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Comparison of Analytical Hierarchy Process and Fuzzy Analytical Hierarchy Process Models for E- Banking Websites Quality Evaluation

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Abstract
The process of evaluating the quality of e-banking websites has gained rapid attention in recent years with the adoption of multi-criteria decision-making (MCDM) approaches. The Analytical Hierarchy Process (AHP) and the fuzzy AHP models which are well suited to determine the outcomes of the e-banking website quality evaluation are explored in this study. In both cases, the decision-making activity is broken into criteria and sub-criteria usually arranged as a pairwise comparison matrix layout. Though the latter is meant to be an advancement over the former, this paper compares the performances of the two MCDM approaches in evaluating e-banking websites of top-four Nigerian banks by profit margin. The data was collected from 33 out of 50 initially selected respondents using e-banking apps in Minna, Niger State through a non-random sampling technique. The outcome showed that the AHP and FAHP models are closely correlated based on the ranking of the weights of criteria and alternatives used in the study. Using the Wilcoxon Signed Rank Test, the Asymp Sig. (2-tailed) of criteria and sub-criteria is 0.500 for AHP and FAHP models indicating highly correlated decisions of the respondents. Also, the Wilcoxon Signed Rank Test (Asymp Sig. (2-tailed)) of alternatives is 1.000 for AHP and FAHP models indicating fairly correlated decisions on e-banking websites quality of alternatives (banks). However, the FAHP performances were superior to the AHP, which is consistent with some existing studies.

Keywords: *Websites Quality, Multi-Criteria Decision-Making, E-Banking Evaluation*

1. Introduction

The growing importance of websites in both personal and business contexts worldwide has underscored the need for assessing their quality. Such evaluations involve assessing websites against a set of criteria to gather valuable insights for improving their design and functionality. The term "quality" here refers to how well a website aligns with certain inherent characteristics and meets user needs. These characteristics, including functionality and user experience, form the basis for evaluating websites according to the perspectives of experts, developers, and users [1]. Websites and internet technologies have become integral and trustworthy components of marketing communication. They play a crucial role in all organizations, prompting significant endeavours to create websites that not only boast appealing aesthetics but also offer usability and high quality. However, a key challenge lies in evaluating these websites to guarantee user satisfaction with their quality and usability [2].

Websites encompass various dimensions and attributes that are typically taken into account when assessing their quality. However, new users often rely on a website's reputation as a proxy for quality. Essentially, users form opinions about a website's reputation based on other quality attributes such as the quality of its content and system functionality. Previous measures of website information quality include usefulness, currency, reliability, sufficiency, and other factors like relevance, understandability, believability, format, and competitive intelligence, as outlined by Kwak *et.al.,* [3].

Over recent years, methods and tools of various types used for evaluating website quality have been proposed by both scholars and professionals. Some are broadly applicable and can be used to evaluate any type of website. On the other hand, others have been personalised to the specific characteristics of websites used in particular sectors, as noted by Morales-Vargas *et. al.,* [4]. Multi-criteria

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decision-making (MCDM) approaches have been identified as capable of handling the complexity inherent in the website evaluation process, according to Adepoju *et.al.,* [5]. Among these approaches, the Analytical Hierarchy Process combined with fuzzy logic has emerged as a preferred method for website evaluation.

Several successes have been observed with the Analytical Hierarchy Process (AHP) when applied to complex decision-making scenarios, utilizing criteria and sub-criteria organized in pairwise comparisons [6]. However, the AHP approach proves to be less suitable for handling multi-criteria and intricate decision-making processes. To address this limitation, a Fuzzy AHP model has been developed to introduce a logical and scientific approach in order to facilitate decision-making in multi-criteria settings, such as criteria for evaluating website quality [7]. This study compares the performances of the AHP and Fuzzy AHP models in the assessment of e-banking websites quality.

The majority of individuals often resort to holistic approaches when making decisions, preferring to select the most appealing option without delving into critical analysis. However, in real-life scenarios, complex decision-making involves multiple criteria that surpass the capacity of the human brain to effectively and intuitively synthesize. Hence, holistic approaches are deemed inadequate for tackling serious complex decisions, leading to the consideration of scientific and logical techniques. Consequently, the AHP was introduced as a theoretical framework in 1980 by Saaty for formulating and analysing complex decision-making processes. The underlying principle of AHP is to simplify complex decision problems by representing them hierarchically, comprising criteria and sub-criteria, and conducting pairwise comparisons among them [7].

