DEVELOPMENT OF E-BANKING WEBSITE QUALITY EVALUATION MODEL USING FUZZY ANALYTICS HIERARCHY PROCESS

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M.Tech/S1CT/20I9/10888

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN DEPARTMENT OF COMPUTER SCIENCE, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

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ABSTRACT

E-banking enables user to access banking services virtually on various forms such as home banking, personal computer (PC) banking, Internet banking and mobile banking. Therefore, several benefits are offered including convenience, ease to use, low cost, time factor, fast delivery and online bill payment. Majority of banking institutions have implemented Internet banking systems in an effort to reduce costs while increasing the level of service to customers. Studies have revealed that, high e-banking website quality experiences is capable of increasing customers' optimal patronage and retention. However, the process of determining e-banking website quality is highly critical, which involves complex multi-criteria decision-making process. This study develops of e-banking website quality evaluation model using fuzzy AHP (FAHP). This FAHP is a typical Multi-Criteria Decision Making (MCDM) technique that introduces logic and science to decision making in multi-criteria settings through a hierarchical structure of the best combinations of five criteria/ 11 sub-criteria for evaluating e- banking websites quality. The study administered structured questionnaire on 50 customers of money deposit bank accounts with history of e-banking websites usage in Minna, Niger State using a non-random sampling method to gather the data. It was found that, of all selected criteria for evaluating e-banking website quality, e-satisfaction and product quality had least impact. While, the e-loyalty, ease of use, and e-trust criteria at normalized weights of 30.21%, 25.41%, and 15.69% were three-topmost most impactful. Particularly on sub-criteria, website content, vagueness, and website design at normalized weights of 17.85%, 14.02%, and 11,72% were ranked top three sub-criteria in evaluating e-banking websites quality. The ranking of the alternatives in the order of magnitude were First Bank, Fidelity Bank, Sterling Bank, and Stanbic IBTC Bank, which is consistent with profit margins. The outcomes of the AHP and FAHP models are closely correlated in terms of the weights of criteria and alternatives considered. This study is vital in banking industry so as to ensure that the quality of their websites given needed priority in order to improve customer's satisfaction.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Consumers can interact with businesses and institutions in a variety of ways thanks to ongoing developments in online technologies and related applications. To increase their online market share, an increasing number of businesses are making significant investments in electronic customer-centric solutions and technologies. These days, businesses put a lot of effort into enhancing the aesthetics and design of their websites as well as the interactive experiences of their customers. One of the most profitable e-commerce platforms is internet banking. (Bacik *et al.*, 2021).

In particular, electronic banking (E-banking) involves numerous services performed through computer, digital television, telephone and mobile phone on the basis of needs and device of choice by the customers (Chaimaa, Najib and Rachid, 2020). Majority of banking institutions have implemented Internet banking systems in an effort to reduce costs while increasing the level of service to customers (Bacik *et al.*, 2021).

The website is considered as a veritable tool in dispensing information for the purpose of meeting diverse needs of individuals from all works of life. People visit the website for various purposes ranging from information sourcing to online marketing of goods and services. Again, it is used for communicating and promoting organizational identities in which enterprises rely on in growing and attaining higher-levels of successes. Websites continue to enhance human computer interactions through the provision of friendly interfaces for active interaction. The process of measuring website quality characteristics relies heavily on the perceptions of the users, developers and experts. The type service

rendered through the website is the main determinant for assessing the quality including: information content, ease of navigation, usability, download speed, customization, and security. These apply to different domains such as e-banking, e-commerce, e-health, e-government, e-education and e-entertainment (Orhionkpaiyo and Momodu, 2021).

Websites entail multiple dimensions and attributes, which are often considered in measuring their quality. Though, new consumers make use of reputation of a website as substitute for quality. In other words, users make judgments about reputation of a website on the basis of other quality attributes such as information content quality and system quality. Other website information quality measured previous utilized are: usefulness, currency, reliability, sufficiency and others (relevance, understandability, believability, format, and competitive intelligence) according to Kwak *et al.* (2019). Both academics and industry experts have recently suggested a variety of different approaches and instruments for assessing the caliber of websites. While some are universal and can be used to evaluate any website type, others have been tailored to the unique features of the websites used in a particular industry (Morales-vargas *et al.* 2020).

Quality concerns for websites started to surface almost as soon as they were developed. Professionals in interface design and human-computer interaction, like Nielsen (2000); Shneiderman (2000); and Norman (2002) cautioned against the need for websites to lack specific features that would ensure the best user experience. Consequently, the concept of website quality evaluation was born, which is a critical and complex because it entailed quality, accuracy and objectivity according to Dragunalescu (2002). Again, “evaluative judgments are frequently followed by important deliberative and decision-making processes” (Dragulanescu, 2002). A range of different approaches, trends and methods

have been developed for evaluating website quality, which are classified in two main groups: user studies, and expert analysis (Morales-vargas *et al*. 2020).

Recently, to predict website quality, a feature selection model has been developed to condense the feature dimension. In this way, several classification algorithms have been used in determining the website quality such as Firefly Search method based on Firefly Algorithm (FA), K-Nearest Neighbour (KNN), Naïve Bayes (NB), Decision Trees (DT), and Random Forest (RF). Often, Information Gain (IG) model have been combined with classification algorithms to improve choice of appropriate features and criteria for predicting website quality (Kumar and Arora, 2019).

The multi-criteria decision-making (MCDM) approaches have capability to cope with complexity within decision-making process for evaluating websites according to Adepoju *et al.* (2020). In particular, the Analytical Hierarchy Process combined with fuzzy logic was evolving and preferred approach for website evaluation.

1.2 Statement of the Research Problem

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 and Momodu, 2021).

In today's marketing communication, websites and internet technologies are well-established and dependable components. Every organization recognizes the value of websites, and great effort is put into creating high-quality websites that not only look good but also function well. However, assessing these websites to make sure users are satisfied with their quality and usability is a crucial task (Bacik *et al.*, 2021).

There are a number of successes recorded with the Analytical Hierarchical Process (AHP) when deployed in making complex decisions through the use of criteria/sub-criteria arranged in a pairwise comparisons style. Nevertheless, this AHP approaches less applicable for undertaking multi-criteria and complex decision-making processes. Therefore, fuzzy AHP model was developed to introduce some form of logical and scientific approach to decision making in multi-criteria settings such as website quality evaluation criteria (Tseng, Wang and Tsai, 2021) as undertaken by this study.

1.3 Aim and Objectives of the Study

The aim of this study is to develop a Fuzzy Analytics Hierarchy Process Model for E-Banking Website Quality Evaluation.

The specific objectives are:

i. To Identify the Criteria and the Subcriteria of e-banking website quality.
ii. To develop a fuzzy analytics hierarchy process model for (i).
iii. To evaluate the performance of the proposed model in (ii) using Wilcoxon Signed Rank Test.

1.4 Significance of the Study

This study will be beneficial to customers of banks, banks, quality control, researchers, product developers, and designers of the e-banking solutions.

This study develops Fuzzy Analytical Hierarchical Process (FAHP) model to improve the decision-making approach concerning the choice of appropriate attributes (criteria and subcriteria) for e-banking website quality evaluation.

This study provides users and customers of banks capability to score their preferences of various criteria and subcriteria composing high quality of e-banking websites using linguistic terms, which are automated by the FAHP.

1.5 Scope of the Study

This study undertakes the development of e-banking websites evaluation model using fuzzy analytics hierarchy process model. The choice of e-banking websites to be evaluated using the proposed model are related to Nigerian Banks and their customers. The study does not cover the development of websites for e-banking products but, rather seeking ways to empirically improve the practice of evaluating the quality of websites on the part of the end-users or consumers. The primary data sourcing approach is adopted using structure questionnaires in order to select appropriate e-banking websites evaluation parameters, while the fuzzy analytics hierarchy process model is used to automate/refine the decision-making process.

1.6 Thesis Organization

The thesis chapters are arranged as follows: Chapter one is the introductory aspects with subsections such as background to the study, statement of the research problem, aim and objectives of the study, the scope of the study, the significance of the study, and expected contributions to knowledge. Chapter two gives literature review under the following subheads: analytical hierarchy process, the concept of electronic banking, website quality evaluation, related works. Chapter three provides the research methodology, research design, analysis of existing model, the proposed model, fuzzy AHP criteria and sub-criteria selection, mathematical definition, data collection, experimental settings, and performance evaluation. Chapter four presents the demographic characteristics of respondents, outcomes of criteria for e-banking quality evaluation, performance evaluation, and discussion of outcomes. Chapter five provides the summary, conclusion, recommendations, contribution to knowledge, and suggestions for further studies.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Analytical Hierarchy Process

The holistic approaches are often adopted by majority of individuals in making decisions, which is the selection of most preferred alternative without critical analysis. Though, in real-life situations, complex decisions making entail multiple criteria that are beyond the capacity of the human brain to synthesize effectively and intuitively. Therefore, the holistic approaches are considered unsuitable for performing serious complex decision which gave rise to considerations of scientific and logical techniques. Consequently, Analytic Hierarchy Process (AHP) was proposed as a measurement theory in 1980 by Saaty for the formulation and analysis of complex decision-making processes. The principle of AHP is to simplify a complex decision problem through hierarchical structure representation composed of criteria and sub-criteria with a pairwise comparison against the criteria (Tseng *et al.* 2021).

There are several applications of AHP and its variants in diverse domains as summarized in Table 2.1:

Table 2.1: Application areas of Analytic Hierarchy Process and its variants.

S/No	Author(s)	Domain	Model	Application(s)
1.	Kieu *et al.* (2021)	Agricultural Logistics	Combined Compromise Solution (CoCoSo) Algorithm and Spherical Fuzzy Analytic Hierarchy Process (SF-AHP).	Distribution centre location selection.
2.	Zhang *et al.* (2021)	Acoustics	Rank score comparison and multi-fuzzy analytic hierarchy process.	Forklift sound quality modelling.
3.	Kumar *et al.* (2021)	Ecological sustainability of rivers.	Fuzzy analytic hierarchy process.	Water quality of river basins, India against pollutants.
4.	Ulutaş (2019)	Website performance evaluation	Fuzzy SWARA and WASPAS-F.	MCDM methods for performance measurement of educational websites.
5.	Radhika and Sadasivam (2021)	Public Cloud Service.	Fuzzy analytic hierarchy process	Virtual machine-based budget provisioning of multi-cloud environment.
6.	Kutlu *et al.* (2021)	Public transport service	Fuzzy analytic hierarchy process and linear assignment.	Convenient and low-cost timetable development for passenger, non-passenger, and decision-makers (or government).
7.	Liang *et al.* (2019)	Internet banking industry	Pythagorean fuzzy VIKOR-TODIM	Evaluation of Ghanaian e-banking websites quality.
8.	Yu, *et al* (2020)	Electricity market	Cloud model and intuitionistic fuzzy analytic hierarchy process	Credit risk analysis of electricity retailers in China.
9.	Yee *et al.* (2021)	Wastewater treatment process.	FAHP.	Wastewater discharge and treatment with accurate criteria selection.
10.	Yalcinkaya and Kirtiloglu (2021)	Geographic information system	Fuzzy analytic hierarchy process model.	Location of potential municipal solid waste management facilities.
11.	Karczmarek *et al.* (2021)	Decision-making theory.	Fuzzy Analytic hierarchy process.	Graphic representation of choice of alternatives rather than linguistic or numeric.
12.	Majumdar *et al.* (2020)	Green clothing supply chains.	Fuzzy Analytic hierarchy process.	product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers and end-of-life management of the product after its useful life.

13.	Tseng, *et al.* (2021)	Third-party booking system.	Analytic hierarchy process.	The development of model for choosing between e-commerce systems.
14.	Chen and Wu (2020)	Multi-criteria decision-making problem.	Fuzzy collaborative intelligence FAHP.	Three-dimensional printer selection process.
15.	Chaudhry *et al.* (2019)	Groundwater resources management.	Fuzzy analytic hierarchy process and geospatial technique.	Mapping of the groundwater potential zones Rupnagar district, Punjab State, India.
16.	Song *et al.* (2021)	Chemical Manufacturing	Cloud model and nonlinear fuzzy analytic hierarchy process.	Safety level prediction of chemical production.
17.	Nguyen (2021)	Hospitality industry.	FAHP and SERVQUAL.	Hotel service quality evaluation criteria generation.
18.	Al-Shammari and Mili (2019)	Banking.	Fuzzy analytic hierarchy process.	-Customers' top priorities when choosing commercial banks. -Development strategies of banks.

From Table 2.1, the concept of the MCDM problems is associated with a decision-making process with a choice of alternatives, prioritization, or ranking. AHP is an established technique of the decision-making theory using pairwise comparisons and applied to numerous aspects of human endeavours including banking, agriculture, hospitality, and GIS. After the inception of AHP by Saaty (1980), several application variants have been developed as highlighted.

In particular, the AHP has involved largely in selection, evaluation, prioritization, or forecasting whenever the need arises to quantify the decision of an expert or a group of experts at various of levels of generality (hierarchy) or survey. AHP in expressed in numeric (or simplest) procedure, and it is relatively easy to use even for non-experts in the field (Karczmarek *et al.* 2021).

There are evidences of potential effectiveness of the AHP and its variants in MCDM process problems such as website quality criteria selection for e-banking sector (Al-Shammari and Mili, 2019; Tseng *et al.* 2021).

