

Highlighting the Main Factors of Internet Banking via Multiple Criteria Decision Analysis

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Abstract

From the rapid development of technology has emerged a novel banking service called internet banking or e-banking. Since E-banking enable customers to communicate with their banks and bank accounts via internet, a wide range of services can be provided to customers. These capabilities turn e-banking as one the crucial factors for competitive success in banking. Therefore, banks are increasingly investing on customer-centric analytical tools in order to investigate the better client buying and channel usage patterns, which can help build and improve customer relationships. However, banks need to seek how to reduce costs while they are trying to improve customer demands and business success. Thus, banks aim to focus on customer-centric factors and at the same time, cost-centric factors to survive in this competitive business world. This paper aims to identify the main e-banking aspects which can influence the customer satisfaction positively and reduce costs. These factors are derived from the literature, and are analyzed via a fuzzy AHP method in order to highlight the crucial criteria of E-banking.

Keywords

E-banking, multi criteria decision analysis, fuzzy AHP

Introduction

The increasing number of computer and internet users has encouraged industries to use technology wisely to reduce the costs and at the same time, to increase customer satisfaction. With the advancement of technology, it has become ideal and profitable to start the electronic delivery of banking services for banks to meet or exceed customer's expectations. Banks are trying to survive and compete with each other by providing e-banking. However, quality of information, quality of service, and quality of system are critical factors in e-banking success [1]–[5]. Poon [6] and Lamb et.al. [7] stated that the internet banking or electronic delivery of banking services is a great way to have a close customer relationship and thus, banks can meet or exceed customers' expectations using e-banking. In the near future, internet banking will be more common and usable than the traditional banking in most of countries [8].

In this study, the e-banking users are asked with a survey to compare the most critical factors based on their opinions. The results from the users are utilized in the fuzzy AHP MCDM method to evaluate and rank the criteria from the most important to the least important to the users of e-banking. The results of this study could provide a clear-cut starting point for banks who would like to start or develop e-banking services.

In this work, an extensive literature review is conducted in order to list the most important factors for e-banking services. Figure 1 indicates three main criteria along with several sub-criteria that are investigated. A pair-wise comparison questionnaire was designed and sent to the users of e-banking services. Then, an AHP-Fuzzy method was utilized to map the judge's opinion to a fuzzy scale in order to evaluate and rank the most critical factors of e-banking services.

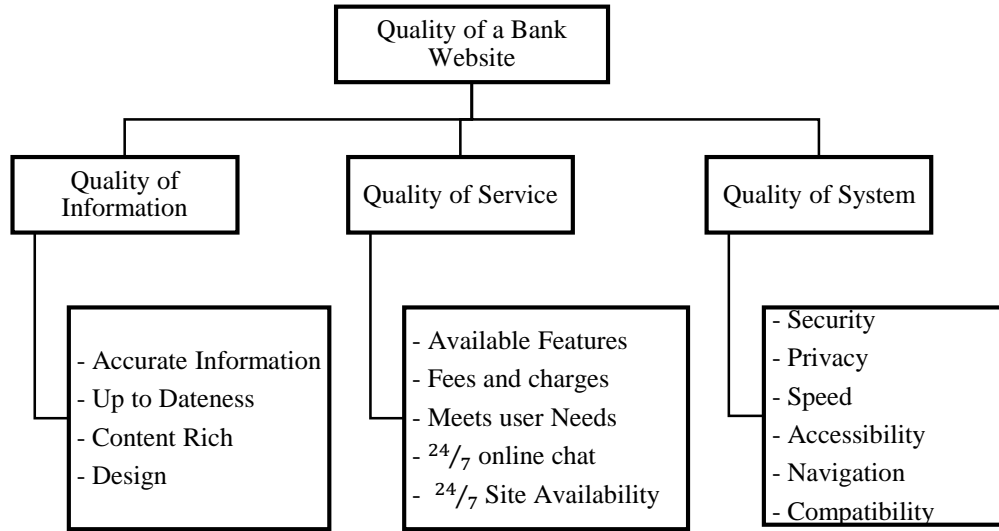


Figure 1- The criteria of the quality of a bank website

Literature Review

Kahraman and Kaya [9] used fuzzy AHP-ELECTRE methodology to study the quality of e-banking. In this study, multiple criteria including: product quality, reliability, responsiveness, competence, access, information content, ease of use, and security are compared, and the most important quality factors are concluded as security and competence. Hu and Liao [10] utilized a fuzzy MCDM approach to evaluate and rank the criteria of service quality of internet banking. Conducting a questionnaire for the users of internet banking, authors received fuzzy data and used it in the evaluation process. The fuzzy MCDM method the authors used gave the results that “efficiency, reliability, continuous improvement and tangibility” are the most critical factors to internet banking users. Poon [6] made an extensive literature review to find ten e-banking criteria of “convenience of usage, accessibility, features availability, bank management and image, security, privacy, design, content, speed, and fees and charges” to evaluate the rate of importance to users. Author made a face to face 4 point Likert scale questionnaire with 500 people in different states of Malaysia. Authors introduced “privacy and security” and “accessibility, convenience, design, and content” as the most important factors to the users.

