Improved E-Banking Websites Quality Evaluation Approach based Fuzzy Hierarchy Process Model

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Abstract

Electronic banking (e-banking) enables user to access services virtually on banking platforms such as home, personal computer (PC), mobile and Internet. It offers ease to use, convenience, low cost, fast delivery, time factor, and online bill settlement. Website quality evaluation entails numerous dimensions and attributes from its conception. The evaluation processes are critical and complex requiring quality, accuracy and objectivity. In real-life scenarios, complex decisions making (such as e-banking websites quality evaluation) entail multiple criteria that are beyond the capacity of the human brain to synthesize effectively and intuitively. Recently, the multi-criteria decision-making (MCDM) model became popular in which fuzzy analytical hierarchy process (FAHP) was mostly preferred due its ability to expand numbers of decision-makers across multiple criteria/sub-criteria. The specific criteria are required to evaluate e-banking website quality, which best define good quality websites attributes. This paper developed an e-banking website evaluation model for Nigerian banking sector using content and semantic analyses, and computerized approaches. The FAHP model outcomes revealed that, ease of use, e-loyalty, e-satisfaction, e-trust, and product quality are most influencing criteria for evaluation e-banking websites. While, the best top-three criteria for evaluating e-banking websites are e-satisfaction, product quality, and e-trust.

Keywords: Multi-Criteria Decision-Making, Fuzzy AHP, Website, Quality, E-banking, Evaluation, Criteria.

1.0 Introduction

The indispensability of the website in day-to-day lives of individuals globally have raised the concerns about websites quality evaluations. This kind of evaluation ventures attempt to measure the website by means of a set of quality requirements with the goal of fetching valuable feedback about necessary information needed to assist in the design and development of high quality and interactive websites. The term quality connotes to the degree to which objects adhere to a collection of inherent characteristics satisfies a set of requirements.

These intrinsic characteristics refer to the features available in an object or entity being evaluated to ensure that it attains the needs of users. One of the intrinsic characteristics is quality, which embodies the behavioural characteristics of the object (or system). Therefore, these factors or characteristics establish the non-functional requirements utilized in judging the operations of websites operations on the basis of the perception of the expert evaluators, developers and users (Orhionkpaiyo & Momodu, 2021).

Accordingly, five (5) key quality factors of website common to financial websites in terms of degree of importance include: up-to-date, accuracy, multiple sources, easy-to-navigate, and timeliness. In educational domain, quality factors of websites include: easy-to-navigate, search tool, accuracy, comprehensiveness, and layout. In the case of government websites, top quality factors include: easy-to-navigate, layout, up-to-date, search tool, and accuracy. In case of e-commerce website, the most sought-after quality factors include: security, easy-to-navigate, appropriate explanatory text, search tool, and product/service concerns. In health/medical website considers the following quality factor: accuracy, easy-to-navigate, search tool, up-to-date, and comprehensiveness. While, in the entertainment domain, the renowned quality factors are visual design, easy-to-navigate, responsiveness, multimedia, and up-to-date (Orhionkpaiyo & Momodu, 2021).

Websites and Internet technologies are now well-established and reliable elements of marketing communication. Websites are important in every organisation and tremendous effort is made to design

websites that not only look and feel good, but are usable and of high quality. Nevertheless, one critical task is how to evaluate these websites to ensure that users are satisfied with its quality and usability (Bacik *et al.*, 2021). In this paper, multi-criteria and complex decision-making processes were developed by introducing some form of logical and scientific approach to decision making in determining criteria for e-banking website quality evaluation (Tseng *et al.*, 2021).

2.0 Related Works

Al-Shammari & Mili (2019) implemented a FAHP multi-criteria decision model to enable customers of commercial banks to make choice of preferred bank. Five Bahraini retail commercial banks were utilised for the formulation of a decision problem designed in three-step hierarchies based on six criteria. Thereafter, the FAHP was utilised in arriving at the relative weights of the criteria of evaluation. The outcomes revealed that, most of preferred banks considered pricing strategy against facilities offered by the banks. Customers were mostly attracted to the banks using deposits and credits' interest rates alongside costs of transactions. This support decision makers in developing the appropriate strategies towards their preferences of customers.