2.2 The Concept of Electronic Banking

E-banking was created as a result of globalization, competition, and the explosive development of information technology systems. Through various technological services like the Internet and mobile phones, it has evolved into the self-service delivery channel that enables banks to offer information and services to their customers with greater convenience (Chaimaa et al. 2020). Many organizations have embraced this new technology to improve customer service delivery and quality while spending less money than they would have otherwise. E-banking is frequently seen as a low-cost way to carry out banking transactions, exchange data, and buy and sell goods and services from anywhere at any time. Additionally, it is a strategy for retaining current clients and luring new ones to the bank (Chaimaa et al. 2020).

E-banking is currently the technology that banks use most frequently. E-banking suggests that any customer with a personal computer and a web browser can link to the websites of his account in order to conduct any one of the digital financial institutions. E-banking is a result of technological development and competition. In reality, banking has made use of digital and telecommunications networks to provide a wide range of value-added goods and services. As part of their e-banking strategy, modern distribution platforms offered customer Automated Teller Machines (ATM) or Cash Dispensers (CD), Phone-banking, Internet-banking, and Mobile-banking (Dhanya and Velmurugan, 2021).

The electronic banking (e-Banking) enables customers of banks to use their services without the need for direct contact with the bank officials, which is a kind of self service. Though, in 1995, Rogers highlighted that, assurance factor was a challenge faced by individuals operating new technologies. The education and understanding levels of

customers are different but, assisting banks to develop and tailor their e-banking channels to meet customers' needs, and ease of use of e-banking services. Other service quality metrics include: innovation, perceived security, accessibility, tangibility, perceived usefulness, and trust. In particular, there are more concerns about security and privacy as a number of products and services are offered through Internet backbone such as websites and software applications (Chhaya and Mittal, 2021).

Presently, there are almost no organizations without a web presentation (comparable to an ID card), which enables them to become visible on the Internet. Web presentation become a significant factor in the business in order to keep pace with other organizations, retain competitive advantage, and attracting new customers. The process of improving web presence of organizations requires MCDM, an operational research approach for problems when a decision is to made by selecting two or more possible alternative solutions. In this case, key evaluation criteria have been applied to evaluating websites for the purpose of revealing their quality and weaknesses in various areas of education, information, e-commerce and finance (Stanujkic *et al.* 2018).

In the evaluation of the quality of a website, the focus is on three main approaches as reported by (Abbasi *et al.* 2018):

i. Machine: A website's key features are automatically recorded using software in the machine approach. The procedure is entirely automated, and visitor feedback is not requested.
ii. Expert as judge: In the expert judge approach, the researchers typically start by identifying a set of traits to categorize the sites.
iii. Customer as judge: Although expert and machine approaches may recognize significant website characteristics, they ignore the customers' perspective, which

is the true test of a website's success. The final strategy is to request feedback on the website from users and consumers of information.

2.3 Website Quality Evaluation

Website quality evaluation on the part of the users attempt to determine that features of a website meet their needs, which depicts the overall excellence of a website. In this case, the success of websites relies on whether the design is tailored towards the needs of consumers. Diverse criteria and sub-criteria have been developed to enable the website quality evaluation achievable (Chang & Chen, 2008; Akincilar and Dagdeviren, 2014) including security oriented (privacy, security, and trust), other factors (visual appearance, interactivity, multimedia, site design, technological integration, site management, and site content), customer oriented (fulfilment, personalization, playfulness, customer retention, responsiveness, feedback, and contact information), marketing oriented (advertising, promotion, online transaction, order confirmation, and customer service), and technology-oriented (usability, accessibility, navigability, and information quality).

A website's fineness can be assessed using a set of criteria, which make up the core of a website quality model. A website's quality can be predicted by its quality attributes. Large sets of features, however, might make models more complex and lengthen prediction computation times. A measure of website quality that forecasts consumer use of a site is one aspect of website quality prediction. It is essential to create a tool that is specifically intended to gauge how well consumers think a website is made. Relevance, Total Size, Broken Links, Communication, Loading Time, Social Media Connectivity, Overall Theme, Compatibility, Global Audience, Resolution, Typography and Font, Color Scheme, and Keyword Matching or Page Rank are some examples of quality attributes that can be used to predict the quality of a website (Kumar and Arora, 2019).

Other criteria of website quality evaluation have been developed over the years from different perspectives such as online banking content, special content quality, appearance quality, technical quality, general content quality (Bacik *et al.*, 2021). The level of satisfaction of consumers of online service platforms depends on the website quality. The process of evaluating website quality conside rs 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 (Sari and Pangaribuan, 2019).

2.3.1 Website Quality Evaluation Criteria

To achieve these, evaluation criteria are required; according to (Abbasi et al. 2018), there are a few key characteristics that a high-quality website should have. These characteristics are known as the evaluation criteria. The website must first have a pleasing appearance, excellent design, and flawless execution. Then, a successful website should be a major information source, offer comprehensive details about the goods and services, and enable easy access to information using tools like search engines. Customers also expect appropriate levels of service interaction, including the ability to make reservations for tickets, pay for them in a variety of ways, and modify or cancel their reservations. The website's name ought to be simple to recall. The website should also offer the right levels of customer service interaction, personalization, and contact ease for the events.

2.3.2 Benefits of Website Quality Evaluation

The financial services sector is revolutionized by information technology, which gives them the chance to expand their customer base and offer significant advantages for conducting financial transactions. Unbanked people now have more ways to participate and directly use banking services thanks to mobile phone banking. It provides many practical services like online bill payment, money transfers, and depositing money

without physically going to the neighbourhood branch. Financial institutions are using technology, such as electronic fund transfers, interbank financial telecommunication, the internet, mobile banking, crowdfunding, and cryptocurrencies, to strengthen and improve the financial innovation system (Ahmad *et al.*, 2021).

Banks must offer high-quality e-banking services by utilizing competitive advantages. The level of customer loyalty to e-banking can be raised by the bank by improving service quality. Individual customer expectations for service quality and customer perceptions of service quality can vary between traditional banking and online banking. Reliability, privacy and security, website design interface, service and support, and trust are a few of the e-banking service quality (EBSQ) dimensions that can be used to gauge the factors that influence customers' loyalty to e-banking services (Chhaya and Mittal, 2021; Ullah, 2021).

2.4 Related Works

In order to gauge consumers' e-loyalty toward e-banking services, the Ghali (2021) study primarily focused on factors like security/privacy, responsiveness, website design, and convenience. The findings demonstrated that convenience, security/privacy, and e-satisfaction variables have been significantly influenced by each other. Once more, responsiveness and website design significantly affect only Saudi Arabian customers' e-satisfaction.

Charity websites were used as a multi-attribute donation channel by Kwak et al. (2019), consisting of four system quality attributes (navigability, download speed, visual appeal, and security) and three attributes of information content quality (mission information, financial information, and donation information). According to the framework, four types

of halos—collective (attribute-to-attribute), aesthetics (attribute-to-dimension), reciprocal-quality features (dimension-to-dimension), and quality (dimension-to- dimension)—were found to be pertinent to the evaluation of charity websites. The outcomes of analyses such as structural equation modelling and other analyses support the various proposed halos.

A new multiple-criteria decision-making (MCDM) model was introduced by Stanujkic et al. (2018). It is based on the Weighted Sum Preferred Levels of Performances (WS PLP) method for alternative selection and the Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA) method for weighing the evaluation criteria. Efficiency and usability are crucial factors to consider when evaluating a website. To allow customers to choose their preferred commercial banks, Al-Shammari and Mili (2019) implemented a fuzzy analytic hierarchy process (FAHP) multi-criteria decision model. Five Bahraini retail commercial banks and six criteria are used to create a decision-making problem with three levels of hierarchies. The FAHP is used to establish the relative weights of the evaluation criteria after the hierarchies have been structured. The findings indicate that the majority of the chosen banks give pricing strategy more attention than bank services. The primary factors used to draw customers are interest rates on deposits and credit cards as well as transaction costs. For decision-makers to create the best strategies for their customers' preferences, the study offers several implications.

In a study published in 2020, Aziz, Riana, and Mulyanto used the WEBUSE method to analyze the site usability evaluation system on covid19.go.id, one of the informational websites about COVID-19. 24 usability criteria that were divided into five usability categories (content, organization, and readability, navigation and links, user interface design, performance and effectiveness, and educational purpose) were the basis for the

basic analysis. Each category focuses on a different usability topic. To gather comprehensive system data and user satisfaction ratings for the website covid19.go.id, a survey was created online. Data was analysed using the WEBUSE method to determine the website's usage point and usability level. The user satisfaction and usability levels on the website covid19.go.id were good and acceptable for the general public from all walks of life, according to the case study. Even after taking satisfaction in the user interface design category into account, a few respondents were still uneasy with how the website appeared.

A new viewpoint on a compromised solution was put forth by Liang et al. (2019), who used the Portuguese acronym TODIM—interactive multi-criteria decision making—to handle the decision maker's psychological behaviour. The weights of the criteria were predetermined using Pythagorean fuzzy entropy and cross-entropy measures. Then, the psychological behaviour of the customer was measured with the both TODIM and VIKOR. Therefore, these two methods were developed as Approach I and Approach II respectively. Both approaches were applied in ranking Internet banking websites in the Ghanaian banking industry, which revealed their validity and applicability. Then, the Wilcoxon signed-rank test outcomes were compared with the VIKOR, TODIM and the proposed methods.

The significance of the effect of website quality on the anticipated performance and the actual use of e-banking was understudied by Bacik et al. in 2021. A model was developed to determine how well-designed websites affect people's use of electronic banking. The specific characteristics of websites and their effect on tourists' use of internet banking in destinations were determined using the Unified Theory of Acceptance and Use of Technology (UTAUT) and technology as the theoretical foundation. The findings

indicate that there are many different aspects to how well a website is perceived. The user's behaviour, as shown by how frequently they use internet banking, is indirectly influenced by the website's quality. The expected performance factor mediates this indirect effect. In the banking industry, there are issues with low technology adoption and a narrow scope (Islamic banking).

Ahmed *et al.* (2021) attempted to assess the level of service quality in Pakistan's Islamic e-banking industry by e-customer loyalty and satisfaction. The modified multiple-item scale (E-S-QUAL) model was used, and it is based on two new dimensions: the accessibility of an online system and the individual needs of the users. In addition, two mediators: religiosity and trust in the Islamic e-banking perspective were considered. The results revealed a strong and positive correlation between e-customer satisfaction and loyalty. Additionally, the results of the serial mediation relationship demonstrated that e- customer satisfaction, trust, and religiosity were mediators between e-customer loyalty and the modified E-S-QUAL model characteristics. The study provides the framework for the banking industry's decision-making processes regarding service improvement.

In the context of e-banking in Washington, DC, the United States of America, a theoretical framework was developed by Emam *et al.* (2021) to investigate the effects of gamification on several aspects of websites, such as usability, page attributes, content, and design. 400 bank customers who utilized a gamified e-banking website to track their financial transactions are surveyed online for the study's data. The results showed that gamification significantly affects usability, webpage characteristics, website content, and website design in the context of e-banking. But, the approach relied on manual method to arrive at the best decision-making on e-banking products and services improvements.

In the context of Pakistan, Butt (2021) examined consumer behavior and intentions about the use of online banking services. It took into account the mediating impact of customers' trust on the relationship between the quality of the e-banking service (E-BSQ) and their behaviour intention (BI) as service users. Author utilised e-service quality criteria such as efficiency, security/privacy, responsiveness/communication, reliability, system/fulfilment, trust, customer behaviour intentions, e-banking service quality. The findings will enable management and decision makers valuable information on the significance of improving customer trust and improving online-banking services for customers' retention.

Sari and Pangaribuan (2019) made an effort to gauge website quality and agent satisfaction. The Webqual 4.0 method was used to analyze 30 registered agent sample data. Usability of the website and customer happiness are the key measuring criteria, whereas service quality, emotional impact, price, cost, and product quality are the sub-criteria. The study found that improving the payment website's usability can increase agent satisfaction. This suggests that agent satisfaction would rise in accordance with the amount of convenience (Usability) at which online payment website quality is attained. But, there is the need to have standard website usability criteria in place especially e-banking websites.

Giannakoulopoulos *et al.* (2019) studied the degree to which a university's academic standing and the calibre of its online presence are related. A technique was created to evaluate the top 100 universities in terms of website quality and search engine optimization (SEO) on the Academic Ranking of World Universities (ARWU) Shanghai ranking. Each website was evaluated and tested using a variety of tools, which resulted in rankings for each website's Web quality, SEO performance, and overall web ranking.

The results suggested a connection between an institution's academic success and the caliber of its online presence (website), but this clearly does not imply a causal link.

Das and Ravi (2021) determine how each aspect of service quality, including dependability, website design, security/privacy, and communication/ responsiveness, impacts on satisfaction of customers. The data was gathered through an online questionnaire from 149 respondents. The data was analysed using Correlation, Regression, ANOVA/Weighted average tests. The outcomes can assist banks in planning service quality improvements of e-banking service in order to attain customer satisfaction. There is need to investigate usability of e-banking services with customer's satisfaction.

Gill *et al.* (2021) considered superior online banking services essential for retaining customers. The study population consisted of users of the top five commercial Pakistani private banks' online banking services. For the hypothesis analysis, a structural equation modeling method was used. Based on motivational relational, cognitive theory, the findings demonstrated the significant influence of dependability, website design, and security on customer trust offer higher loyalty. The study's conclusions have a wide range of theoretical and practical ramifications for bank management, who can use them to improve the security features and user-friendliness of their internet banking websites in order to increase customer trust and loyalty. But, this study can be extended to other developing countries such Nigeria.