The paper covers gaps in research by applying AHP and FAHP techniques in evaluating e-bank websites quality in Nigeria context which till now lacks adequate studies. Considering the importance of banking in Nigeria economy and the impart of its website on customers, the study is very relevant and contributes significantly in HCI (Human Computer Interaction) and MCDM.

2. Related Works

There are several applications of AHP and its variants in diverse domains as summarized in Table 1. The concept of the MCDM problems is linked to a decision-making process that involves selecting alternatives, prioritizing options, or ranking choices. AHP is an established technique of the decision-making theory that involves the use of pairwise comparisons. It is applicable in numerous aspects of human endeavours including banking, agriculture, hospitality, and GIS. After the inception of AHP by Saaty [8] several application variants have been developed as highlighted.

The AHP has been involved largely in selection, evaluation, prioritization, or forecasting whenever the need arises to quantify the judgments of an expert or a group of experts across different levels of generality (hierarchy) or through surveys. AHP is expressed in a numeric (or simplest) procedure, and it is relatively easy, making it accessible even for non-experts in the field [9]. There is evidence of the potential effectiveness of the AHP and its variants in MCDM process problems such as problems such as website quality criteria selection for the e-banking sector [7, 10].

The AHP technique is a valuable tool for solving decision-making problems. Some researchers agreed that Saaty's AHP strategy has a few limitations including uncertainty (vulnerability) when related to the planning of main judgment to number, uncovered in the AHP. Leader's judgement and inclination have enormous impact on the AHP outcomes. To overcome these, adjustment was made in the Saaty's AHP and fuzzification was introduced to figure and control the vulnerability identified in the previous works [8]. In the case of FAHP, the soothing of the uncertainness of AHP strategy is to be achieved using the fuzzy correlations proportions. When contrasted with AHP, FAHP offer greater flexibility to a decision maker as it enables mapping of a relative priority to several possible values.

Table1. Application areas of AHP and variants.

S/No	Author(s)	Domain	Model	Application(s)
1.	Zhang *et.al.*,[11],	Acoustics	Comparison of rank scores and the multi-fuzzy analytic hierarchy process.	Forklift sound quality modelling.
2.	Kieu *et al,.[*12]	Agricultural Logistics	Spherical Fuzzy Analytic Hierarchy Process (SF-AHP) and Combined Compromise Solution (CoCoSo) Algorithm.	Selection of Distribution center location.
3.	Singh *et.al.,* [6]	Ecological sustainability of rivers.	Fuzzy analytic hierarchy process.	Quality of river water basin in India against pollutants.
4.	Uluta [13]	Evaluation of Website performance	Fuzzy SWARA and WASPAS-F.	MCDM methods for performance measurement of educational websites.
5.	Radhika, and Sadasivam [14]	Public Cloud Service.	FAHP	Virtual machine-based budget provisioning of multi-cloud environment.
6.	Kutlu *et.al.,* [15]	Public transport service	FAHP and linear assignment.	Convenient and low-cost timetable development for passengers, non-passenger, and decision-makers (or government).
7.	Liang *et.at.,* [16]	Internet banking industry	Pythagorean fuzzy VIKOR-TODIM	Evaluation of Ghanaian e-banking website quality.
8.	Yu *et.al.,[*17]	Electricity market	Cloud model and intuitionistic FAHP	Credit risk analysis of electricity retailers in China.
9.	Yee *et.al.,[*18]	Wastewater treatment process.	FAHP	Wastewater discharge and treatment with accurate criteria selection.
10.	Yalcinkaya *et.al.,* [19]	Geographic information system	FAHP	Locating potential municipal solid waste management facilities.
11.	Karczmarek *et.al.,* [9]	Decision-making theory.	FAHP	Graphic representation of choice of alternatives rather than linguistic or numeric.
12.	Majumdar *et.al.,*[20]	Risk classification in clothing supply	FAHP	Green clothing supply chains.
13.	Tseng *et al,* [7]	Third-party booking system.	AHP	The development of model for choosing between e-commerce systems.
14.	Chen and Wu [21]	Multi-criteria decision-making problem.	Fuzzy collaborative intelligence FAHP.	Three-dimensional printer selection process.
15.	Chaudhry *et.al.,[*22]	Groundwater resources management.	FAHP and geospatial technique	Mapping of the groundwater potential zones Rupnagar district, Punjab State, India.
16.	Song *et.al.,* [23]	Chemical Manufacturing	Cloud model and nonlinear FAHP	Chemical production safety level prediction
17.	Nguyen [24]	Hospitality industry.	FAHP and SERVQUAL	Quality of Hotel service evaluation criteria generation.
18.	Al Shammari, and Mili [10]	Banking.	FAHP	-Priority ranking of customers selection in commercial banks.