Bacik *et al.* (2021) understudied the essence of website quality on the anticipated performance and the e-banking actual usage. A model was created that determine the effect of website quality on the e-banking usage. Use of technology, and Unified Theory of Acceptance and Use of Technology (UTAUT) served as theoretical underpins, the recognizing precise attributes of websites and their influence on the internet banking usage by tourists in destinations. From the outcomes obtained, the perceived website quality is a multi-dimensional problem. The website quality is indirect influence on the user's behaviour, often estimated as the internet banking- frequency of usage. This indirect influence is explained by the projected performance indicator. There is the problem of low acceptance of technology in banking sector and restricted scope (Islamic banking).

Sari & Pangaribuan (2019) attempted to estimate the website quality and agent satisfaction. The WebQual 4.0 technique was used to analyse 30 samples of listed agent. The main measurement criteria including: satisfaction of customers, and usability of website, while the sub-criteria include: emotional, service quality, cost, price, and product quality. The study revealed that, the payment website usability can be used to enhance satisfaction of agents. This implies that whenever online payment websites the quality is at the level of ease (usability); then, agent satisfaction rises correspondingly. But, there is the need to have standard website usability criteria in place especially e-banking websites.

Gill *et al.* (2021) noted that, top-quality online banking services are significant in retaining customers. E-banking services customers of top five Pakistani banks served as population of the study. A structural equation modelling was used for hypotheses analysis. There are significant influence of website design, reliability, and security on customer trust giving rise to more loyalty by means of theory of cognitive and motivational relation. Therefore, numerous practical and theoretical implications can be derived for management of banks in improving e-banking website design in order to win over trust of their customers, and reinforce loyalty.

Hammouri et al. (2021) developed a theoretical framework for examining the association between trust and security in terms of e-banking. Seven variables were collected in relation to the security issues in Internet banking including: availability, integrity, confidentiality, authentication, non-repudiation,

authorization, and privacy. Thereafter, a research model was proposed for e-banking services without evaluation.

Reddy & Megharaja (2021) investigated the association between the factors of e-banking service quality and customer satisfaction for purpose of identifying dimension with most impact on satisfaction of customer. Data were obtained from Lebanese's bank customers through a survey instrument. The SEM and AMOS were used for analysis revealed that, service quality, and reliability as strong predicator of customer satisfaction.

Chhaya & Mittal (2021) attempted to identify factors mostly influencing the service quality in adopting e-banking services. The primary survey method was used to gather data across bank customers in the Indian banking sector. Using structural equation modelling (SEM) analyser, service quality factors greatly influence the service quality of e-banking such as ease of use and perceived security. Also, the quality of e-banking service remained one of the unavoidable components of the banking sector for increasing profits, reputation, and competitive edge through raising customer satisfaction levels.

Chaimaa, Najib & Rachid (2020) highlighted on e-banking concept, security risks, and challenges associated with technology usage. The different security solutions introduced were evaluated in order to differentiate between the e-banking user needs. Most security solutions for e-banking platforms are susceptible to attacks, complex to use and expensive. Therefore, these solutions proposed do not satisfy customer requirements for the Internet banking system.

Ullah (2021) examined the impact of e-banking service quality (EBSQ) factors on the loyalty of customer mediated by customer's trust. The data of 220 participants drawn from five commercial banks in Malaysia was obtained for study. Thereafter, website design, reliability, customer service and support were statistically significant; while security and privacy had impact on loyalty of customer. Again, customer trust mediated role had high influence in determining relationship between EBSQ attributes and customer loyalty.