Hammouri *et al.* (2021) developed a theoretical framework for examining the relationship between security and trust in terms of online banking. The seven evaluation attributes were identified from literatures surveyed as directly related to the security issues of Internet banking including: integrity, confidentiality, authentication, availability,

authorization, privacy and non-repudiation. However, authors did not evaluate the research model proposed for e-banking services.

In order to determine which dimension may have the most potential to effect customer satisfaction, the relationship between the e-Banking service quality dimensions and customer satisfaction was explored by Reddy and Megharaja (2021). Data was gathered using a survey tool that was distributed to bank customers in the Lebanese banking sector. The data was analysed with SEM and AMOS which indicated that, service quality, and reliability as predicator of customer satisfaction. But, this model can be tested in different cultural contexts other than Lebanon.

Chhaya and Mittal (2021) examined how adopting E-banking services affected factors that affect service quality. In the city of Ahmedabad, Gujarat, bank clients from both private and nationalized banks participated in a primary survey that was used to collect data. Statistical analysis of the data was performed using structural equation modelling (SEM). The ease of use and perceived security of the e-banking service were shown to be significantly impacted by all of the service quality influencing factors. Also, the e-banking service quality remained one of the unavoidable components of the banking sector for increasing profits, reputation, and competitive edge through raising customer satisfaction levels. Future works to increase the geographic spreads for further validation of model.

Abbasi *et al.* (2018) developed a model for assessing the function of top-five Iranian airlines website using fuzzy TOPSIS. The process of validating the model involved data collection and analysis by the questionnaire administered on respondents. Thereafter, process data were taken into the fuzzy setup in order to determine the final weights of the key criteria and subcriteria based on the FAHP TOPSIS. The outcomes showed that,

transactional content, website design, and content have significant effect on quality of websites in airline industry. But, more factors can be considered for measuring website quality in the future.

Kumar and Arora (2019) created a two-stage feature selection method based on a hybrid filter-wrapper technique for a website quality prediction efficiency model. 13 quality attributes were optimized by the model. First, the Information Gain (IG) approach is used to rank each feature. Second, the highly ranked attributes from the earlier stage were subjected to the Firefly Search Algorithm (FA) in order to produce six fewer sub-selections. These sub-selections included information quality, technical evaluation, interaction, usage, visual appeal, and page rank. There is need to obtain fewer and refined features for evaluating website quality in the future.

Ullah (2021) examined the interconnection among the factors of e-banking service quality (EBSQ) and customer loyalty, as well as the mediating role of customer trust. The authors adopted a structured questionnaire to gather information from 220 respondents in five Malaysian commercial banks. According to the study, website design, customer support, and reliability all have statistically significant effects. While customer loyalty is negatively impacted by privacy and security. Once more, the mediation function of customer trust has a big influence on figuring out how the EBSQ dimensions and customer loyalty relate to one another.

Orhionkpaiyo and Momodu (2021) e-banking, e-commerce, education, hospitality or tourism, and health websites were examined in order to reveal the critical quality features in each field. Using conceptual content analysis of the available literature, the quality characteristics that are important in each of the domains were highlighted. The outcomes showed that, Academics highly ranked e-banking website quality characteristics include:

privacy, accessibility, availability, usability, and efficiency. While, the developers graded privacy, reliability, and security as topmost features. Though, these respondents were drawn from the academic and developers, it should be extended in future works.

Kimiagari and Baei (2021) attempted to evaluate fresh decision-making factors influencing users' actual and intended use of e-banking. The authors developed a model by integrating the TOE framework with TAM theory and applied to Iranian banks. While partial least squares were used to explain the inter-correlations within constructs of the model such as social influence, behavioural intention, initial trust, bank reputation, structural assurance, task-technology, and task characteristics. The study found that, perceived bank size or geographical spread, and social media campaigns of banks can increase users' e-banking actual usage. However, other factors can be investigated about increasing usability of e-banking services especially in low-income countries.

Academics and industry experts have put forth a variety of techniques and tools for assessing the calibre of websites. The majority of these methods have general applications and are helpful for evaluating any type of website, while others have been modified to take into account the unique features of websites used in a particular industry. In order to identify the most pertinent articles, its leading authors, and the particular industries catered to by the websites quality under consideration, Morales-Vargas *et al.* (2020), conducted an analysis of the already-existing body of knowledge in this topic. The main subcriteria identified include: usability, information architecture, user experience, content, legal aspects, multimedia, sociability and participation, advertising and marketing, performance/ The study found that, usability, content, information architecture, user experience, graphic design and technology/security had more influence

on website quality evaluated. But, the field of website quality testing is evolving and diverse.

The summary of related works reviewed in terms of the author(s), domain of study, criteria and sub-criteria, strength and limitation are presented in Table 2.1.

Table 2.2 Summary of related works reviewed on websites quality evaluations.

S/N	Author(s)	Domain	Criteria	Sub-criteria	Methodology	Strength	Limitation
1.	Ghali (2021)	E-banking	e-loyalty, e-satisfaction, e-trust	Security/privacy, convenience, responsiveness and website design	Online survey data collection and Structural equation modelling.	It offers clear directions for practitioners on service improvement.	Saudi Arabia customers only.
2.	Kwak *et al.* (2019)	Charity	Information content quality, and system quality.	Mission information, financial information, and donation information; and navigability, download speed, visual aesthetics, and security.	structural equation modelling.	The use of halo effects for multi-attributes of objects judgement.	Data sourced from child relief and development websites.
3.	Stanujkic *et al.* (2018)	Hospitality	Facilities information, guest contact information, reservation/price information, surrounding area information, management of the website, and company profile.	Quality and reliability of the information provided, simplicity, substantiality, relevancy of links and the ability to print all or part of a composition.	Weighted Sum Preferred Levels of Performances (WS PLP) for selecting alternatives and Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA)	Website quality evaluation and weaknesses identification.	Study covered website evaluation of the hotels in Timok region (Eastern Serbia).
4.	Al-Shammari and Mili (2019)	Banking	Pricing strategy, quality of service,	Interest rates on loans and deposit and fees, and commission;	FAHP multi-criteria decision model.	The fuzzy numbers are used in AHP to avoid uncertainties	Five Bahraini retail commercial banks

			and bank facilities.	number of branches and number of ATMs; transactions delays and staff recommendation.		in group decision making.	for the period of 2008–2012.
5.	Aziz, *et al.* (2020)	Website services (Covid-19)	Content, organization, and readability, navigation and links, user interface design, performance and effectiveness, educational purpose	24 attributes.	Online evaluation questionnaire, and WEBUSE method.	Usability of website is enhanced.	COVID-19 information provider websites were considered.
6.	Liang *et al* (2019)	Banking website	Product quality, ease of use, security, responsiveness and privacy.	vagueness, uncertainty and ambiguity; correctness of the transaction and the customers' privacy;	TODIM and Pythagorean fuzzy VIKOR approaches.	It improves customers' retention of banks.	Study was restricted to Ghana banking sector websites.
7.	Bacik *et al.* (2021)	Banking website	User behaviour, Quality of website, expected performance.	Web design, web quality factor, content quality, technical quality.	Unified Theory of Acceptance and Use of Technology (UTAUT)	It impacts on the behaviour of the user or frequency of usage of internet banking.	Multidimensional constructs are to be applied to e-banking technology.
8.	Emam, *et al.* (2021)	Banking	Ease-of-use, webpage characteristics, website	Search tool of bank website, Well categorizing website, Quick process, Website	Gamification.	It enhances customer experience, behaviour and engagement in different activities.	It is effective for attracting customers to online business rather than e-

			information, and website design.	interface, Website mental effort, Attractiveness of graphics, Text style, Digital animations, Light colours. Information security, Intensive information, Complexity of information, Existing avatars or digital animations, Categorization of website information, The quality of information. Attractiveness of bank website, Nice design, Navigation bar and links, Interactive design of bank website.			banking applications.
9.	Ahmed *et al.* (2021)	Banking	Online system availability, personal needs of customers.	E-customer satisfaction, trust, religiosity, e-customer loyalty.	Modified E-S-QUAL Model and Second-Order PLS-SEM.	It enhances decision-making for Islamic e-banking effectiveness	It is limited to fewer factors and scope (Islamic banking).

10.	Butt (2021)	Banking	Trust, e-banking service quality, customer behaviour intentions.	Reliability, reputation, integrity, satisfaction, transparency, goodwill, perceived benefits, responsiveness, fulfilment, efficiency, privacy, and security.	E-SQUAL, and Theory of Planned Behaviour.	It increases retention of customers in terms of trust e-service.	There is need to increase factors in measuring e-banking service quality and behavioural intention.
11.	Sari and Pangaribuan (2019)	Online payment websites (e-commerce).	Customer satisfaction, usability of website (or quality).	Emotional, cost, price, service quality, product quality.	Webqual 4.0 and t-statistic.	Usability of website can be linked to satisfaction of customers, which a variable of quality of website.	There are no standard quality or usability measurement criteria.
12.	Giannakoulopoulos *et al.* (2019)	Education	Website quality, search engine optimization performance.	Website accessibility, website structure, website performance.	Reckoning tool and specific requirements of website design and development.	It boosts general presence and status of academic institutions.	It relates academic performance od universities to quality of websites.
13.	Das and Ravi (2021)	Banking	Service quality, customer satisfaction.	reliability, security and privacy, website design, and responsiveness and communication.	Correlation, Regression, ANOVA & Weighted average tests.	It enables improve their e-banking services offerings to satisfy customers.	There is no established link between usability of e-banking websites and satisfaction.
14.	Gill *et al.* (2021)	Banking	e-banking quality, customer loyalty.	Trust, reliability, website design, security	Partial least squares	It increases trust and loyalty of customers	Study limited to an instance of

					structural equation modelling (PLS-SEM) technique.	to e-banking services.	developing countries.
15.	Hammouri *et al.* (2021)	Banking	Trust and security	Confidentiality, availability, authorization, non-repudiation, privacy, authentication, integrity.	Systematic literature review.	It recognised the impacting factors on customers' trust in e-banking services usages.	There is no evaluation of proposed model.
16.	Reddy and Megharaja (2021)	Banking	Customer satisfaction, service quality.	Reliability, responsiveness, assurance, tangibles, empathy.	SEM and AMOS.	It is used to determine e-banking service quality based on satisfaction of customers.	There is need to explore this model in multiple cultural scenarios.
17.	Chhaya and Mittal (2021)	Banking	Customer satisfaction, service quality.	Ease of use, security, usefulness, innovation, assurance.	SEM	Ease of use and perceived security influence on the customer satisfaction level.	Model to be validated in more geographical spread.
18.	Abbasi *et al.* (2018)	Aviation	Website quality.	Website design, website evaluation, other services, remembrance, contact, transactional content, content.	Fuzzy AHP and Fuzzy TOPSIS.	It links customers intention to use websites to its quality.	The model can be extended to other evaluation factors.
19.	Chaimaa *et al.* (2020)	Banking	E-banking Service quality,	Low cost, time factor, ease of use/ user friendliness, of	Literature survey.	It provided challenges, risks and	Security of e-banking services is a top issue.

			customer satisfaction.	transaction, vulnerability, security, availability.		solutions to e-banking services.	
20.	Kumar and Arora (2019)	Website quality prediction	Information quality, technical assessment, interaction, usage, page rank	Relevance, accuracy, completeness, updation. Total size, broken, loading time, links. Communication, social media connectivity. Browser compatibility, resolution, global audience. Overall theme, colour scheme, typography/font.	Filter-wrapper based features selection. Ranking with Information Gain; feature selection: Firefly Search Algorithm.	It achieved 36.53% reduction in features at 0.015 seconds for building a classifier.	Better classification accuracy than 89.905% to obtain features selection.
21.	Ullah (2021)	Banking	EBSQ and customer loyalty.	Website design, privacy, reliability, customer service/ support, customer trust.	Structured questionnaire.	It showed that customer's trust influence customer loyalty.	The number of EBSQ dimensions can be expanded.
22.	Orhionkpaiyo and Momodu (2021)	Websites	Website key quality characteristics (E-banking)	Accessibility, security, content, privacy, reliability, security, usability/ usefulness, search capability/ search engine, customization, efficiency, availability.	Conceptual thematic content analysis method.	It identified accessibility, privacy, availability, efficiency and usability as top ranked e-banking website key quality characteristics.	The respondents were drawn from developers and academic only.
23.	Kimiagari and Baei (2021)	Banking	E-banking services behavioural	Bank reputation, initial trust, structural assurances, task-	A TOE/TAM theory-based	It was found that, perceived bank size and social media	Model can be extended to low-income countries to

			intention and actual usage.	technology, task characteristics, social influence, behavioural intention.	model. PLS for analysis.	highly influence increase e-banking usage.	study usability of e-banking services.
24.	Morales-Vargas *et al.* (2020)	Unspecified	Website quality	Usability, information architecture, user experience, content, legal aspects, multimedia, sociability and participation, advertising and marketing, performance/ effectiveness, interactivity, technology, graphic design.	Usability, content, information architecture, user experience, graphic design and technology/security had more influence on website quality.	The field of website quality testing is evolving and diverse.	Generalised scope.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This subsection outlines the complete steps performed in developing of e-banking website quality evaluation model using FAHP. The main activities in achieving the research objectives are described as follows:

i. Thorough and critical literature reviews are performed to identify research problems and weaknesses.
ii. The primary and secondary sources of data were collected for the selection of the e-banking website quality evaluation criteria and sub-criteria (objective one).
iii. The formulation of the novel e-banking website quality evaluation model using fuzzy analytics hierarchy process (objective two).
iv. The experimental setup for the implementation of the developed FAHP based e-banking website quality evaluation model.
v. The determination of the performance of developed e-banking website quality evaluation model (objective three).
vi. The documentation and presentation of research outcomes.