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In the case of FAHP, the soothing of the uncertainness of AHP strategy is to be achieved using the fuzzy correlations proportions. When contrasted with AHP, FAHP offer greater flexibility to a decision maker as it enables mapping of a relative priority to several possible values. The first step in this technique involves using triangular fuzzy numbers for pairwise comparisons based on the FAHP scale. Next, the degree analysis method is applied to obtain priority weights using synthetic degree values. Thereafter, a fuzzy evaluation matrix for the criteria is then created through pairwise comparisons.
This is obtained from various attributes that relevant to the overall objective by using semantic variables and triangular fuzzy numbers. 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 and sub-criteria, coding of criterion and sub criterion with possible indiscriminative values, application of relevant criteria and sub criteria in evaluating e-banking website quality, fuzzy judgement matrices for decision-making, outcomes of e-banking website quality evaluation (defuzzification).

The main activities for developing the fuzzy analytical hierarchical process (FAHP) model in determining the most relevant criteria for evaluating e-banking website quality similar to the previous approaches are depicted in Table 2 as algorithm.

The relative important of each criterion and sub-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 3.

Table 2: Algorithm for FAHP

INPUT: Comparison matrix	
OUTPUT: Normalised Weighted and Ranked criteria and sub criteria	
START	
Step 1	DEVELOPMENT of analytical hierarchy. The proposed model utilized a typical hierarchy arrangement based on different levels. **Substep 1**. The DETERMINATION of the prospective of website dimensions and features. **Substep 2.** The ANALYSIS of prospective website quality attributes/criteria and sub-criteria. **Substep 3.** DEVELOPMENT of a pairwise comparison matrix based on AHP scale and its TRANSFORM into a fuzzy triangular (FT).
Step 2	DEVELOP a pairwise fuzzy comparison matrix based on selected website quality criteria and sub-criteria. The pairwise fuzzy matrix is to be constructed using crisp numeric values, which is an evaluation method which provide a single numeric value and categorized website quality.
Step 3	CALCULATE the fuzzy geometric mean from lower, median and upper fuzzy geometric mean.
Step 4	CALCULATION of fuzzy weight using the lower, median and upper fuzzy weight.
Step 5	CALCULATION of the parameter weight.
Step 6	NORMALIZE weights of website quality criteria and sub-criteria for e-banking.
Step 7	RANK criteria and sub criteria using normalized weights
STOP	

Table 3. The adopted membership function and linguistic scale

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 Equation 1

$$\begin{bmatrix} (1,1,1) & A_{12}B_{12}C_{12} & \dots & A_{1n}B_{1n}C_{1n} \\ A_{21}B_{21}C_{21} & (1,1,1) & \dots & A_{2n}B_{2n}C_{2n} \\ A_{n1}B_{n1}C_{n1} & A_{n2}B_{n2}C_{n2} & & (1,1,1) \end{bmatrix} \quad (1)$$

By using Chang extent analysis 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 Equation 2.

$$b_{k1}^{h}, b_{k2}^{h}, \dots, b_{kn}^{h}, g1,2, \dots, n. \quad (2)$$

The fuzzy values in each criterion's entire target set are summed individually, and the $\sum_{g=1}^{h} b_{kg}^{k}$ values are realized as given by Equation 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 Equation 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 Equation 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 Equation 6.

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

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 Equation 7.