Recently, fuzzy Technique for Order of Preference by Similarity to Ideal Solution (fuzzy-TOPSIS), and fuzzy Best–Worst Method (fuzzy-BWM) were combined in modelling the preference of m-banking platforms in (Roy and Shaw, 2022). It was found that, applications' convenience, functionality, and performance expectancy were important factors in choosing an m-banking platforms, trailed by security, performance quality, and compatibility. This enables complex decisions and ambiguity of identifying potential factors for choosing m-banking applications available by customers using fuzzy set theory approach.

The evaluation of e-banking website quality for 27 Poland banks were carried out using own conversion, Promethee II, PROSA and TOPSIS methods was conducted by (Chmielarz and Zborowski, 2022). The obtained results showed superiority of automated evaluation approaches against others for MCDM problems undertaken.

3.0 Methodology

This paper adopts the fuzzy analytical process (AHP) based quality criteria to assess the website quality. The AHP approach is a powerful tool in decision-making problems; though a group of analysts has

alluded to the Saaty's AHP strategy's limitations including vulnerability (uncertainty) during the preparation of chiefs' judgment to number of alternatives uncovered by AHP. Also, the inclination and distinct leader's judgment have high influence on the outcomes of the AHP. To overcome these, the Saaty's AHP was accustomed and fuzzified to number to manage the vulnerability according to Kumar *et al.* (2021).

3.1 The Proposed Model

In the proposed FAHP, the soothing of the uncertainness of AHP strategy is to be achieved using the proportions of the fuzzy correlations. In 1996, Chang introduced a new method for dealing with pair-wise evaluation scale reliant on the three-sided (triangular) fuzzy values based on survey degree of investigation technique for determination of the pairwise correlation. More so, when contrasted with AHP, FAHP offers a decision maker better flexibility due to its capability to map a relative priority to different probable values (Chen & Wu, 2020).

The foremost phase in this method is to adopt three-sided fuzzy values for pairwise correlation through FAHP scale, and then, succeeding stage use degree investigation approach to realize needed loads through engineered degree esteems. The grid of fuzzy assessment measures is to be constructed by means of the pairwise correlation of different ascribes relevant to the overall target using the triangular fuzzy numbers, and semantic factors. The key components of the FAHP for selecting the relevant criteria in determining quality of websites in e-banking sector include: selection of website quality criteria, coding of criterion with possible indiscriminative values, application of relevant criteria in evaluating e-banking website quality, fuzzy judgement matrices for decision-making, outcomes of e-banking website quality evaluation (defuzzification). These are depicted in Figure 1.

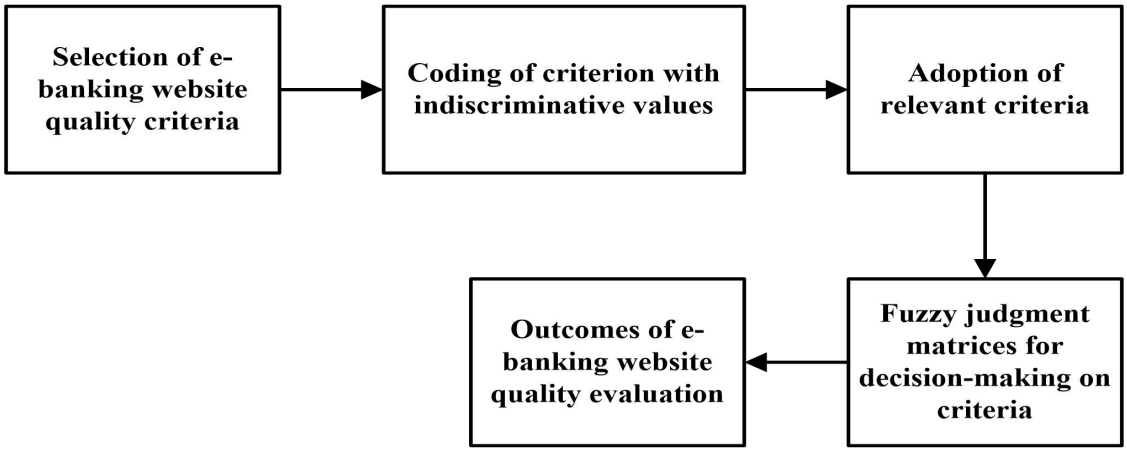

Figure 1. The proposed FAHP model for e-banking website quality evaluation.