These phases involved in developing the FAHP based e-banking website quality evaluation model are depicted in Figure 3.1.

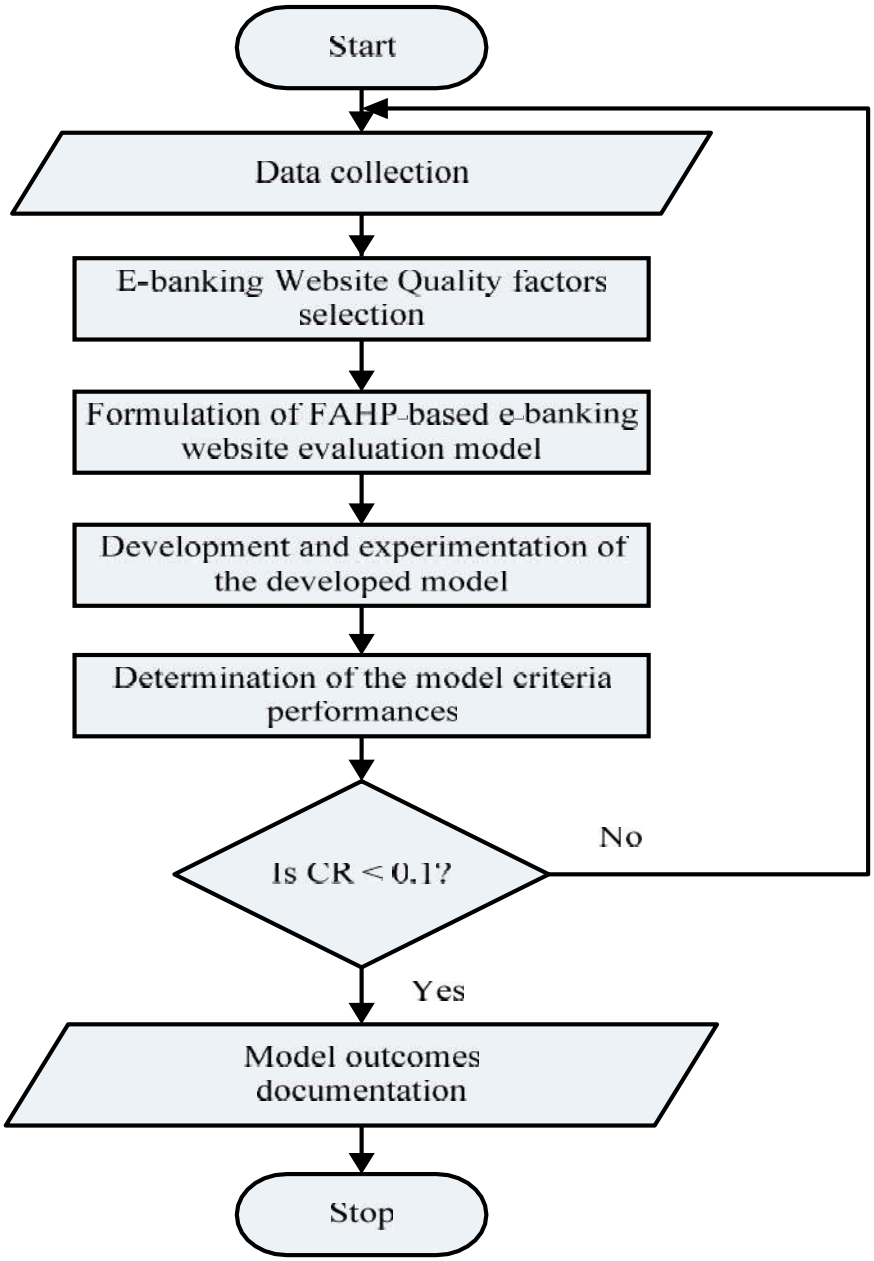

Figure 3.1: The research process design flowchart.

3.2 Analysis of Existing Model

The fuzzy analytical process (AHP)-based quality criteria are used in this study to assess the website's quality. Although many analysts agree that Saaty's AHP strategy has some drawbacks, including uncertainty (vulnerability) related to the planning of chiefs' judgment to number, uncovered in the AHP, some analysts believe that the AHP technique is a

fantastic asset in decision problems. The AHP results are greatly influenced by the leader's preference and personal judgment. To address these, the Saaty's AHP was modified and fuzzified in order to identify and manage the vulnerability noted in the earlier works.

3.3 The Proposed Model

The fuzzy correlations proportions are used in the proposed FAHP to reduce the uncertainty of the AHP strategy. FAHP provides a decision maker with more flexibility than AHP because it allows them to map a relative priority to a variety of potential values.

Three-sided fuzzy numbers are employed in the first stage of this technique to perform pairwise correlation using FAHP scale methods, and degree investigation strategy is used in the second stage to calculate need loads utilizing manufactured degree esteems.

The fuzzy evaluation grid of the measures will be built utilizing the pairwise correlation of several ascribes pertinent to the overall aim using triangular fuzzy numbers and semantic variables. The main elements of the FAHP for choosing the pertinent criteria in assessing the calibre of websites in the e-banking sector are: choice of website quality criteria and sub-criteria, coding of criterion and sub-criteria with potential indiscriminative values, application of relevant criteria and sub-criteria in assessing e-banking website quality, fuzzy judgement matrices for decision-making, and results of e-banking website quality evaluation (defuzzification).

3.4 Fuzzy Analytical Hierarchical Process Criteria and Sub-Criteria Selection

The main activities for the 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.

Algorithm 3.1: FAHP criteria and sub-criteria selection

INPUT**: Comparison matrix**
OUTPUT**: Normalised Weighted and Ranked criteria and subcriteria**

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. A pairwise comparison matrix based on AHP scale and TRANSFORM into a fuzzy triangular (FT) scale are to be developed.

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 regarded as an evaluation method which provide a single numeric value and categorized website quality.

Step 3 The CALCULATION of the fuzzy geometric mean from the lower fuzzy geometric mean, median fuzzy geometric mean, and upper fuzzy geometric mean.

Step 4 CALCULATION of fuzzy weight using the lower, medial and upper fuzzy weight accordingly.

Step 5 CALCULATE weight of parameter.

Step 6 NORMALIZE weights of website quality criteria and sub-criteria for e-banking.

Step 7 RANK criteria and subcriteria using normalized weights

STOP

3.4.1 Model Criteria and Sub-Criteria Development Stages

The first stage is concerned with the criteria and sub-criteria identification and Bank selection. These are used for the development of e-banking websites quality model based on hierarchical architecture as shown in Figure 3.2.

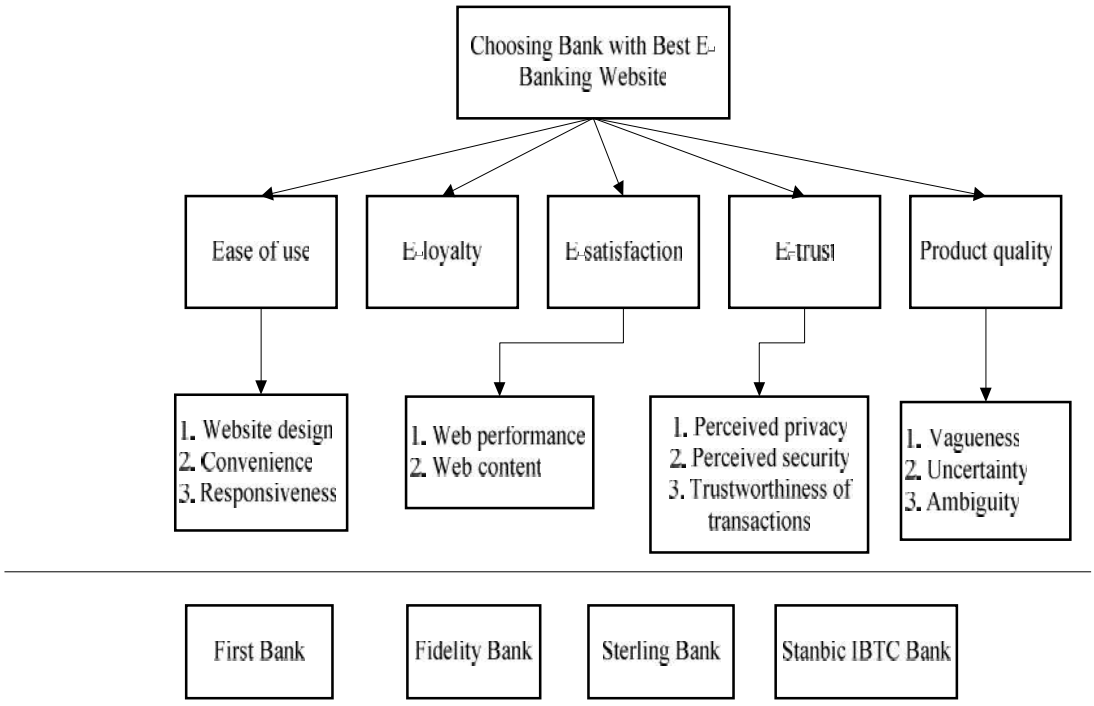

Figure 3.2: **Hierarchical architecture of the Banks' e-banking solutions websites usability criteria and subcriteria.**

The second stage is the actual construction of the Fuzzy AHP model. By determining priorities from the value judgment of an individual or group engaged in the decision-making process, the application of AHP for multi-criteria decision analysis enables the breakdown of the choice problem in a hierarchical design. This study adopts the criteria defined for e-banking websites in the previous studies.

The conventional AHP's crisp pairwise comparison, which relies on the weaknesses, vagueness, and uncertainty observed with decision makers' judgments, is largely unsatisfactory and inaccurate in fully capturing the decision makers' judgments. To overcome these drawbacks, fuzzy logic is used as a complement to the AHP's pairwise comparison. The method is called the fuzzy AHP. The fundamental tenet of fuzzy set theory is that each element in a fuzzy set has a grade of membership, which is represented by a

membership function. The membership function is frequently used in the [0, 1] unit interval range. There are elements in a fuzzy set that are members to varying degrees.

However, there are many types of fuzzy membership functions that have been used in fuzzy logic methods. But the monotonic, triangular, and trapezoidal shapes are the most prevalent. Given that the fuzzy set is a convex function, the triangular or trapezoidal functions are suitable approximations.

The fourth step involves normalization of the normalisation of the aggregated weights computed for each factor using the FAHP model, the matching criteria of the website evaluation will be used to generate the output. The selected parameters provide the basis for deciding website quality through FAHP decision matrix, multi-criteria decision-making approach.

3.4.3 Mathematical Definition

Definition 3.1: A function ω: R $\rightarrow$ [0, 1] is a *fuzzy number* if and only if there exists an x_0 such that $\omega(x_0) = 1$ 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 Trianguar 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 t largest possible values and most promising value explaining any fuzzy events.

a) The hierarchal structure is developed for converting the complex problem in a raw format.

b) 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 3.1.

Table 3.1: 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 *g*th data for the B target was determined in relation to these symbols as given by Equation 3.1.

$$\begin{bmatrix} (1,1,1) & A_{21}B_{21}C_{21} & \cdots & A_{1n}B_{1n}C_{1n} \\ A_{21}B_{21}C_{21} & (1,1,1) & \cdots & A_{2n}B_{2n}C_{2n} \\ A_{n1}B_{n1}C_{n1} & A_{n2}B_{n2}C_{n2} & & (1,1,1) \end{bmatrix} \quad 3.1$$

All of $(h: 1, 2, 3, \ldots, b)$ b_{kg}^{h} were fuzzy triangular members. Again, $Y = (y_1, y_2, \ldots, y_n)$ was the set of decision, and $Q = (q_1, q_2, \ldots, q_n)$ is the target matrix. The fuzzy membership triangular representation is represented in Equation 3.2.

$$b_{k1}^{h}, b_{k2}^{h}, \ldots, b_{kn}^{h}, g = 1, 2, \ldots, n. \quad 3.2$$

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 Equation 3.3.

$$\sum_{g=1}^{n} b_{kg}^{k} = \left\{ \sum_{k=1}^{h} A_k, \sum_{k=1}^{h} B_k, \sum_{k=1}^{h} C_k \right\} \quad 3.4$$

For each 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 3.5.

$$\sum_{k=1}^{n} \sum_{g=1}^{n} b_{kg}^{k} = \left\{ \sum_{a=1}^{n} A_k, \sum_{a=1}^{n} B_k, \sum_{a=1}^{n} C_k \right\} \quad 3.5$$

The corresponding inverse vector can be expressed by Equation 3.6.

$$\left[\sum_{k=1}^{n} \sum_{g=1}^{h} b_{kg}^{k} \right]^{-1} = \left\{ \frac{1}{\sum_{g=1}^{n} A_k}, \frac{1}{\sum_{g=1}^{n} B_k}, \frac{1}{\sum_{g=1}^{n} C_k} \right\} \quad 3.6$$

The synthetic extent value, E_g, for each criterion can be computed by Equation 3.7.

$$E_g = \sum_{a=1}^{h} b_{kg}^{k} \cdot \left[\sum_{k=1}^{n} \sum_{g=1}^{h} b_{kg}^{k} \right]^{-1} \quad 3.7$$

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 3.8.

$$U(b_1 \geq b_2) = \sup_{x \geq y} [\min(\omega_{b_1}(x), \omega_{b_2}(y))] \quad 3.8$$

3.5 Data Collection

Target population of 50 customers who have bank accounts linked to the e-banking platform (that is, website) in Minna, Niger State. A non-random sampling method was used to gather the data because the Personal Information Protection Act, which forbids financial institutions from disclosing personal information about customers, made it difficult to obtain the sampling frame. The survey's participants agreed to participate voluntarily. In the end, 33 respondents in total were chosen through a physical contact interview and questionnaire distributed to chosen bank staff and customers, which is similar to the comparable studies.