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

2.1 Website Quality Evaluation

Website quality evaluation involves determination of the features website must possess so as to meet users' needs. It shows the total performance of a website. In this context, websites success or failure depends on whether the design is tailored towards the users' needs. Different types of criteria and sub-criteria over the years have been developed to enable the website quality evaluation realisable [25][26]. These include those that focus on security like trust, privacy and security, other on technology like (navigability, information quality, accessibility and usability. Others focus on factors like multimedia, visual appearance, site design, interactivity, site content, technological integration and site management. Those that focus on customer include customer retention, fulfilment, contact information, personalization, responsiveness, feedback, and playfulness. Lastly, marketing oriented is focused on customer service, advertising, order confirmation promotion and online transaction.

Essentially, website quality model is a made of a set of criteria which is used in determining whether a website has reached certain degree of quality. To predict website quality, quality attributes are very important. The primary objective in predicting website quality is to create a measurement system that assesses website quality and forecasts consumer usage of the site. It is essential to develop a tool specifically designed to assess consumers' perceptions of website quality. Some of the attributes used in website quality are relevance, Total Size, Colour Scheme, Compatibility Communication, Global Audience, Social Media Connectivity, Overall Theme, Page Rank, Typography and Font Resolution, Loading Time, Broken Links and Keyword matching according to Kumar and Arora [27].
Using different perspective, other criteria of website quality evaluation have been developed over the years which include online banking content, technical quality, appearance quality, special content quality, general content quality [2].

The level of satisfaction of consumers of online service platforms depends on the website quality. The process of evaluating website quality considers its usability as a quality attribute. The goal of WebQual 4.0 evaluation is to evolve a development strategy for improving service and agent satisfaction [28].

In order to evaluate websites appropriately, evaluation criteria are required. There are several core features that should be possessed by a good quality website according to Abbasi et.al., [29]. These are appealing look, great design, good and reliable source of information. Others are availability of complete information on the products and services, easy access to information using search engines. Additionally, the website name should be easily remembered, and it should offer appropriate levels of service interaction, including customer support, personalization, and easy contact options for events.
The related works reviewed in terms of the author(s), sector, criteria and sub-criteria, methodology, and target are presented in Table 4.

3.0 Research Methodology

Methodology that is used in this research are as follows:

3.1 Criteria and Sub-Criteria Identification Stage

The first stage involves criteria and sub-criteria identification as well as Bank selection. These are used for the development of e-banking websites' quality models based on hierarchical architecture as depicted in Figure 1.

Stage two is the actual construction of the Fuzzy AHP model. Using AHP for MCDM enables the breakdown of the decision problem in a hierarchical architecture by identifying priorities from the value judgment of an individual or group participating in the decision-making process. This study adopts the criteria defined for e-banking websites in the previous studies. To use FAHP, the usage of fuzzy membership functions is involved. The most common of them include: trapezoidal, triangular and monotonic. Since the fuzzy set is a convex function, triangular function or the trapezoidal function approximate the convex function appropriately. The third step involves normalization of the aggregated weights computed for each factor using the FAHP model, the matching criteria of the website evaluation was used to generate the output. The selected parameters provide the basis for deciding website quality through FAHP decision matrix MCDM approach.

Each criterion and sub-criterion relative importance was determined from the views of experts in order to construct the comparison matrix using membership functions of linguistic scale, AHP scale and fuzzy AHP scale presented in Table 4.

3.2 Data Collection

At the initial stage fifty customers who have bank accounts linked to the e-banking platform in Minna, Niger State were selected for the study. The sampling frame was challenging to obtain due to Personal Information Protection Regulations Act that restricts financial institutions from disclosing personal data about users, hence a non-random sampling method was adopted for data collection. The respondents were voluntarily involved in the survey.

Table 4. FAHP model-based website quality evaluations.