3.2 Criteria selection

The steps for selecting criteria are provided as follows:

1st Step: The hierarchal structure is developed for converting the complex problem in a raw format.

2nd Step: The relative importance of each criterion is to be determined from the views of experts in order to construct the comparison matrix using membership functions of linguistic scale and fuzzy number presented in Table 1 (Al-Shammari and Mili, 2019; Kumar *et al.*, 2021).

Table 1: Linguistic scale and membership function.

Fuzzy number	Linguistic scale	Scale of triangular fuzzy	Scale of triangular fuzzy reciprocal
9	Extreme importance	9 9 9	1/9 1/9 1/9
8	Very, very strong	7 8 9	1/9 1/8 1/7
7	Very strong or demonstrated importance	6 7 8	1/8 1/7 1/6
6	Strong plus	5 6 7	1/7 1/6 1/5
5	Strong importance	4 5 6	1/6 1/5 1/4
4	Moderate plus	3 4 5	1/5 1/4 1/3
3	Moderate importance	2 3 4	1/4 1/3 1/2
2	Weak or slight	1 2 3	1/3 1/2 1
1	Equal importance	1 1 1	1 1 1

The pairwise comparison matrix is composed of all the items of the matrix (A_{gh}, B_{gh}, C_{gh}) denoting the important values of the criteria. The importance of analysing the gth data for the B target was determined in relation to these symbols as given by (1).

$$\begin{bmatrix} (1,1,1) & A_{21}B_{21}C_{21} & \dots & A_{1n}B_{1n}C_{1n} \\ A_{21}B_{21}C_{21} & (1,1,1) & \dots & A_{2n}B_{2n}C_{2n} \\ A_{n1}B_{n1}C_{n1} & A_{n2}B_{n2}C_{n2} & & (1,1,1) \end{bmatrix} \quad (1)$$

All of $(h: 1, 2, 3, \dots, b)$ b_{kg}^{h} were fuzzy triangular members. Again, $Y = (y_1, y_2, \dots, y_n)$ was the set of decision, and $Q = (q_1, q_2, \dots, q_n)$ is the target matrix. The fuzzy membership triangular representation is represented in (2).

$$b_{k1}^{h}, b_{k2}^{h}, \dots, b_{kn}^{h}, g = 1,2, \dots, n. \quad (2)$$

The fuzzy values in each criterion's entire target set are summed individually, and the $\sum_{g=1}^{h} b_{kg}^{k}$ values is realized as given by (3).

$$\sum_{g=1}^{h} b_{kg}^{k} = \left\{ \sum_{k=1}^{h} A_k , \sum_{k=1}^{h} B_k , \sum_{k=1}^{h} C_k \right\} \quad (3)$$

For each fuzzy value in the decision set is summed up to obtain $\sum_{k=1}^{n}\sum_{g=1}^{h} B_{kg}^{k}$ as depicted in (4)

$$\sum_{k=1}^{n}\sum_{g=1}^{h} b_{kg}^{k} = \left\{ \sum_{g=1}^{n} A_k , \sum_{g=1}^{n} B_k , \sum_{g=1}^{n} C_k \right\} \quad (4)$$

The corresponding inverse vector can be expressed by (5).

$$\left[\sum_{k=1}^{n}\sum_{g=1}^{h} b_{kg}^{k} \right]^{-1} = \left\{ \frac{1}{\sum_{g=1}^{n} A_k}, \frac{1}{\sum_{g=1}^{n} B_k}, \frac{1}{\sum_{g=1}^{n} C_k} \right\} \quad (5)$$

The synthetic extent value, E_g, for each criterion can be computed by (6).