3.5.1 Instrument Construction

The study constructed structured questionnaire utilised for collecting the required data, which is 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 3, which are adapted from comparable studies presented in Table 3.2.

Table 3.2: The e-banking website quality evaluation measurement scale.

Criteria	Sub-criteria	Website quality scale (1 – 9)
Ease of use	*Website design*	
	1. Search tool of bank website.	
	2. Well categorizing website.	
	3. Quick process.	
	4. Website interface.	
	5. Website mental effort.	
	Convenience	
	1. Looks attractive.	
	2. Looks organized.	
	3. Easy to read.	
	4. Use of appropriate colours.	
	5. Uses appropriate multimedia content.	
	Responsiveness	
	1. Functional links.	
	2. Interactive features.	
	3. Easy to access.	
	4. Load quickly.	
	5. Easy to navigate.	
	6. Adequate search system.	
E-loyalty	1. Effectiveness of addressing queries and concerns.	
	2. Availability of services for all round transactions.	
	3. Internet networks connect easily with bank accounts.	
	4. Frequency of using e-banking website.	
	5. Ease of transactions.	
	6. Lower costs of transactions and services.	
	7. Timely and saves times.	

E-satisfaction	*Web performance*
	1. Website performs better than conventional platforms.
	2. Product characteristics.
	3. Technology is appropriate.
	4. Website characteristics.
	Website content
	1. Website content is helpful.
	2. Website content is complete.
	3. Website content is Clear.
	4. Website page has description.
	5. Website is current/up-to-date information.
	6. Website has accurate and truthful information.
E-trust	1. Perceived privacy.
	2. Perceived security.
	3. Trustworthiness of transactions.
Product quality	*Vagueness, uncertainty and ambiguity.*
	1. Corresponding contact information.
	2. General bank information.
	3. Details of products and services of bank.
	4. Customer policy information.
	5. Customer services information.
Alternatives	*Bank type* (Top four by Profit Margin Q4, 2022)
	1. Bank A: First Bank
	2. Bank B: Fidelity Bank
	3. Bank C: Sterling Bank
	4. Bank D: Stanbic IBTC Bank

3.6 Experimental Settings

The proposed model for evaluating the e-banking websites quality was implemented on MATLAB R2019b because of the discrete nature of the research on Personal Computer (PC) with the following specifications:

i. Hardware:

Processor: AMD E1-1200 APU with Radeom^{TM} Graphics 1.40 GHz.

RAM: 4.00 GB

System Type: 64-bit Operating System, x64-based processor.

ii. Software:

Rating: 3.5 Windows Experience Index

Windows Edition: Windows 8 Single Language 2012

Operating System: Windows 8

3.7 Performance Evaluation Metrics

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

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Demographic Characteristics of Respondents

The details and properties who 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. These are analysed in frequency and percent as shown in Tables 4.1 and 4.2. These include personal and social characteristics of respondents.

Table 4.1: Personal characteristics of respondents (Author's Field Work)

Variable	Frequency (n=33)	Percent (%)
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

From Table 4.1, 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. The female respondents were more willing 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.

Table 4.2: Social characteristics of respondents (Author's Field Work)

Variable	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

From Table 4.2, 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 holder 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. This puts more validity on responses offered by respondents on the concept of quality of e-banking websites.

On 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 study.

4.2 Criteria for E-Banking Website Quality

The first research question is to investigate which criterium is most important for e-banking website quality evaluation? The respondents' responses from the survey are presented in Table 4.2.

Table 4.3: The fuzzy pairwise comparison matrix of respondents' responses on main evaluation criteria of in e-banking websites.

Criteria	Ease of use			E-loyalty			E-satisfaction			E-trust			Product quality		
Ease of use	(1.00	1.00	1.00)	(0.89	1.60	2.25)	(0.65	1.07	1.88)	(0.82	1.47	2.76)	(0.80	1.37	3.19)
E-loyalty	(0.44	0.62	1.12)	(1.00	1.00	1.00)	(2.02	3.08	4.64)	(0.80	1.00	1.47)	(1.17	2.36	4.53)
E-satisfaction	(0.53	0.93	0.22)	(0.34	0.50	0.50)	(1.00	1.00	1.00)	(0.68	1.11	1.66)	(0.80	1.00	1.72)
E-trust	(0.36	0.68	1.21)	(0.68	1.00	1.26)	(0.60	0.90	1.47)	(1.00	1.00	1.00)	(0.76	0.93	1.25)
Product quality	(0.31	0.73	1.26)	(0.22	0.42	0.86)	(0.58	1.00	1.26)	(0.80	1.08	1.32)	(1.00	1.00	1.00)

From Table 4.3, the normalized geometric mean was computed using equations and processes described section 3.4.3. The values of criteria normalized weights, consistency ration are presented in Table 4.4.

Table 4.4: The outcomes of FAHP model-based criteria selection.

Criteria	Normalized Weight	Rank	CR
Ease of use	0.2541	2	0.0942
E-loyalty	0.3021	1	-
E-satisfaction	0.1421	5	-
E-trust	0.1569	4	-
Product quality	0.1449	3	-

From Table 4.4, the answer to the research question 1 can be obtained by ranking the normalized weights computed. The top three criteria ranked by respondents as highly influencing the quality of e-banking websites evaluation are e-loyalty (30.21%), ease of use (25.41%), and e-trust (15.69%). The respondents decisions were accepted on the choice of e-loyalty criterium with observed CR (0.0942) < 0.1 as expected for consistency within responses otherwise rejected.

The graphical illustrations of the responses of respondents on the criteria of evaluating quality of e-banking websites is shown in Figure 4.1.

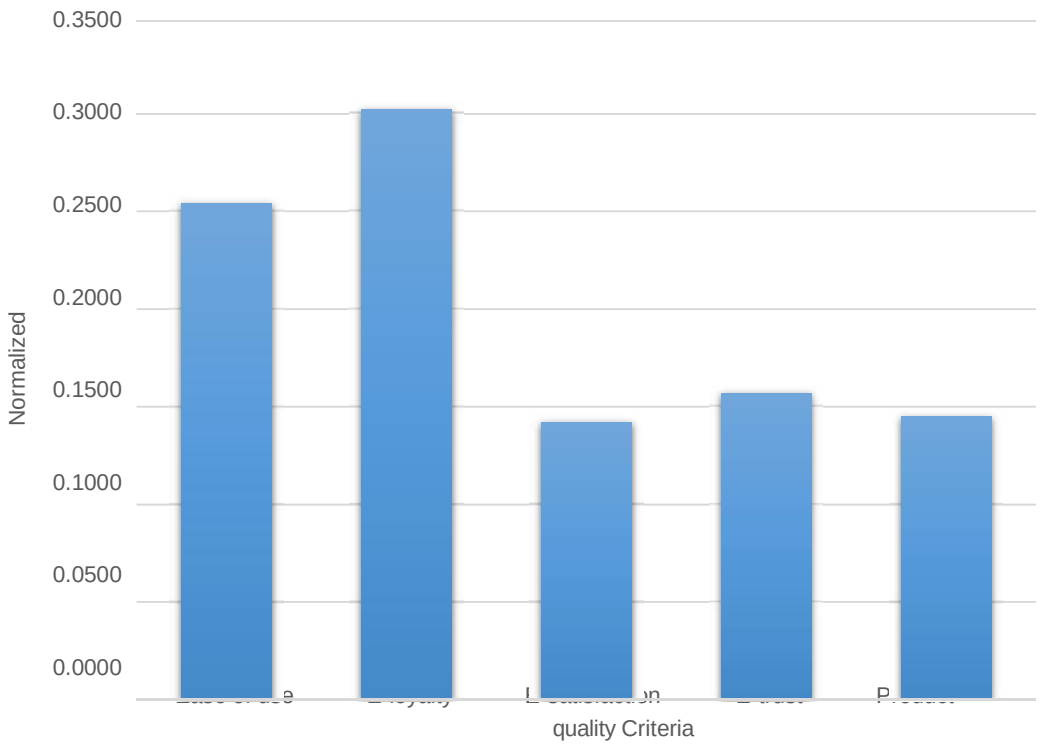

Figure 4.1: Weights of criteria for evaluating quality of e-banking websites by respondents.

4.3 Sub-Criteria of Ease of Use in E-Banking Website Quality

The second research question is to investigate which sub-criterium is most important for ease of use in e-banking website quality evaluation? The respondents' responses from the survey are presented in Table 4.5.

Table 4.5: The fuzzy pairwise comparison matrix of respondents' responses on e-trust in e-banking website evaluation.

Sub-criteria	Website design			Convenience			Responsiveness		
Website design	(1.00	1.00	1.00)	(1.52	2.52	3.52)	(0.44	1.44	2.44)
Convenience	(0.28	0.39	0.66)	(1.00	1.00	1.00)	(0.74	2.63	2.70)
Responsiveness	(0.41	0.69	2.26)	(0.37	0.38	1.36)	(1.00	1.00	1.00)

From Table 4.4, the normalized geometric mean was computed using equations and processes described section 3.4.3. The values of criteria normalized weights, consistency ration are presented in Table 4.6.

Table 4.6: The outcomes of FAHP model-based ease of use sub-criteria selection.

Subcriteria	Normalized Weight	Rank	CR
Website design	0.4689	1	-0.057
Convenience	0.2523	3	-
Responsiveness	0.2788	2	-

From Table 4.6, the answer to the research question 2 can be obtained by ranking the normalized weights computed. The top three criteria ranked on basis of respondents' decision as highly influencing sub-criteria in the quality of e-banking websites evaluation include: website design (46.89%), responsiveness (27.88%), and convenience (25.23%). The respondent's decisions were accepted on the choice of website design sub-criterium

with observed CR (-0.057) < 0.1 as expected for consistency within responses otherwise rejected.

The graphical illustrations of the responses of respondents on the criteria of evaluating quality of e-banking websites is shown in Figure 4.2.

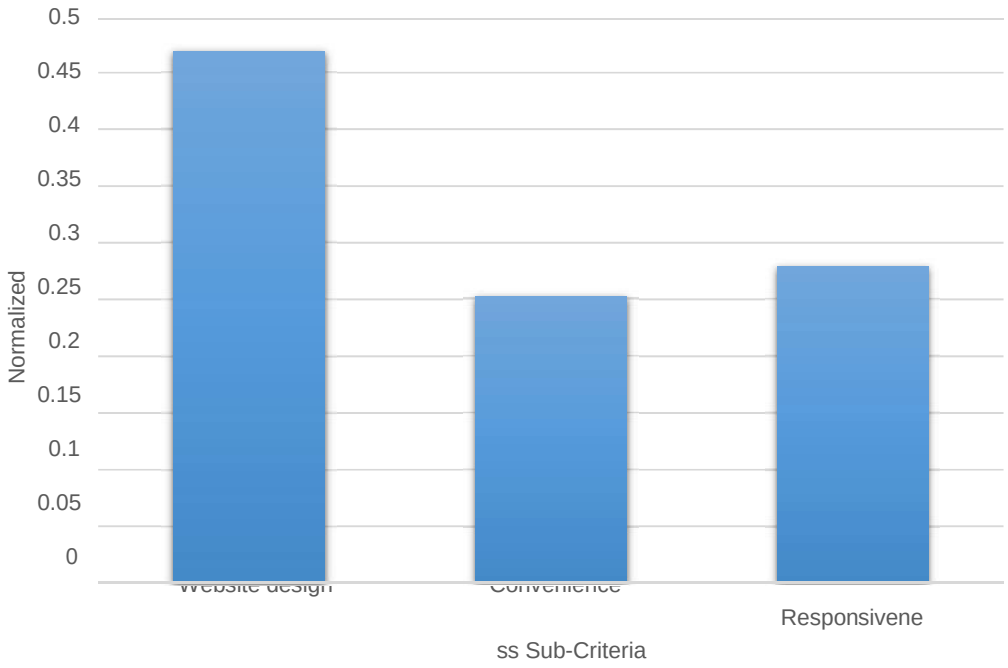

Figure 4.2: Subcriteria weights of ease of use in e-banking websites quality

4.4 Subcriteria of E-Satisfaction in E-Banking Website Quality

The third research question is to investigate which sub-criterium is most important for e-satisfaction in e-banking website quality evaluation? The respondents' responses from the survey are presented in Table 4.7.

Table 4.7: The fuzzy pairwise comparison matrix of respondents' responses on e-satisfaction in e-banking website evaluation.

Subcriteria	Website content			Website product		
Website product	(1.00	1.00	1.00)	(0.31	0.39	0.56)
Website content	(1.80	2.50	3.00)	(1.00	1.00	1.00)

From Table 4.7, the normalized geometric mean was computed using equations and processes described section 3.4.3. The values of criteria normalized weights, consistency ratio are presented in Table 4.8.

Table 4.8: The outcomes of FAHP model-based e-satisfaction sub-criteria selection.