S/N	Author(s)	Criteria	Sub-criteria	Method-ology	Target
1	Al Shammari, and Mili [10],	Pricing strategy, quality of service, and bank facilities.	Interest rates on loans and deposits, as well as associated fees, and commission; number of branches and number of ATMs; transactions delays and staff recommendation.	FAHP.	Decision -making.
2	Liang *et.al.,[*16]	Product quality, security, responsiveness, ease of use and privacy.	vagueness, uncertainty and ambiguity; transaction correctness and the customers' privacy;	TODIM and Pythagorean fuzzy VIKOR	Custom-ers' retention.
3	Reddy and Megharaja, [30]	Customer satisfaction, service quality.	Reliability, responsiveness, assurance, tangibles, empathy.	SEM and AMOS.	E-banking service quality.
4	Abbasi *et.al.,[*29]	Website quality.	Website design, website evaluation, other services, remembrance, contact, transactional content, content.	Fuzzy AHP and Fuzzy TOPSIS.	Website usability.

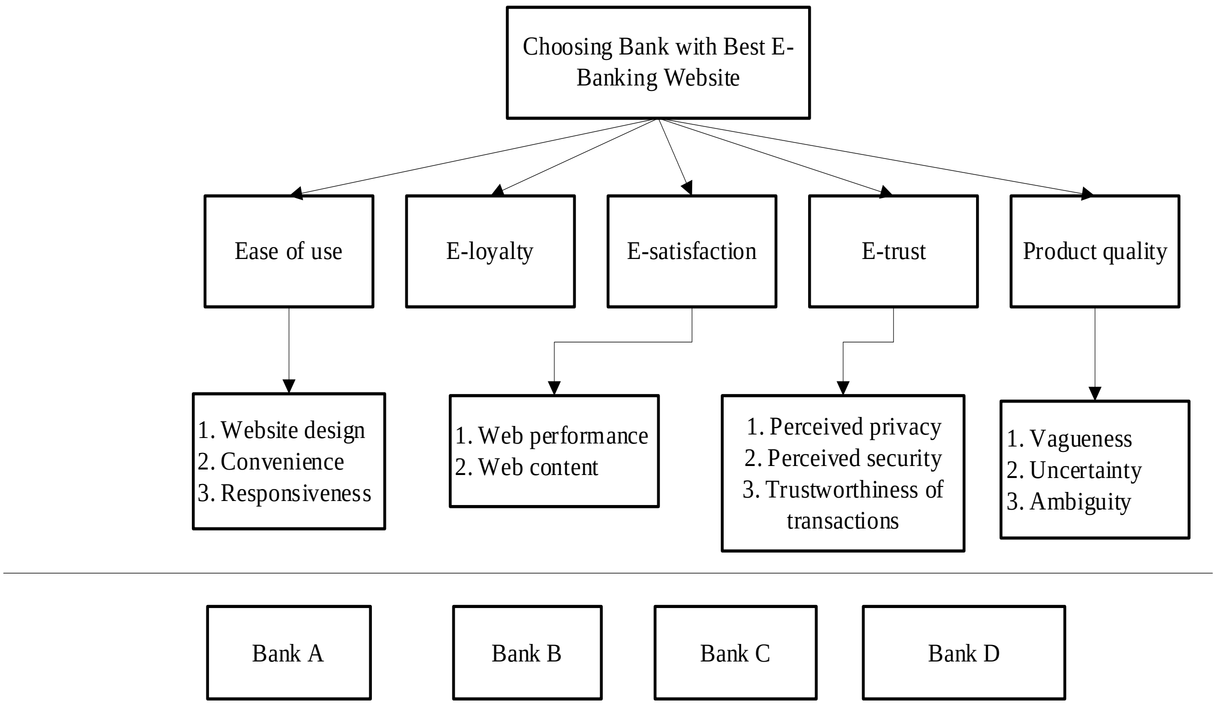

Figure 1. Hierarchical architecture of the Banks' e-banking websites quality evaluation criteria and sub criteria.

Table 5. The membership function and linguistic scale.

Linguistic scale	AHP scale	FAHP scale
Extreme importance	9	9 9 9
Very, very strong	8	7 8 9
Very strong or demonstrated importance	7	6 7 8
Strong plus	6	5 6 7
Strong importance	5	4 5 6
Moderate plus	4	3 4 5
Moderate importance	3	2 3 4
Weak or slight	2	1 2 3
Equal importance	1	1 1 1

At the end, a total number of 33 respondents responded and were eventually recruited through a physical contact interview and questionnaire drawn on the selected banks customers and staff, which are similar to the comparable studies.