$$E_g = \sum_{g=1}^{h} b_{kg}^{k} . \left[\sum_{k=1}^{n}\sum_{g=1}^{h} b_{kg}^{k} \right]^{-1} \quad (6)$$

Whereas, the degree of possibility of $b_1(A_1, B_1, C_1) \geq b_2(A_2, B_2, C_2)$ is given by (7).

$$U(b_1 \geq b_2) = \sup_{x \geq y}[\min(\omega_{b_1}(x), \omega_{b_2}(y))] \quad (7)$$

A function ω: R $\rightarrow$ [0, 1] is a *fuzzy number* if and only if there exists an x_0 such that ω (x_0) = 1 and all the upper-level sets of ω are convex, that is, the set $\{x \in R|\ \omega(x) \geq \Omega\}$ is convex for all $0 < \Omega \leq 1$. R is the rule lists for FAHP.

Consequently, the Triangular Fuzzy Numbers (TFNs) are expressed by three real numbers $(a, b, c) \in (A, B, C)$. The parameters a, b and c indicate the smallest possible value from the set $\{A, B, C\}$, the most promising number and the largest probable values explaining any fuzzy events.

3.3 Data Collection

Target population of customers who have bank accounts linked to the e-banking platform (that is, website) in Minna, Niger State. The study will collect data from the customers through online survey. In particular, consumers with third-party booking system experience were requested to partake in the online survey. Since the sampling frame was hard to obtain due to the Personal Information Protection Act that restricts financial institutions from releasing personal data concerning users, a non-random sampling approach is utilised for data collection. Respondents were enlisted over a link to online opinion poll of the selected banks websites (Al-Shammari & Mili, 2019; Chen & Wu, 2020; Karczmarek, Pedrycz & Kiersztyn, 2021; Tseng, Wang & Tsai, 2021).

3.4 Experimentation

The proposed model for evaluating e-banking websites is to be experimented on MATLAB R2019b on PC with the following specifications:

Hardware: Processor: AMD E1-1200 APU, Radeom™ Graphics 1.40 GHz.
RAM: 4.00 GB
System Type: x64-based processor, 64-bit Operating System.
Software: Rating: 3.5 Windows Experience Index
Windows Edition: Windows 8 Single Language 2012
Simulator: MATLAB R2019b.

4.0 Results and Discussions

The outcomes of multiple respondents on the main influencing criteria for evaluating the e-banking websites quality on the basis of the developed FAHP model developed are shown in Table 2.

Table 2: Weights and ranks of criteria for evaluating e-banking websites quality.

Criteria	Normalized Weight	Rank
Ease of use	0.2541	2
E-loyalty	0.3021	1
E-satisfaction	0.1421	5
E-trust	0.1569	3
Product quality	0.1449	4

From Table 2, the top three ranked criteria mostly influencing the decision of respondents evaluating e-banking websites quality are e-satisfaction, product quality, and e-trust. While, e-loyalty is least influencing criteria. Therefore, this paper selected the main criteria for evaluating e-banking websites based FAHP model as presented in Table 3.

Table 3: Optimal Criteria for evaluating e- banking websites quality.

Criteria	Rank
e-satisfaction	1
Product quality	2
e-trust	3

From Table 2, the overall performance of the criteria revealed that, most influencing e-satisfaction followed by product quality, and e-trust placed last as selected multiple respondents using the FAHP model.

5.0 Conclusion and Recommendations

This paper identified e-banking quality evaluation as complex endeavours comprising of several criteria and sub-criteria. It was found that, the different criteria exhibit dissimilar influences on the process of determining e-banking website quality. The FAHP model (a MCDM) was developed that is basically a hierarchical structure of criteria to realize the best combinations of criteria for evaluating e-banking websites quality.

It was found that, the overall performance of the criteria revealed that, most influencing criteria include: e-satisfaction, product quality, and e-trust as selected by multiple respondents. The future work can consider more criteria and sub-criteria for the FAHP model for the purpose of improving the MCDM process of e-banking websites quality evaluation.

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