Subcriteria	Normalized Weight	Rank	CR
Website product	0.2862	2	0.000
Web content	0.7138	1	-

From Table 4.8, the answer to the research question 3 can be obtained by ranking the normalized weights computed. The top three criteria ranked on basis of respondents' decision as highly influencing sub-criteria in the quality of e-banking websites evaluation include: website content (71.38%), and web product (28.62%). The respondent's decisions were accepted on the choice of website design sub-criterium with observed CR (0.000) < 0.1 as expected for consistency within responses otherwise rejected. The graphical representations of the respondent's decisions are illustrated in Figure 4.3.

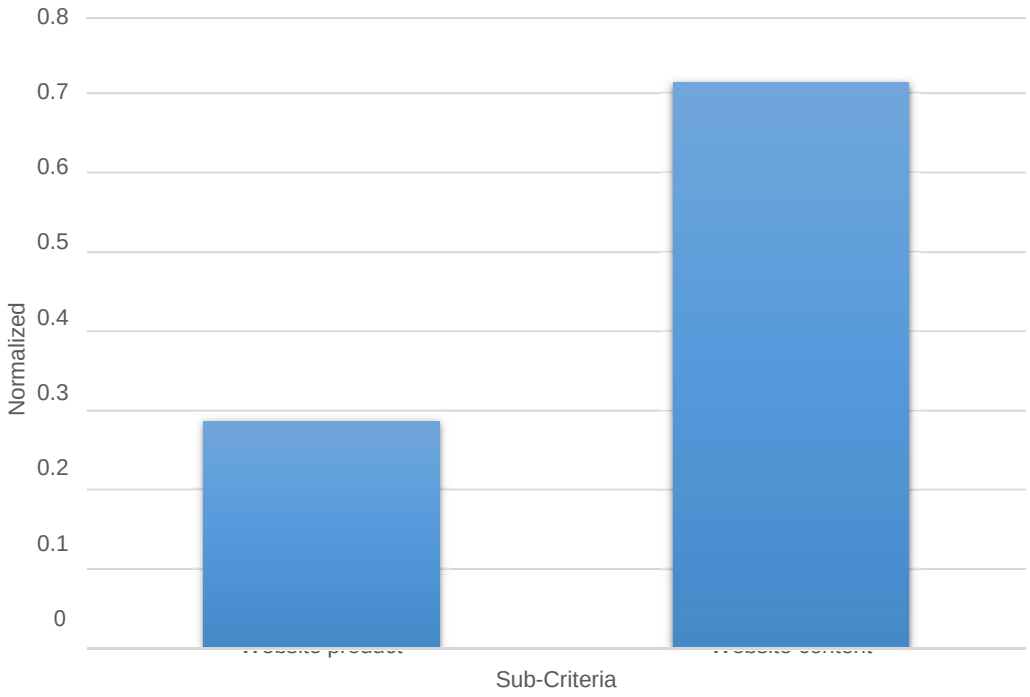

Figure 4.3: Sub-criteria weights of e-satisfaction in e-banking websites quality

4.5 Subcriteria of E-Trust in E-Banking Website Quality

The fourth research question is to investigate which sub-criterium is most important for e-trsut in e-banking website quality evaluation? The respondents' responses from the survey are presented in Table 4.9.

Table 4.9: The fuzzy pairwise comparison matrix of respondents' responses on e-trust in e-banking website.

Subcriteria	Website perceived privacy			Website perceived security			Trustworthiness of transactions		
Website perceived privacy	(1.00	1.00	1.00)	(2.00	3.00	4.00)	(4.00	5.00	6.00)
Website perceived security	(0.25	0.33	0.50)	(1.00	1.00	1.00)	(1.00	2.00	3.00)
Trustworthiness of transactions	(0.17	0.20	0.25)	(0.33	0.50	1.00)	(1.00	1.00	1.00)

From Table 4.9, the normalized geometric mean was computed using equations and processes described section 3.4.3. The values of criteria normalized weights consistency ratio is presented in Table 4.10.

Table 4.10: The outcomes of FAHP model-based e-trust sub-criteria selection.

Sub-criteria	Normalized Weight	Rank	CR
Vagueness	0.5608	1	-0,1619
Uncertainty	0.2638	2	-
Ambiguity	0.1754	3	-

From Table 4.10, the answer to the research question 4 can be obtained by ranking the normalized weights computed. The top three criteria ranked on basis of respondents' decision as highly influencing sub-criteria in the quality of e-banking websites evaluation include: vagueness (56.08%), uncertainty (26.38%), and ambiguity (17.54%). The respondent's decisions were accepted on the choice of website design sub-criterium with observed CR (-0.1619) < 0.1 as expected for consistency within responses or rejected. The graphical representations of the respondent's decisions are illustrated in Figure 4.4.

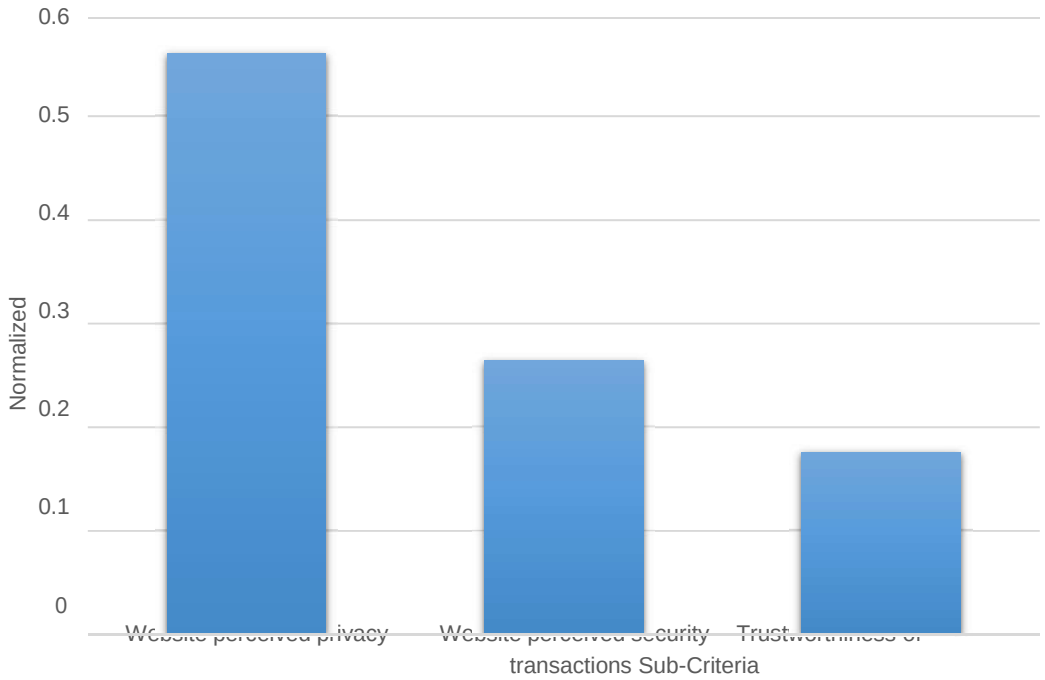

Figure 4.4: Criteria weights on e-trust in e-banking websites quality

4.6 Subcriteria of Product Quality in E-Banking Website Quality

The fifth research question is to investigate which sub-criterium is most important for product quality in e-banking website quality evaluation? The respondents' responses from the survey are presented in Table 4.11.

Table 4.11: The fuzzy pairwise comparisons matrix of respondents' responses on product quality in e-banking websites.

Sub-criteria	Website perceived privacy			Website perceived security			Trustworthiness of transactions		
Website perceived privacy	(1.00	1.00	1.00)	(0.66	1.16	1.69)	(1.15	1.44	1.70)
Website perceived security	(0.59	0.86	1.52)	(1.00	1.00	1.00)	(1.19	1.58	2.15)
Trustworthiness of transactions	(0.59	0.69	0.87)	(0.47	0.63	0.84)	(1.00	1.00	1.00)

From Table 4.11, the normalized geometric mean was computed using equations and processes described section 3.4.3. The values of criteria normalized weights, consistency ration are presented in Table 4.12.

Table 4.12: The outcomes of FAHP model-based product quality sub-criteria selection.

Sub-ccriteria	Normalized Weight	Rank	CR
Website perceived privacy	0.3776	2	0.0440
Website perceived security	0.3810	1	-
Trustworthiness of transactions	0.2414	3	-

From Table 4.12, the answer to the research question 5 can be obtained by ranking the normalized weights computed. The top three criteria selected on basis of respondents' decision as highly influencing sub-criteria in the quality of e-banking websites evaluation include: website perceived security (38.10%), website perceived privacy (37.76%), and trustworthiness of transaction (24.14%). The respondent's decisions were accepted on the choice of website design sub-criterium with observed CR (0.0440) < 0.1 as expected for consistency within responses. The graphical representations of the respondent's decisions are illustrated in Figure 4.5.

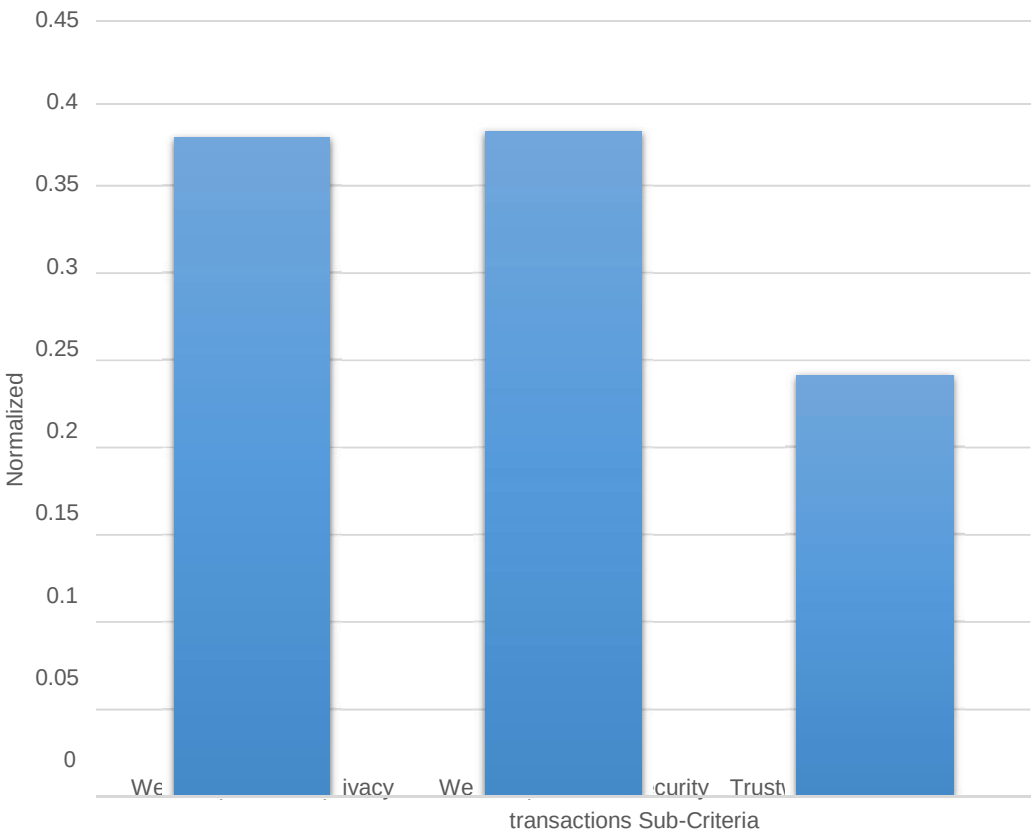

Figure 4.5: Criteria weights on product quality in e-banking websites quality

4.7 Choice of Bank by E-Banking Website Quality Attributes

The sixth research question is to investigate which bank of the top four by margin has the most e-banking website quality? The respondents' responses from the survey are presented in Table 4.13.

Table 4.13: The fuzzy pairwise comparison matrix of respondents' choice of best bank with e-banking website quality.

Sub-criteria	Bank A			Bank B			Bank C			Bank D		
Bank A	(1.00	1.00	1.00)	(0.66	1.16	1.69)	(1.15	1.44	1.70)	(1	1	1)
Bank B	(0.59	0.86	1.52)	(1.00	1.00	1.00)	(1.19	1.58	2.15)	(1	1	1)
Bank C	(0.59	0.69	0.87)	(0.47	0.63	0.84)	(1.00	1.00	1.00)	(1	1	1)
Bank D	(0.59	0.69	0.87)	(0.47	0.63	0.84)	(1.00	1.00	1.00)	(1	1	1)

From Table 4.13, the normalized geometric mean was computed using equations and processes described section 3.4.3. The values of criteria normalized weights, consistency ration are presented in Table 4.14.

Table 4.14: The outcomes of FAHP model-based bank selection using the determined website quality criteria.

Bank	Normalized Weight	Rank	CR
Bank A	0.5298	1	0.0963
Bank B	0.1831	2	-
Bank C	0.1791	3	-
Bank D	0.1079	4	

From Table 4.14, the answer to the research question 6 can be obtained by ranking the normalized weights computed. The top three banks ranked by respondents' decision based on criteria/sub-criteria of e-banking websites quality evaluation include: Bank A (52.98%), Bank B (18.31%), Bank C (17.91%), and and Bank D (10.79%). The respondent's decisions were accepted on the rank of banks with observed CR (0.0963) < 0.1 as expected for consistency within responses it is otherwise rejected. The graphical representations of the respondent's decisions are illustrated in Figure 4.5.