The study constructed structured questionnaire which was utilised for collecting the required data. This was used for developing an effective e-banking website quality evaluation model. The lists of criteria and sub-criteria identified by this study were used to construct the questionnaire and with associated nominal scale (1 – 9) of website quality attributes as defined in Table 5.

3.3 Performance Evaluation Parameters

The developed FAHP-based e-banking quality evaluation model was evaluated to ascertain the performance using the following metrics: Weighted mean, normalised weighted mean, rank, and percentage. These metrics measure the summaries of the model based on the location and spread of the normalised weights of evaluation factors of e-banking website quality. The Wilcoxon Signed Rank Test [31] was used to compare the outcomes of the traditional AHP and Fuzzy AHP models for Alternatives.

4.0 Results and Discussion

The demographic data of volunteered for the online survey such as age, gender, marital status, highest qualification, type of account operated, experience with e-banking websites, products and services familiarity were collected. These are analysed in frequency and percent as shown in Tables 6 and 7. These include the personal and social characteristics of respondents.

From Table 6, majority of respondents were in the 21-30 age bracket with 48.48%, and 12.12% were 31 years and above. This implies that, the younger generation of respondents have more affinity to technology thereby influencing their acceptance of e-banking solutions against those of older respondents. The gender distribution of respondents showed that, 66.67% were female, and 33.33% were male. There was more willingness among female respondents to participate in the survey than the male respondents due to gender biases to the researcher. The highest qualification by respondents were holders of B.Sc./B.Tech degrees at 27.27%, closely followed by 24.24% as HND holders. This showed high literacy levels of the respondents, and the understanding of the concepts undertaken by this study.

From Table 7, the respondents were majorly holders of savings accounts with a money deposit bank at 63.64%, with current holders in second place at 24.24%. No respondent had the domiciliary account. This implies that, majority of respondents were holders of at least bank account type. The implication for this study is to increase reliability of responses provided by respondents. On access of respondents to e-banking services across website applications were highest at 69.70%. While, only 30.30% of respondents had accessed e-banking solutions through mobile applications.

Table 6. Demographic data of respondents

Variable	Category	Frequency (n=33)	Percentage (%)
Age (years)			
	18-20	13	39.39
	21-30	16	48.48
	Above 31	4	12.12
Gender			
	Male	11	33.33
	Female	22	66.67
Marital Status			
	Single	16	48.48
	Married	14	42.42
	Other	3	9.09
Highest Qualification			
	NCE	4	12.12
	OND	6	18.18
	HND	9	24.24
	B.Sc/B.Tech	8	27.27
	M.Sc	4	12.12
	Ph.D	2	6.06

Table 7. Social characteristics of respondents

Variable	Category	Frequency (n=33)	Percent (%)
Type of Account			
	Savings	21	63.64
	Current	8	24.24
	Corporate	2	6.06
	Domiciliary	0	0.00
	Company	2	6.06
Access to e-banking Services			
	Website application	23	69.70
	Mobile application	10	30.30
Products and services familiarity			
	Account enquiry	5	15.15
	Fund transfers	10	30.30
	Airtime purchases	6	18.18
	Cable TV subscription	8	24.24
	Mini-statement	2	6.06
	Compliant lodgment	2	6.06

This puts more validity on responses offered by respondents on the concept of quality of e-banking websites. As regards the most patronized e-banking websites products and services, fund transfer was topmost at 30.30% of respondents. While cable TV subscription (24.24%), and account inquiry (15.15%) respectively. The least services experienced by respondents were mini-statement (6.06%), and complaint lodgment (6.06%). This shows that, respondents have deep knowledge of the subject matter investigated in the paper. Table 8 presents the ranking of the normalized weights computed using FAHP. The banks ranked by the responds based on criteria/sub-criteria of e-banking websites quality are Bank A (52.98%), Bank B (18.31%), Bank C (17.91%), and Bank D (10.79%) respectively. The respondent's decisions were accepted on the rank of banks with observed CR (0.0963) < 0.1 as expected for consistency within responses else it is otherwise rejected. This study discovered that, the profit margins of banks are partly associated with their quality of e-banking services provided as across mobile and website platforms. Accordingly, the ranking of the top four banks by profit margin corresponds to the relative preferences of their e-banking platforms as determined by the respondents with the top four by Profit Margin or e-banking services in Q4 of 2022.

