. The fuzzy weights can be described by

\[
w_j = (\alpha_j, \beta_j, \gamma_j, \delta_j)
\]
This paper focuses on evaluating the service quality of state and private banks; so, we assume that questionnaire has collected completely and will start with building dataset that are collected. The evaluators have linguistic variables employed in this study according to their subjective judgments. The evaluators then adopted linguistic terms to express their opinions about the rating of every band regarding each capability criteria, based on the data of the four banks listed in Table 4.

Table 4: Subjective cognition results of evaluators towards the 11 levels of linguistic variables.

<table>
<thead>
<tr>
<th></th>
<th>Melli Bank</th>
<th>Sepah Bank</th>
<th>Persian Bank</th>
<th>Tosee Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible</td>
<td>(0.4,0.5,0.5,0.6)</td>
<td>(0.4,0.5,0.5,0.6)</td>
<td>(0.6,0.7,0.7,0.8)</td>
<td>(0.5,0.6,0.6,0.7)</td>
</tr>
<tr>
<td>Reliability</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.6,0.7,0.7,0.8)</td>
</tr>
<tr>
<td>Responsibility</td>
<td>(0.4,0.5,0.5,0.6)</td>
<td>(0.4,0.5,0.5,0.6)</td>
<td>(0.7,0.8,0.8,0.9)</td>
<td>(0.6,0.7,0.7,0.8)</td>
</tr>
<tr>
<td>Assurance</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.7,0.8,0.8,0.9)</td>
<td>(0.6,0.7,0.7,0.8)</td>
</tr>
<tr>
<td>Empathy</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.5,0.6,0.6,0.7)</td>
<td>(0.5,0.6,0.6,0.7)</td>
</tr>
</tbody>
</table>

Step 3: Normalize the Decision Matrix. The normalized fuzzy-decision matrix denoted by $\tilde{R}$ is shown as following formula:

$$\tilde{R} = [\tilde{r}_{ij}]_{m \times n} , \ i = 1,2,\ldots,m \ ; \ j = 1,2,\ldots,n$$  \hspace{1cm} (13)

For normalizing decision matrix we use linear scale transformation as follows:

$$r_{ij} = \begin{cases} \frac{x_{ij}^{+}x_{j}^{*}}{x_{i}^{+}} = \left( \frac{a_{ij}}{d_{j}}, \frac{b_{ij}}{c_{j}}, \frac{c_{ij}}{b_{j}}, \frac{d_{ij}}{a_{j}} \right) & \text{Is a benefit attribute} \\ \frac{x_{j}^{-}x_{i}^{+}}{x_{j}^{-}} = \left( \frac{a_{i}}{d_{j}}, \frac{b_{i}}{c_{j}}, \frac{c_{i}}{b_{j}}, \frac{d_{i}}{a_{j}} \right) & \text{Is a cost attribute} \end{cases}$$  \hspace{1cm} (14)

Where $x_{ij} = (a_{ij}, b_{ij}, c_{ij}, d_{ij})$ and $x_{j}^{*} = (a_{j}^{*}, b_{j}^{*}, c_{j}^{*}, d_{j}^{*})$, thus $\tilde{r}_{ij}$ can obtain as Eq.15:
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So normalized decision matrix will be as follow:

\[
\begin{bmatrix}
    a_1 & b_1 & c_1 & d_1 \\
    d_2 & c_2 & b_2 & a_2 \\
    \vdots & \vdots & \vdots & \vdots \\
    c_n & b_n & a_n \\
\end{bmatrix}
\]

Using this step we can normalize the fuzzy-decision matrix as Table 5.