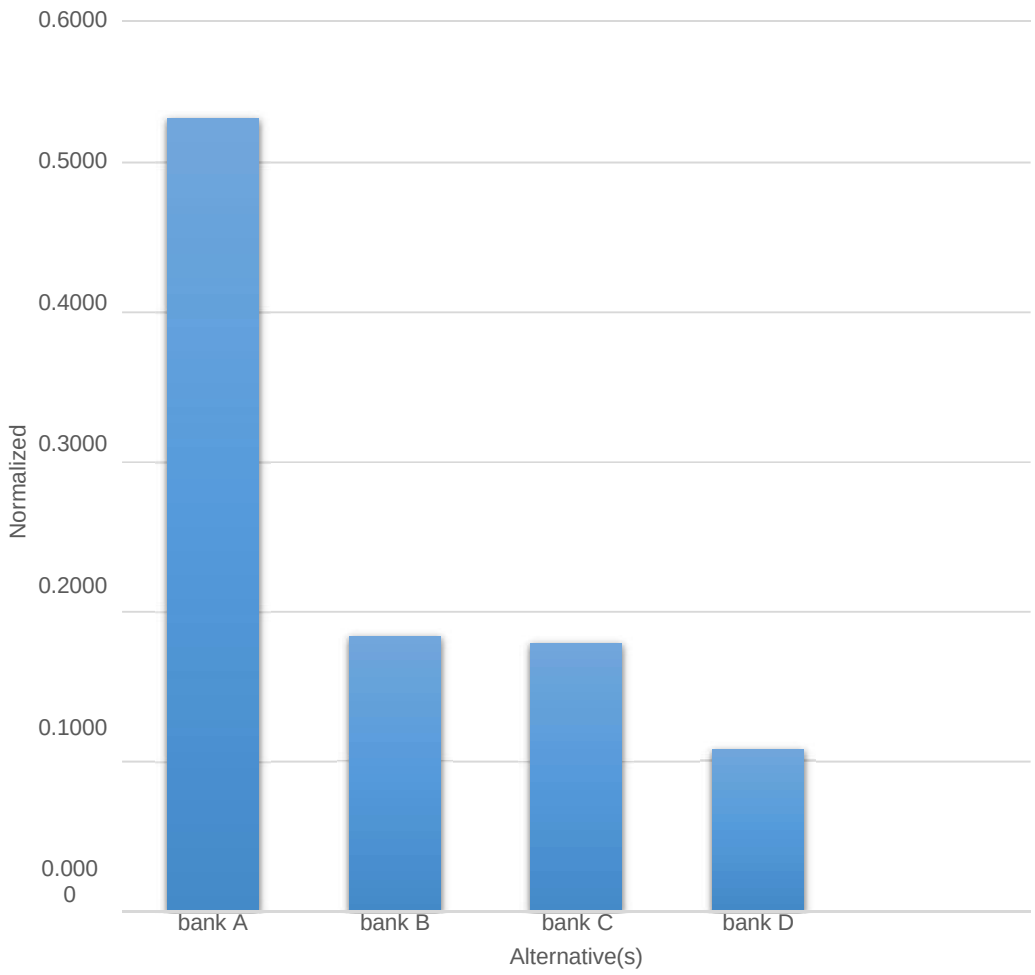

Figure 4.5: The choice of bank using e-banking website quality evaluation criteria.

4.8 Performance Evaluation

The results obtained using traditional AHP methodology and those from FAHP are contrasted in the work to ascertain the validity of the FAHP methodology. The Wilcoxon Signed Rank Test, used in the study by Alzarrad et al. (2019), is used to accomplish this. Examining the median difference between the outcomes at two levels (local weights of the criteria and final aggregated weights for the alternatives) is the goal of this process. First off, Tables 4.15 and 4.16 show the results of the AHP model using the AHP algorithm,

which makes use of crisp values (or fuzzy values in the case of FAHP). In Tables 4.15 and 4.16, the results of the two models, FAHP and AHP, are displayed.

Table 4.15: Wilcoxon Signed Rank Test on FAHP and AHP on criteria weights.

Ranks (FAHP-AHP)				Test Statistics[d] 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.

The visual comparisons of the two models are shown in Figure 4.6. The results' close proximity shows a high level of model validity.

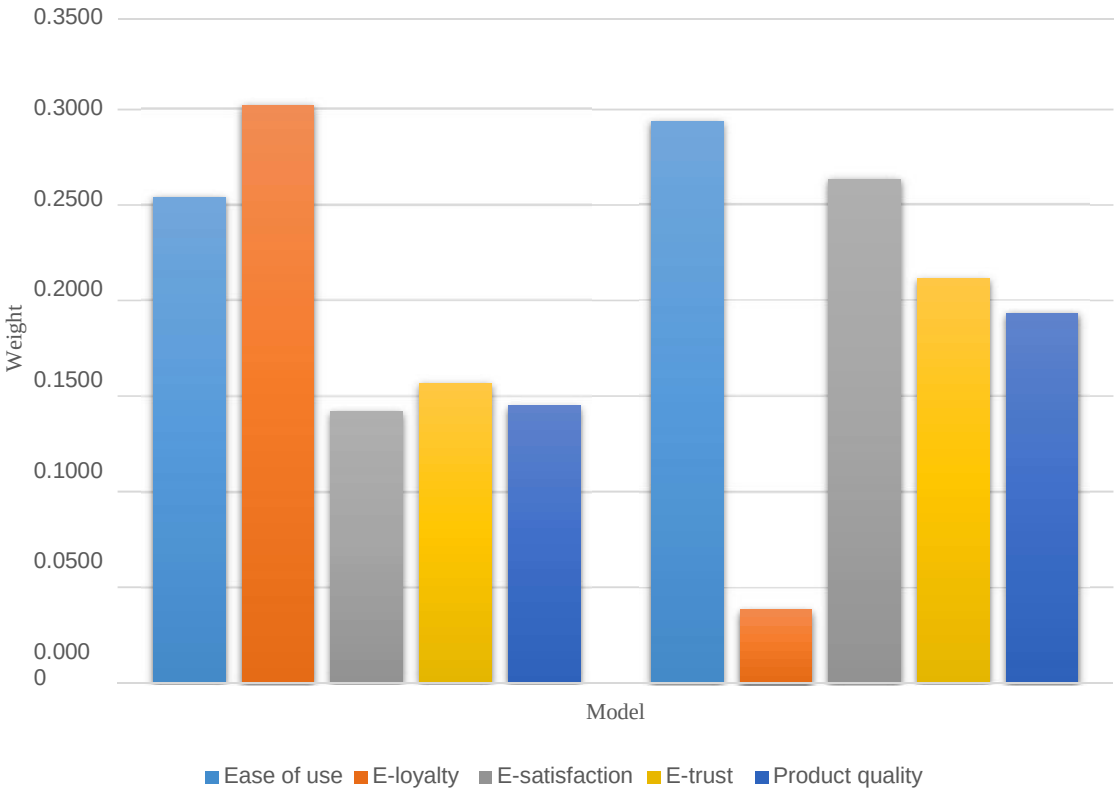

Figure 4.6: The comparative analysis of FAHP and AHP outcomes.

Table 4.16: 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.

Figure 4.7 shows he pictorial comparisons of the two models. The closeness of the results indicates the higher degree of model validity.

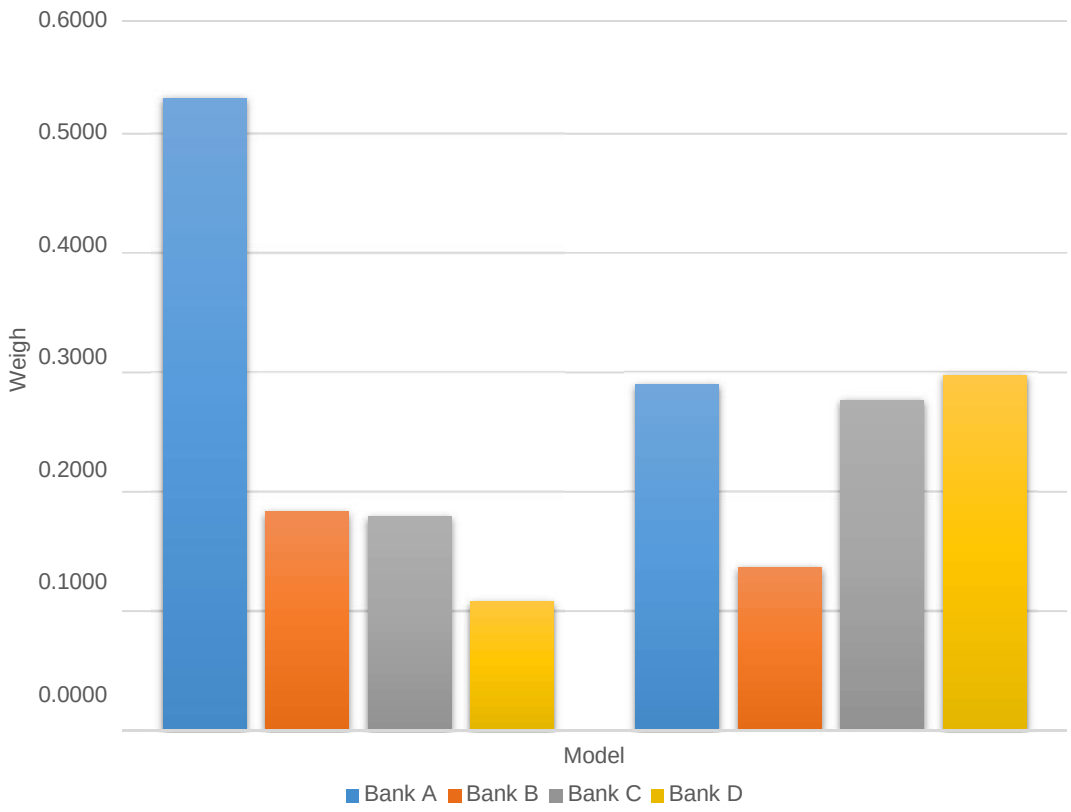

Figure 4.7: The comparative analysis of FAHP and AHP outcomes.

4.9 Discussion of Outcomes

From the respondents 'responses, the overall criteria and sub-criteria for evaluating quality of e-banking websites in Nigeria can be represented diagrammatically using the FAHP model developed by this study. The top three criteria and sub-criteria for determining the quality of e-banking websites and ranking of banks' e-banking websites as realized from the process of FAHP model is shown in Table 4.17.

Table 4.17: Hierarchical structure of the FAHP model-based e-banking evaluation criteria and sub-criteria.

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		

From Table 4.17, the cross influences of all selected criteria for evaluating e-banking website quality put e-satisfaction and product quality as least impactful. While, the e-loyalty, ease of use, and e-trust criteria were ranked three-topmost using the FAHP model developed by this study. The various criteria weights are illustrated in Figure 4.8.

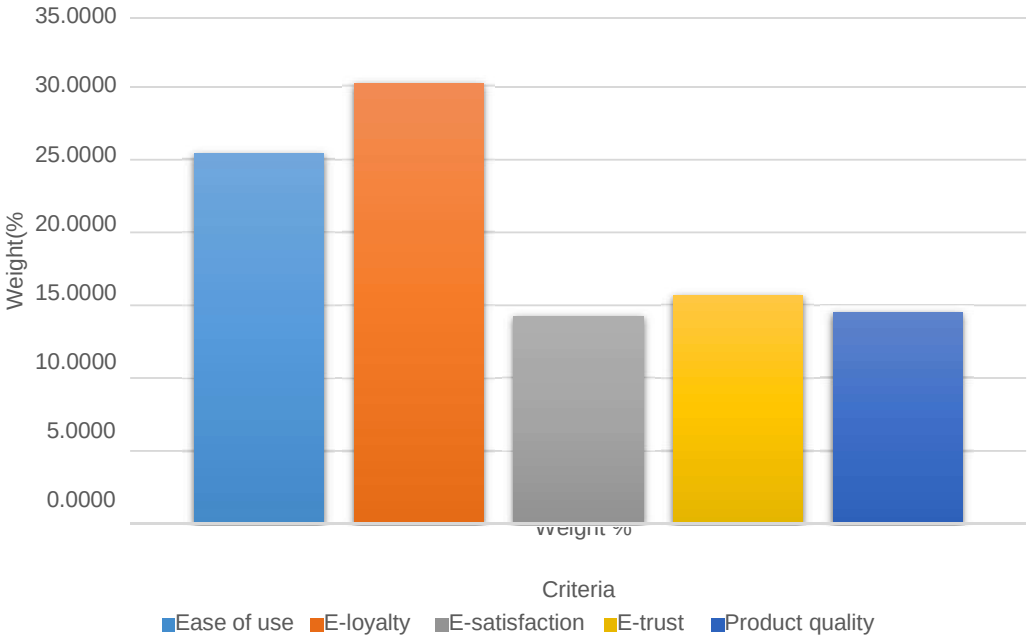

Figure 4.8: Criteria selected using FAHP model for determining e-banking websites quality.

Also, as displayed in Table 4.17, the influence of each subcriteria on the evaluation process of e-banking websites quality revealed that, website content, vagueness, and website design were considered top three subcriteria. Whereas, ambiguity, uncertainty, and trustworthiness of transactions retained in the bottom three subcriteria during evaluation of e-banking websites quality in Nigeria. These outcomes are illustrated in Figure 4.9.