4.1 Comparative Performances of AHP and FAHP Models

To determine the validity of the FAHP methodology, the outcomes obtained from conventional AHP methodology is compared with that obtained from FAHP in the work. This is accomplished by using the Wilcoxon Signed Rank Test adopted in the study by Alzarrad *et.al.*, [32]. This is carried out to examine the median difference between the obtained outcomes at two levels (local weights of the criteria, and the final aggregated weights for the alternatives).

The outcomes of the AHP and FAHP models are closely correlated in terms of the weights of criteria and alternatives considered. Particularly on sub-criteria, the evaluation process of e-banking websites quality revealed that, website content, vagueness, and website design were ranked top three sub-criteria by respondents. Whereas, ambiguity, uncertainty, and trustworthiness of transactions were ranked bottom three sub-criteria by respondents in evaluation of e-banking website quality. Results obtained for the criteria and alternatives ranking AHP and FAHP are shown in Figure 2 and Figure 3 respectively. Figure 2 shows the pictorial comparisons of the two models. The closeness of the results indicates the high degree of model validity.

Figure 2. The comparative analysis of FAHP and AHP criteria weights

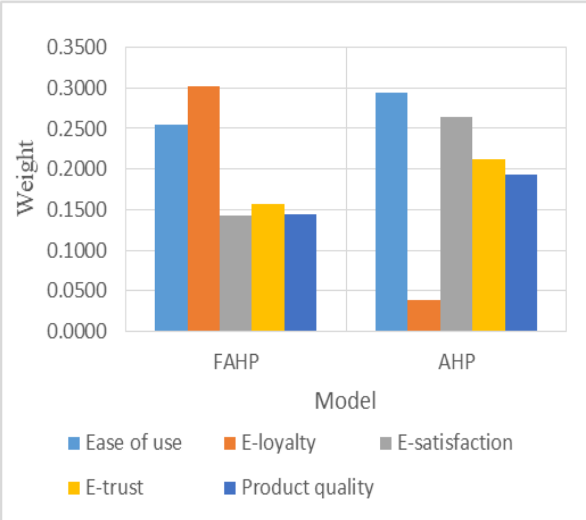

Table 8: Overall summary of FAHP results

E-banking website quality evaluation	Criteria	Weight (%)	Sub-criteria	Weight (%)
	Ease of use	25.41	Website design	11.72
			Convenience	6.31
			Responsiveness	6.97
	E-loyalty	30.21	-	-
	E-satisfaction	14.21	Website product	7.15
			Website content	17.85
	E-trust	15.69	Vagueness	14.02
			Uncertainty	6.59
			Ambiguity	4.38
	Product quality	14.49	Website perceived privacy	9.44
			Website perceived security	9.53
			Trustworthiness of transactions	6.03
	Alternatives			
	Bank A	52.98		
	Bank B	18.31		
	Bank C	17.91		
	Bank D	10.79		