<table>
<thead>
<tr>
<th></th>
<th>Melli Bank</th>
<th>Sepah Bank</th>
<th>Persian Bank</th>
<th>Tosee Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible</td>
<td>0.50,0.62,0.62,0.75</td>
<td>0.50,0.62,0.62,0.75</td>
<td>0.75,0.87,0.87,1.00</td>
<td>0.62,0.75,0.75,0.87</td>
</tr>
<tr>
<td>Reliability</td>
<td>0.62,0.75,0.75,0.87</td>
<td>0.62,0.75,0.75,0.87</td>
<td>0.62,0.75,0.75,0.87</td>
<td>0.75,0.87,0.87,1.00</td>
</tr>
<tr>
<td>Responsibility</td>
<td>0.44,0.55,0.55,0.66</td>
<td>0.44,0.55,0.55,0.66</td>
<td>0.77,0.88,0.89,1.00</td>
<td>0.66,0.77,0.77,0.88</td>
</tr>
<tr>
<td>Assurance</td>
<td>0.55,0.66,0.66,0.77</td>
<td>0.55,0.66,0.66,0.77</td>
<td>0.78,0.88,0.88,1.00</td>
<td>0.66,0.77,0.77,0.88</td>
</tr>
<tr>
<td>Empathy</td>
<td>0.71,0.85,0.86,1.00</td>
<td>0.71,0.85,0.85,1.00</td>
<td>0.71,0.85,0.85,1.00</td>
<td>0.71,0.85,0.85,1.00</td>
</tr>
</tbody>
</table>

Step 4: Obtain the Weighted Normalized Decision Matrix. The weighted fuzzy normalized decision matrix is shown as following matrix \( \tilde{V} \):

\[
\tilde{V} = [\tilde{v}_{ij}]_{m \times n}, \quad i = 1,2,...,m; \quad j = 1,2,...,n
\]

Where:

\[
\tilde{v}_{ij} = \tilde{w}_{ij} \otimes \tilde{w}_{ij}
\]

Whereas both \( \tilde{w}_{ij} \) and \( \tilde{w}_{ij} \) are fuzzy numbers, multiply operation will be as Eq.19 and 20:

\[
\begin{align*}
\tilde{w}_{ij} & = \tilde{w}_{ij} = \left( \frac{a_{ij}}{d_{ij}}, \frac{b_{ij}}{c_{ij}}, \frac{c_{ij}}{b_{ij}}, \frac{d_{ij}}{a_{ij}} \right) \\
\tilde{w}_{ij} & = \tilde{w}_{ij} = \left( \frac{a_{ij}}{d_{ij}}, \frac{b_{ij}}{c_{ij}}, \frac{c_{ij}}{b_{ij}}, \frac{d_{ij}}{a_{ij}} \right)
\end{align*}
\]
Eq. 19 is used when the \( j \)\textsuperscript{th} attribute is a benefit attribute. Eq. 20 is used when the \( j \)\textsuperscript{th} attribute is a cost attribute. Final weighted fuzzy normalized decision matrix is shown as Eq. 21:

\[
\bar{R} = \begin{pmatrix}
X_1 & \ldots & X_j & \ldots & X_n \\
A_i \left( \nu_{i1} & \ldots & \nu_{ij} & \ldots & \nu_{in} \right) \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
A_m \left( \nu_{m1} & \ldots & \nu_{mj} & \ldots & \nu_{mn} \right)
\end{pmatrix}
\] (21)

The forth step in the analysis is to find the weighted fuzzy-decision matrix; the resulting fuzzy-weighted decision matrix is shown as Table 6.

**Table 6: Weighted normalized fuzzy-decision matrix.**

<table>
<thead>
<tr>
<th></th>
<th>Melli Bank</th>
<th>Sepah Bank</th>
<th>Persian Bank</th>
<th>Tosee Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible</td>
<td>0.04,0.07,0.07,0.12</td>
<td>0.04,0.07,0.07,0.12</td>
<td>0.06,0.10,0.10,0.16</td>
<td>0.05,0.09,0.09,0.14</td>
</tr>
<tr>
<td>Reliability</td>
<td>0.06,0.11,0.11,0.18</td>
<td>0.06,0.11,0.11,0.18</td>
<td>0.06,0.11,0.11,0.18</td>
<td>0.08,0.13,0.13,0.20</td>
</tr>
<tr>
<td>Responsibility</td>
<td>0.05,0.09,0.09,0.15</td>
<td>0.05,0.09,0.09,0.15</td>
<td>0.09,0.15,0.15,0.23</td>
<td>0.08,0.13,0.13,0.21</td>
</tr>
<tr>
<td>Assurance</td>
<td>0.09,0.15,0.15,0.26</td>
<td>0.09,0.15,0.15,0.26</td>
<td>0.13,0.20,0.20,0.34</td>
<td>0.11,0.18,0.18,0.30</td>
</tr>
<tr>
<td>Empathy</td>
<td>0.16,0.27,0.27,0.45</td>
<td>0.16,0.27,0.27,0.45</td>
<td>0.16,0.27,0.27,0.45</td>
<td>0.16,0.27,0.27,0.45</td>
</tr>
</tbody>
</table>