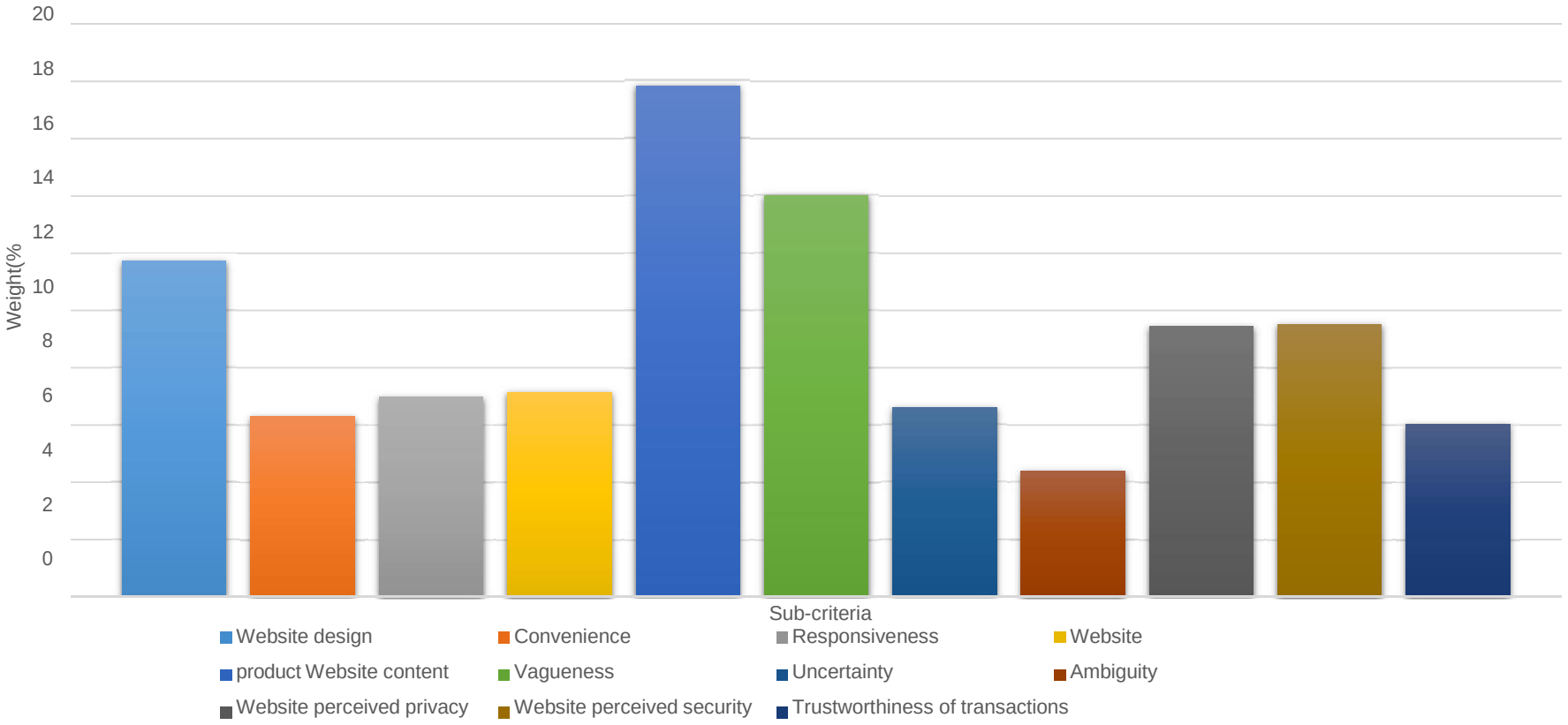

Figure 4.9: Subcriteria FAHP model weights in evaluation of e-banking websites quality.

Lastly, the Table 4.17 shows the ranking of banks'e-banking websites quality using the determined criteria/subcriteria by respondents based on the FAHP model developed. The ranking of banks based on E-banking services was First Bank, followed by Fidelity, then, Sterling Bank, and lastly, Stanbic IBTC as depicted in graphical illustration of the preferred alternatives in Figure 4.9.

This study is in agreement about loyalty towards e-banking products and services as measureable through e-banking service quality (EBSQ) dimensions such as reliability, privacy and security, website design interface, service and support, and trust (Chhaya and Mittal, 2021; Ullah, 2021).

Different criteria of website quality evaluation have been developed over the years from different perspectives such as online banking content, special content quality, appearance quality, technical quality, general content quality (Bacik *et al.*, 2021). The perceptive undertaken is in this work is dissimilar. Tseng *et al.* 2021).

From the findings of this study, the evaluation criteria are required to measure e-banking website quality which account for core features that good quality websites possess as noted by (*Abbasi et al. 2018).* In fact, the website needs to look appealing and be perfectly constructed. Then, a successful website should be a major information source, offer comprehensive details about the goods and services, and enable easy access to information using tools like search engines. Customers also expect the proper levels of service interaction. The website's name ought to be simple to recall. The website should also offer the proper levels of customer service interaction, personalization, and contact ease for the events.

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 as Bank A: First Bank, 2. Bank B: Fidelity Bank, 3. Bank C: Sterling Bank, and 4. Bank D: Stanbic IBTC Bank. The outcomes of the AHP and FAHP models are closely correlated in terms of the weights of criteria and alternatives considered.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study collected data for the purpose of identifying and selecting the relevant criteria and subcriteria required for the e-banking website quality evaluation using primary and secondary sources. The outcomes achieved the objective one. The FAHP model, a MCDM, was identified as capable of improving the decision-making process into somewhat hierarchical structure of criteria and subcriteria, which are used to determine the best combinations for evaluating e-banking websites quality serving as the outcomes of objective two.

Therefore, FAHP model was developed, a MCDM, which is basically a hierarchical structure of criteria and subcriteria used to grade the best combinations of criteria/sub-criteria for evaluating e-banking websites quality. It was found that, of all selected criteria for evaluating e-banking website quality, e-satisfaction and product quality were least ranked by respondents. While, the e-loyalty, ease of use, and e-trust criteria were ranked three-topmost by respondents based on the FAHP model developed by this study.

Particularly on subcriteria, 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. The alternatives (or banks) used for the study were ranked based on FAHP model in terms of e-banking website quality measures selected by respondents. The respondents ranked the alternatives in the order of preference as follows: First Bank, Fidelity Bank,

Sterling Bank, and Stanbic IBTC Bank respectively. These activities and associated outcomes achieved the third objective. The outcomes of the AHP and FAHP models are closely correlated using the weights of criteria and alternatives considered.

5.2 Recommendations

This study makes the following recommendations: Financial institutions are utilizing technology, such as electronic fund transfers, interbank financial telecommunication, the internet, mobile banking, crowdfunding, and cryptocurrencies, to deepen and enhance the financial system. 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.

This study makes the following suggestions for future works:

There is the need to consider more criteria and sub-criteria for the FAHP model 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.

5.3 Contribution to Knowledge

The study has been able to redefine e-banking websites and developed an FAHP model that can be used for ranking the e-banking websites quality.

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APPENDIX

(a) Source codes listing

```
clc
% The index of optimism (It should be given by the user.)
a=0.7; %0.8
% The pairwise matrix
% (It should be composed using fuzzy pairwise comparison scale by the
user.)
load P1.mat;

[S1,W1]=fuzzAHP1(P);
[S2,W2,CR2]=fuzzAHP2(P,a);
% ------------------------------------------------------------------------------------------------------------------------ %
% Returns the Random Index (m)
% "Thomas L. Saaty, Liem T. Tran,
% On the invalidity of fuzzifying numerical judgments
% in the Analytic Hierarchy Process, Mathematical and Computer
Modelling,
% Volume 46, Issues 7-8, 2007, Pages 962-975,
% ISSN 0895-7177, https://doi.org/10.1016/j.mcm.2007.03.022."
% ------------------------------------------------------------------------------------------------------------------------ %
% AUTHORS
%           Demet CILDEN
%           Dogus GULER (gulerdo.dogus@gmail.com)
% lAST UPDATE
%           March 30, 2018
% ------------------------------------------------------------------------------------------------------------------------
--- %
function [m]=RI(n)
if n>=1
    if n==1 || n==2
        m=0;
    elseif n==3
        m=0.52;
    elseif n==4
        m=0.89;
    elseif n==5
        m=1.11;
    elseif n==6
        m=1.25;
    elseif n==7
        m=1.35;
    elseif n==8
        m=1.40;
    elseif n==9
        m=1.45;
    elseif n>=10
        m=1.49;
    end
else
    warning('The number n should be larger than or equal to 1!')
end
end


% ------------------------------------------------------------------------------------------------------------------------ %
% This function is built in order to
% find the weights of the criteria
```

```
% according to "Tian-Shy Liou, Mao-Jiun J. Wang, Ranking fuzzy numbers
with
% integral value, Fuzzy Sets and Systems, Volume 50, Issue 3, 1992,
% Pages 247-255, ISSN 0165-0114,
% https://doi.org/10.1016/0165-0114(92)90223-Q."
% ---------------------------------------------------------------------- %
% INPUTS
%           P: Pairwise Matrix
%           a: The index of optimism
% OUTPUTS
%           S: The value of fuzzy synthetic extent
%           W: Weights
%           CR: Consistency Ratio
% ---------------------------------------------------------------------- %
% AUTHORS
%           Demet CILDEN
%           Dogus GULER (gulerdo.dogus@gmail.com)
% lAST UPDATE
%           March 30, 2018
% ---------------------------------------------------------------------- %
function [S,W,CR]=fuzzAHP2(P,a)
nn=size(P); n=nn(1);
B=zeros(n,3); C=B; t=0;
[m]=RI(n); % Random Index
for i=1:n
    k=1;
    for j=1:n
        B(i,1)=B(i,1)+P(i,k);
        B(i,2)=B(i,2)+P(i,k+1);
        B(i,3)=B(i,3)+P(i,k+2);
        C(i,1)=C(i,1)+sum(P(:,k+2));
        C(i,2)=C(i,2)+sum(P(:,k+1));
        C(i,3)=C(i,3)+sum(P(:,k));
        M(i,j)=(P(i,k)+4*P(i,k+1)+P(i,k+2))/6;
        k=k+3; t=t+1;
    end
end
C=1./C; S=B.*C;
k=1;
% Weights
for i=1:n
    W1(i)=0.5*(a*S(i,3)+S(i,2)+(1-a)*S(i,1));
end
W=W1'./sum(W1);
A1=M*W;
lambda=mean((A1./W));
CI=(lambda-n)/(n-1);
CR=CI/m;
if CR<0.1
    fprintf('The consistency ratio is acceptable. (Wangs approach)\n')
else
    warning('The consistency ratio is not acceptable! (Wangs
approach)')
end
end
```

(b) Sample dataset

Aggregated fuzzy AHP comparison tables

Q1

	Ease of use	E-loyalty	E-satisfaction	E-trust	Product quality
Ease of use	(1,1,1)	(8/9,1 3/5, 2 1/4)	(2/3,1,1 7/8)	(5/6,1 1/2, 2 3/4))	(4/5, 1 3/8,3 1/5)
E-loyalty	(4/9,5/8,1 1/8))	(1,1,1)	(2,3,4 2/3)	(1, 1 1/2, 1 1/2)	1 1/6,2 1/3, 4 1/2)
E-satisfaction	(1/2,1,2/9)	(1/3,1/2,1/2)	(1,1,1)	(2/3,1 1/9, 1 2/3)	(4/5,1,1 5/7)
E-trust	(1/3,2/3,1 1/5)	(2/3,1,1 1/4)	(3/5,8/9,1 1/2)	(1,1,1)	(3/4,1,1 1/4)
Product quality	(1/3, 3/4,1 1/4)	(2/9,3/7,6/7)	(4/7, 1, 1 1/4)	(4/5, 1, 1 1/3)	(1,1,1)

Q2

	Website design	Convenience	Responsiveness
Website design	(1,1,1)	(1 1/2, 2 1/2, 3 1/2)	(4/9,1 4/9, 2 4/9)
Convenience	(2/7,2/5,2/3)	(1,1,1)	(3/4, 2 5/8, 2 5/7)
Responsiveness	(2/5,2/3.2 1/4)	(3/8,3/8,1 1/3))	(1,1,1)

Q3

Criteria	Website product	Website content
Website product	(1,1,1)	(1,3,2/5,5/9)
Website content	(1 4/5, 2 1/2, 3)	(1,1,1)

Q4

	Website perceived privacy	Website perceived security	Trustworthiness of transactions
Website perceived privacy	(1,1,1)	(2,3,4)	(4,5,6)
Website perceived security	(1/4,1/3,1/2)	(1,1,1)	(1,2,3)
Trustworthiness of transactions	(1/6,1/5,1/4)	(1/3,1/2,1)	(1,1,1)

Q5

	Website perceived privacy	Website perceived security	Trustworthiness of transactions
Website perceived privacy	(1,1,1)	(2/3, 1 1/6, 1 2/3)	(1 1/7, 1 4/9, 1 2/3)
Website perceived security	(3/5,6/7, 1 1/2)	(1,1,1)	(1 1/5,1 4/7, 2 1/7)
Trustworthiness of transactions	(3/5,2/3,7/8)	(1/2,5/8,5/6)	(1,1,1)

Q6

	bank A	bank B	bank C	bank D
bank A	(1,1,1)	(2 1/2, 3 1/2, 4 1/2)	(1 1/2, 2 1/2, 3 1/2)	(4 1/2, 5 1/2, 6 1/2)
bank B	(2/9,2/7,2/5)	(1,1,1)	(1, 1 1/2, 2)	(1, 1 1/2,2)
bank C	(2/7,2/5,3/4)	(2/3, 3/4, 1)	(1,1,1)	(1 1/2, 2, 2 1/2)
bank D	(1/7,1/6,2/9)	(2/3, 3/4, 1)	(5/8,2/3,3/4)	(1,1,1)