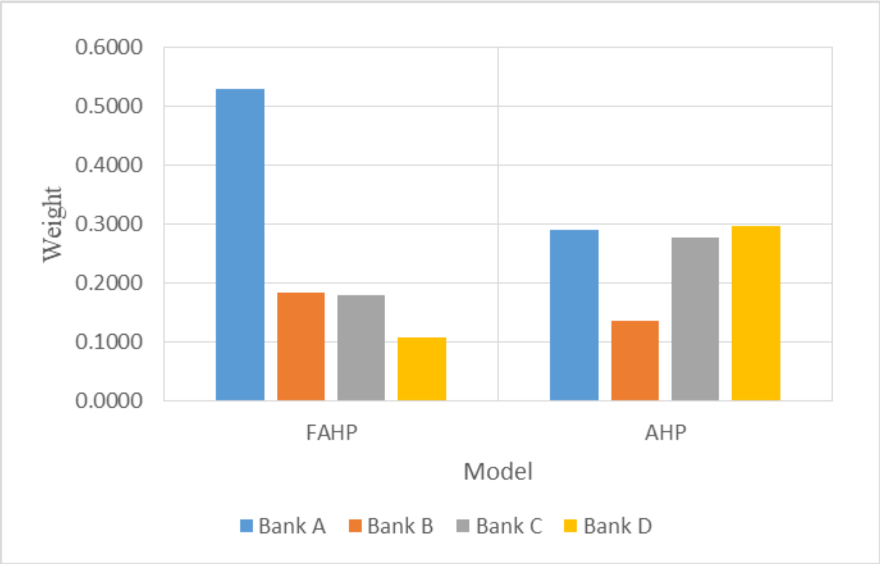

Figure 3. The comparative analysis of FAHP and AHP alternatives weight ranking

Table 9. Wilcoxon Signed Rank Test on FAHP and AHP on criteria weights.

Ranks (FAHP-AHP)				**Test Statistics AHP - FAHP**	
	N	Mean Rank	Sum of Ranks	Z	.674[e]
Negative Ranks	1[a]	5.00	5.00	Asymp. Sig. (2-tailed)	.500
Positive Ranks	4[b]	2.50	10.00		
Ties	0[c]				
Total	5				

a. AHP < FAHP
b. AHP > FAHP
c. AHP = FAHP
d. Wilcoxon Signed Ranks Test
e. Based on negative ranks.

Table 10. Wilcoxon Signed Rank Test on FAHP and AHP alternatives websites weights.

Ranks (FAHP-AHP)				**Test Statistics[d] AHP - FAHP**	
	N	Mean Rank	Sum of Ranks	Z	.000[e]
Negative Ranks	2[a]	2.50	5.00	Asymp. Sig. (2-tailed)	1.000
Positive Ranks	2[b]	2.50	5.00		
Ties	0[c]				
Total	4				

a. AHP < FAHP
b. AHP > FAHP
c. AHP = FAHP
d. Wilcoxon Signed Ranks Test
e. The sum of negative ranks equals the sum of positive ranks.

Wilcoxon Signed Rank Test (Asymp Sig. (2-tailed)) of criteria and sub criteria was .500 for AHP and FAHP models indicating highly correlated decisions of respondents on e-banking websites quality criteria/sub criteria. Also, the outcomes Wilcoxon Signed Rank Test (Asymp Sig. (2-tailed)) of criteria and sub criteria was 1.000 for AHP and FAHP models indicating fairly correlated decisions of respondents on e-banking websites quality of alternatives (banks). Specifically, the FAHP performances were superior to the AHP, which buttressed the findings in existing studies [10][6]. These are shown in Table 9 and Table 10.

From the results, the outcomes of the AHP and FAHP models are closely correlated in terms of the weights of criteria and alternatives considered. This study is in agreement about loyalty towards e-banking products and services as measurable through e-banking service quality (EBSQ) dimensions such as security and privacy, website design interface, reliability, support and service, trust [33][34].

5. Conclusion

MCDM models have been considered in e-banking websites quality evaluation problems. Hence, solutions have been obtained by using the methods of combining AHP and FAHP. These involve choosing the best options from pool of alternatives, ranking of alternatives in acceptable order of preferences and classification by sorting decision alternatives according to specified order of categories [31]. FAHP [10], fuzzy TOPSIS, TODIM and VIKOR [16] have been fund out to be among most adopted methods of e-banking website quality evaluations. Again, the criteria and sub-criteria were constructed in line with products, users and services expectations.

The FAHP technique is a powerful tool for addressing decision-making problems. It reduces uncertainty (vulnerability) related with the planning of chiefs' judgment to number, uncovered in the AHP. Banks need to offer a high-quality e-banking services through increased service quality, thereby raising the level of loyalty towards their e-banking products. Consumers expectations, and perceptions towards service quality vary considerably especially for service quality at physical banking and e-banking. The factors motivating customers' loyalty towards e-banking services should be measured periodically using e-banking service quality (EBSQ) criteria/sub-criteria such as privacy, reliability, security, website design interface, service support, and trust. In future works, there is the need to consider more criteria and sub-criteria for the FAHP model in order to improve the MCDM process of e-banking websites quality evaluation. Also, other variants of MCDM models like Fuzzy TOPSIS, TODIM and VIKOR can also be used in future studies to select the best criteria/sub-criteria for e-banking websites quality.

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