Step 5: Determine the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS). We can define the FPIS \( A^+ \) (aspiration levels) and FNIS \( A^- \) (the worst levels) as following formula:

\[
A^+ = (\bar{v}_{1},\ldots,\bar{v}_{j},\ldots,\bar{v}_{n})
\] (22)

\[
A^- = (\underline{v}_{1},\ldots,\underline{v}_{j},\ldots,\underline{v}_{n})
\] (23)

Where \( \bar{v}_{j} \) and \( \underline{v}_{j} \) are the fuzzy numbers with the largest generalized mean and the smallest generalized mean, respectively. The generalized mean for fuzzy number \( v_{ij}, \forall i,j \) is defined as:

\[
M(v_{ij}) = \frac{-d_y^2 - b_y^2 + c_y^2 + d_y^2 - a_y b_y + c_y d_y}{3(-a_y - b_y + c_y + d_y)}
\] (24)

For each column \( j \), we find a \( v_{ij} \) whose greatest mean is \( \bar{v}_{j} \) and whose lowest mean is \( \underline{v}_{j} \).

Step 6: Calculate the distance of each alternative from FPIS and FNIS. The distances (\( \overline{d}_i \) and \( \overline{d}_i \)) of each alternative from \( A^+ \) and \( A^- \) can be currently calculated by the area compensation method.
Details of distance calculating for fuzzy numbers based on Zadeh (1965)’s study is explained as given in Eq. 27:

\[ d(\tilde{v}_i, \tilde{v}_j) = 1 - \sup_{x} \left[ \mu_{v_i}(x) \wedge \mu_{v_j}(x) \right] = 1 - L_{ij}, \quad \forall i, j \]  

Where \( L_{ij} \) is the highest degree of similarity \( v_i \) and \( v_j \).

Similarly, the difference \( \mu_{v_i}(x) \) and \( \mu_{v_j}(x) \) is defined as:

\[ d(\tilde{v}_i, \tilde{v}_j) = 1 - \sup_{x} \left[ \mu_{v_i}(x) \wedge \mu_{v_j}(x) \right] = 1 - L_{ij}, \quad \forall i, j \]  

Note that both \( d_{ij}^{+} \) and \( d_{ij}^{-} \) are crisp numbers.

Step 7: Compute the Relative Closeness to Ideals. Once the \( d_{ij}^{+} \) and \( d_{ij}^{-} \) of each alternative have been calculated in Step 6, Calculate similarities to ideal solution. This step solves the similarities to an ideal solution by formula:

\[ C_i = \frac{d_{ij}^{-}}{d_{ij}^{+} + d_{ij}^{-}} = 1 - \frac{d_{ij}^{+}}{d_{ij}^{+} + d_{ij}^{-}} \quad i=1,2,...,m \]  

At last the alternatives are ranked in descending order of the \( C_i \) index. From the results of Table 7, we can find out the satisfaction degrees of each bank.

9. The fuzzy SAW method

The SAW method is probably the best known and most widely used multiple attribute decision-making (MADM) method. Formally the value of an alternative in the SAW method can be expressed as:

\[ V(A_i) = V_i = \sum_{j=1}^{n} w_j v_j(x_{ij}), \quad i = 1, 2, ..., m \]  

Where \( V(A_i) \) is the value function of alternative \( A_i \) and \( w_j \) and \( v_j(.) \) are weight and value functions of attribute \( x_j \), respectively. If both \( w_j \) and \( n_j \) are fuzzy sets:

\[ w_j = \{(y_j, \mu w_j(y_j))\}, \quad \forall j \]  

And

\[ n_j = \{(x_{ij}, \mu n_j(x_{ij}))\}, \quad \forall i, j \]  