Methodology

Satty [11] proposed one of the powerful and well-known decision making techniques known as the Analytic Hierarchy Process (AHP). This method is used to determine an overall ranking of alternatives and their priorities among other choices [12]–[14]. In this approach, pairwise comparisons are made to define perceptions of each participant based on a discrete scale between one to nine to evaluate the weight of each criterion and sub-criteria and to form a comparison matrix. This matrix is composed by comparing elements a_{ij} which shows the assessment of criterion i over criterion j . To measure the consistency of the decision maker’s judgment, Consistency Rate (CR) is applied. Although application of AHP is simple, this method has been criticized for not being able to deal with imprecision, uncertainty and vagueness of linguistic assessment. It would not be easy to use numerical values for human judgment over many decision problems. So, in order to eliminate this limitation, the fuzzy AHP method was introduced to tackle the intrinsic nature of linguistic judgment. The fuzzy AHP methodology has been used in this paper in order to rank the main criteria of e-banking. The main parts of the fuzzy AHP approach are:

a. Triangular fuzzy numbers and algebraic operation

In this paper, triangular fuzzy numbers (TFN) are represented as (l, m, n) where $l \leq m \leq n$. The algebraic operation of fuzzy numbers such as addition, multiplication, and inverse are similar to mathematical rules and follow the same procedures. Assume that $\tilde{N}_1 = (l_1, m_1, n_1)$ and $\tilde{N}_2 = (l_2, m_2, n_2)$ are two different triangular fuzzy numbers. For \tilde{N}_1 and \tilde{N}_2 addition, multiplication, inverse, and geometric mean [12] are defined respectively as equations (1), (2), (3), and (4):

$$\tilde{N}_1 \oplus \tilde{N}_2 = (l_1 + l_2, m_1 + m_2, n_1 + n_2) \quad (1)$$

$$\tilde{N}_1 \otimes \tilde{N}_2 = (l_1 \times l_2, m_1 \times m_2, n_1 \times n_2)^{-1} \quad (2)$$

$$\tilde{N}_1^{-1} = \left(\frac{1}{n_1}, \frac{1}{m_1}, \frac{1}{l_1} \right) \quad (3)$$

$$\tilde{g}_{ij} = \left(\prod_{k=1}^n \tilde{a}_{ijk} \right)^{1/n} \quad (4)$$

b. Linguistic terms and triangular fuzzy numbers

The linguistic terms of e-banking system questionnaires' form and their equivalent triangular fuzzy numbers are defined as Table 1.

Table 1 – Equivalent triangular fuzzy number of linguistic scale

| Linguistic scale | Equivalent triangular fuzzy number |
|------------------------------|------------------------------------|
| Absolutely more important | (7/2, 4, 9/2) |
| Very strongly more important | (5/2, 3, 7/2) |
| Strongly more important | (3/2, 2, 5/2) |
| Weakly more important | (2/3, 1, 3/2) |
| Equally important | (1,1,1) |

c. Aggregation method of fuzzy matrix

AHP and fuzzy AHP approaches are based on a pairwise comparisons of a criterion over another criterion. A fuzzy judgement matrix (5) of n criteria has $n \times n$ fuzzy numbers and obtains from $\frac{n \times (n-1)}{2}$ pairwise comparison. Each fuzzy number in the matrix is a preference's indicator of criterion i over criterion j . In the fuzzy matrix, If $a_{ij}=(l_{ij}, m_{ij}, n_{ij})$, then the reciprocal fuzzy number is $\tilde{a}_{ji} = \left(\frac{1}{l_{ij}}, \frac{1}{m_{ij}}, \frac{1}{n_{ij}} \right)$.

$$\tilde{A} = \begin{bmatrix} 1 & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \cdots & 1 \end{bmatrix} \quad (5)$$

To aggregate the fuzzy matrix of all decision makers, the mean method of Buckley for the fuzzy matrix [15], [16] is applied. This method uses fuzzy geometric mean to combine views of n decision makers as shown in equation (4). In this technique, \tilde{a}_{ijk} shows the view of the k^{th} decision maker on the superiority of criterion i over criterion j . The method aggregates the view of all decision makers as one matrix. Then, that aggregated matrix is applied for computing the fuzzy synthetic value and weight vector as a non-fuzzy number.

d. Fuzzy synthetic value, degree of possibility, and minimum degree of possibility

Approximate fuzzy priorities are determined in two phases. First, the fuzzy Synthetic Extent with respect to each criterion is computed according to the equation (6). Then the degree of possibility for two fuzzy numbers $\tilde{N}_1 = (l_1, m_1, n_1)$ and $\tilde{N}_2 = (l_2, m_2, n_2)$ is defined as equation (9) according to Chang's method [17]. Next, the Dubois and Prade [18] approach is used to outline the minimum degree of possibility of each criterion. The $\min V(S_i \geq S_k)$ will be set as the non-fuzzy weight of each criterion.