So utility of each attribute will calculate as:
The membership function $\mu_{ui}(u_i)$ can be calculated using:

$$\mu_{ui}(u_i) = \sup \left\{ \left[ \bigwedge_{j=1}^{n} \mu_{w_j}(y_j) \right] \wedge \left[ \bigwedge_{j=1}^{n} \mu_{n_j}(x_j) \right] \right\}$$

(34)

Where:

$$\vee = (y_1, ..., y_n, x_1, ..., x_n)$$

The membership function $\mu_{ui}(u_i)$ is not directly obtainable when $\mu_{w_j}(y_j)$ and $\mu_{n_j}(x_j)$ are piecewise continuously differentiable functions. To resolve this difficulty and preserve the simplicity of the simple additive weighting method, several approaches have been proposed. One of the easiest methods is one proposed by Bonissone that assumes all piecewise continuously differentiable fuzzy numbers can be approximated by L-R-type trapezoidal numbers.

3.5.1 Bonissone’s (1982) Approach

Bonissone (1982) assume that fuzzy/crisp information in decision problems can be approximated by a parameter-based representation. It is called the L-R-type trapezoidal number (see Fig 5). Fuzzy arithmetic operations with L-R type trapezoidal numbers are given in the following discussion. Let $\tilde{M} = (a, b, \alpha, \beta)$ and $\tilde{N} = (c, d, \gamma, \delta)$ be positive trapezoidal fuzzy numbers:

$$\tilde{M} + \tilde{N} = (a + c, b + d, \alpha + \gamma, \beta + \delta)$$

(35)

$$\tilde{M} - \tilde{N} = (a - d, b - c, \alpha + \delta, \beta + \gamma)$$

(36)

$$\tilde{M} \times \tilde{N} = (ac, bd, a\gamma + \alpha, b\delta + \beta + \gamma)$$

(37)

$$\tilde{M} \div \tilde{N} = \left( \frac{a}{d} \cdot \frac{b}{c} \cdot \frac{a\delta + d\alpha}{d(d + \delta)} \cdot \frac{b\gamma + c\beta}{c(c - \gamma)} \right)$$

(38)
An investigation and ranking public

Fig 5. L-R-Type trapezoidal fuzzy number, \( \tilde{M} = (a, b, \alpha, \beta) \)

Using the algebraic operations above, one can easily compute the performance of an alternative with respect to the attributes by using:

\[
\bar{u}_i = \sum_{j=1}^{n} w_j r_{ij}
\]

where \( w_j \) and \( r_{ij} \) may be crisp or fuzzy numbers represented in the L-R trapezoidal number format.

The last step in our analysis is to find the utility of each attribute and compare with the satisfaction degree value in TOPSIS method; the resulting fuzzy-utility is shown as Table 7.

<table>
<thead>
<tr>
<th></th>
<th>( \bar{d}_i )</th>
<th>( \bar{d}_i )</th>
<th>( \bar{u}_i )</th>
<th>Rank in TOPSIS</th>
<th>Rank in SAW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melli Bank</td>
<td>7.5225</td>
<td>1.5734</td>
<td>(0.4190,0.7150,0.3826,3.0376)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sepah Bank</td>
<td>7.5225</td>
<td>1.5734</td>
<td>(0.4190,0.7150,0.3826,3.0376)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Persian Bank</td>
<td>7.2467</td>
<td>1.8572</td>
<td>(0.5184,0.8559,0.4820,3.5727)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tosee Bank</td>
<td>7.3284</td>
<td>1.7726</td>
<td>(0.4891,0.8143,0.4528,3.4126)</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

10. Conclusion

In this paper, fuzzy decision making procedure provided for evaluation and comparison service quality of four private and public banks according to the criteria meant, was trying. For this purpose, FSAW, FTOPSIS, FAHP methods have been used. Finally (see Table 7) using these methods it was found that service quality in private banks ranked far higher than state banks, which are themselves the reason could be the privatization of state banks. Answer this study ranked
FSAW, FTOPSIS and one that can occur in other issues and even different opinions of experts and customers will change, causing different answers to these two solutions are ranked. The model for those macro-level decision makers who need to evaluate and compare the experts and customers have an activity can be useful and practical.

References


Received: April, 2011