According to Srichetta, and Thurachon [19], the value of the fuzzy synthetic with respect to the i^{th} criterion is defined as:

$$S_i = \sum_{j=1}^m \tilde{g}_{ij} \otimes \left[\sum_{i=1}^n \sum_{j=1}^m \tilde{g}_{ij} \right]^{-1} \quad (6)$$

Where

$$\sum_{j=1}^m \tilde{g}_{ij} = \left(\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m n_j \right) \quad (7)$$

$$\sum_{i=1}^n \sum_{j=1}^m \tilde{g}_{ij} = \left(\sum_{i=1}^n l_i, \sum_{i=1}^n m_i, \sum_{i=1}^n n_i \right) \quad (8)$$

Degree of possibility is defined [Error! Reference source not found.] as:

$$V(S_b \geq S_a) = \begin{cases} 1 & , \text{if } m_b \geq m_a \\ 0 & , \text{if } l_a \geq u_b \\ \frac{l_a - u_b}{(m_b - u_b) - (m_a - l_a)} & , \text{otherwise} \end{cases} \quad (9)$$

Minimum degree of possibility is defined [Error! Reference source not found.] as:

$$V(S_i \geq S_1, S_2, \dots, S_k) = \min V(S_i \geq S_k) = w'(S_i) \quad (10)$$

In this study, an 8-step computational procedure for defining the weight of e-banking customer's satisfaction is applied. This fuzzy AHP approach facilitates weight factors' evaluation in the e-banking system. This method can be applied once all the survey's result are received from users of e-banking systems. The steps of procedure are as follows:

Step 1: converting pairwise comparison questionnaire to triangular fuzzy matrices.

Step 2: constructing aggregated expert fuzzy matrices.

Step 3: calculating the fuzzy synthetic value.

Step 4: decide the preferences each of criterion over another criterion by finding the degree of possibility.

Step 5: determining minimum degree of possibility.

Step 5: computing the relative weight of main criteria by using the minimum degree of possibility.

Step 6: determining the final weight of the main criteria.

Step 7: applying step 1 to 6 for sub-criteria and calculating the relative weight of sub-criteria.

Step 8: determining final weight of sub-criteria by multiplying final weight each main criterion with its sub-criteria.

This part presents the finding of applying the fuzzy AHP approach in e-banking according to the 8-step procedure. As specified, converting pair-wise comparison results of all 25 participants of e-banking service into fuzzy comparisons matrices is the primary step. Table 2 illustrates construction of triangular fuzzy matrices for the main criteria of e-banking systems. Then in the next step, all triangular fuzzy matrices are used to construct the aggregated fuzzy matrices by using equation (4) as shown in Table 3.

Table 2 - The pair-wise comparison matrix of Quality of Information for the 1st participants

| | | C ₁ | C ₂ | C ₃ |
|----------------|----------|----------------|----------------|----------------|
| C ₁ | <i>l</i> | 1.00 | 1.00 | 1.00 |
| | <i>m</i> | 1.00 | 1.00 | 1.00 |
| | <i>n</i> | 1.00 | 1.00 | 1.00 |
| C ₂ | <i>l</i> | 1.00 | 1.00 | 0.67 |
| | <i>m</i> | 1.00 | 1.00 | 1.00 |
| | <i>n</i> | 1.00 | 1.00 | 1.50 |
| C ₃ | <i>l</i> | 1.00 | 0.67 | 1.00 |
| | <i>m</i> | 1.00 | 1.00 | 1.00 |
| | <i>n</i> | 1.00 | 1.50 | 1.00 |

Table 3 - The aggregated fuzzy matrices of Quality of Information by 25 participants

| | | C ₁ | C ₂ | C ₃ |
|----------------|----------|----------------|----------------|----------------|
| C ₁ | <i>l</i> | 1.00 | 0.76 | 0.59 |
| | <i>m</i> | 1.00 | 0.91 | 0.71 |
| | <i>n</i> | 1.00 | 1.12 | 0.87 |
| C ₂ | <i>l</i> | 0.89 | 1.00 | 0.75 |
| | <i>m</i> | 1.10 | 1.00 | 0.91 |
| | <i>n</i> | 1.32 | 1.00 | 1.11 |
| C ₃ | <i>l</i> | 1.16 | 0.90 | 1.00 |
| | <i>m</i> | 1.41 | 1.10 | 1.00 |
| | <i>n</i> | 1.71 | 1.33 | 1.00 |

Determining weight of the main criteria

In the next step, the synthetic values are calculated to define priority of a criterion over another one. Table 4 illustrates how Fuzzy Synthetic values are computed according to equation (6), (7), and (8).

Table 4 - Fuzzy synthetic value

| | | C ₁ | C ₂ | C ₃ | For C ₁ $\sum_{j=1}^m \tilde{g}_{ij} = (2.34, 2.62, 2.98)$ | Fuzzy Synthetic value |
|----------------|----------|----------------|----------------|----------------|--|-------------------------------|
| C ₁ | <i>l</i> | 1.00 | 0.76 | 0.59 | | |
| | <i>m</i> | 1.00 | 0.91 | 0.71 | | |
| | <i>n</i> | 1.00 | 1.12 | 0.87 | | |
| C ₂ | <i>l</i> | 0.89 | 1.00 | 0.75 | $\sum_{i=1}^n \sum_{j=1}^m \tilde{g}_{ij} = (8.04, 9.14, 10.46)$ | $S_{c2} = (0.22, 0.29, 0.37)$ |
| | <i>m</i> | 1.10 | 1.00 | 0.91 | | |
| | <i>n</i> | 1.32 | 1.00 | 1.11 | | |

| | | | | | |
|-------|-----|------|------|------|-------------------------------|
| C_3 | l | 1.16 | 0.90 | 1.00 | $S_{c3} = (0.22, 0.29, 0.37)$ |
| | m | 1.41 | 1.10 | 1.00 | |
| | n | 1.71 | 1.33 | 1.00 | |

The minimum degree of possibility with the help of equation (9) and (10) is calculated as:

$$V(S_{c1} \geq S_{c2}) = (0.254 - 0.371) / ((0.287 - 0.371) - (0.330 - 0.254)) = 0.732$$

$$V(S_{c1} \geq S_{c3}) = (0.293 - 0.428) / ((0.287 - 0.371) - (0.385 - 0.502)) = 0.447$$

$$V(S_{c1} \geq S_{c2}, S_{c1} \geq S_{c3}) = \min(0.732, 0.447) = 0.447 = W'_{c1}$$

Similarly, the weight vector for the main criteria of e-banking is given as:

Table 5 - relative and normalized weight of main criteria

| Criteria | Relative weight W'_c | Normalized weight W_c |
|----------|------------------------|-------------------------|
| C_1 | 0.447 | 0.207 |
| C_2 | 0.712 | 0.330 |
| C_3 | 1.000 | 0.463 |

Determining weight of sub-criteria

Similarly, the weight of the sub criteria of each criterion is calculated according to the explained procedure. Then, the weight of the main criteria multiplied with the normalized weight of the sub criteria as illustrated in Table 5 and Table 6. The result of the overall weight of the sub-criteria of e-banking system is shown in Table 7.

Table 6 - Normalized weight of sub-criteria

| | C_1 | C_2 | C_3 |
|-------------------|-------|-------|-------|
| Sub _{c1} | 0.762 | 0.123 | 0.520 |
| Sub _{c2} | 0.238 | 0.177 | 0.358 |
| Sub _{c3} | 0 | 0.364 | 0.0 |
| Sub _{c4} | 0 | 0.017 | 0.122 |
| Sub _{c5} | N.A | 0.319 | 0 |
| Sub _{c6} | N.A | N.A | 0 |

Table 7 - Weight of sub-criteria with respect to overall weight

| | C_1 | C_2 | C_3 |
|-------------------|-------|-------|-------|
| Sub _{c1} | 0.158 | 0.040 | 0.241 |
| Sub _{c2} | 0.049 | 0.059 | 0.166 |
| Sub _{c3} | 0 | 0.120 | 0 |
| Sub _{c4} | 0 | 0.006 | 0.056 |
| Sub _{c5} | N.A | 0.105 | 0 |
| Sub _{c6} | N.A | N.A | 0 |

Conclusion

In this study, 25 active e-banking users were surveyed by a pairwise comparison to compare the main and sub-criteria of an e-banking system. Then, the criteria weights were generated by a fuzzy AHP procedure since AHP is one of the most powerful and reliable weight assigning methods in MCDM techniques. The main criteria used in the comparison were quality of information, quality of service, and quality of system. The sub criteria were: accurate information, up to dateness, content rich, design, available features, fees and charges, meets user needs, 24/7 online chat, 24/7 site availability, security, privacy, speed, accessibility, navigation, and compatibility. Results showed that two of the quality of system criteria, security and privacy, two of the quality of service criteria, meets user needs and 24/7 site availability, and one of the quality of information criteria, accurate information have a major impact on e-banking users. In the future research, the proposed procedure can be applied on different industries such as e-shopping, online education, and airlines. Future studies can also apply different MCDM techniques on the proposed procedure.

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