Artificial Intelligence Application and Financial Inclusion Nexus on Sustainable Development Goals (SDGs) in Nigeria

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Abstract

This study evaluated Artificial Intelligence Applications and Financial Inclusion Nexus in Nigeria. Financial institutions have always had the problem of meeting the financial needs of the low-income group in society, though, they have done their best to meet their needs, their effort have not yielded good results. Getting individuals and businesses into the formal financial net has been a problem. The present SDGs as constituted rest more on inclusiveness, especially financial inclusion. The SDGs comprise an ambitious 17 goals. While the Sustainable Development Goals (SDGs) do not explicitly address financial inclusion, increased access to financial services is a crucial facilitator for achieving many goals. The financial institutions and products are not suited for the low-income group in society, in addition, rural dwellers do not have access to financial institutions and products. The study used survey instruments and interviews for data collection. That is. using the mixed research method with data from three hundred and eighty-four respondents selected from rural communities, financial institutions, and universities in South-West Nigeria. The data were analysed using descriptive statistics, confirmatory factor analysis, regression analysis, structural equation model (SEM), and narrative technique. The results indicate that AI applications have significantly impacted financial inclusion in South-West Nigeria. Based on this, the study recommended that financial institutions invest in building AI-enabled platforms in local languages that will respond to customers' needs.

Keywords: *Artificial Intelligence, Financial Institutions, Financial Inclusion, Sdgs, Nigeria.*

Introduction

Developing countries exhibit the highest concentration of unbanked or underbanked individuals. Moreover, most of the unbanked population comprises impoverished individuals (Adeleke & Alabede, 2021). A British research firm Merchant Machine survey identified the top six countries with the largest percentage of unbanked citizens as Vietnam, the Philippines, Morocco, Egypt, Mexico, and Nigeria.

Regarding regional demographics, it is reported that 50 per cent of the population in Africa and the Middle East is unbanked. This is closely followed by South and Central America, Eastern Europe, and the Asia Pacific, which has unbanked populations of 38 per cent, 33 per cent, and 24 per cent, respectively (Ventura, 2022). Furthermore, Kshetri (2021) highlights that approximately 200 million small and medium enterprises (SMEs) in developing countries are financially excluded. In developing nations, like Nigeria, the financial sectors are frequently characterised as risky, underdeveloped, predominantly urban, and not conducive to supporting

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disadvantaged groups, particularly young women (Aterido, Beck, & Iacovone, 2013).

The banking sector has made explicit efforts to examine the under/unbanked consumer segments, though success has been limited (Kama & Adigun, 2013). It is assumed that a significant portion of the economy remains untapped, underdeveloped, and less productive (Makina, 2017). Bayero (2015) suggests that the unbanked population, primarily low-income customers, is at risk of financial exclusion. Being financially excluded equates to experiencing economic difficulties (Menyelim et al., 2021). Financial exclusion perpetuates poverty and strengthens its grip on individuals (Central Bank of Nigeria, 2018). These concerns have contributed to the global rise and prioritisation of financial inclusion (Chidozie et al., 2024). Financial inclusion can be defined in various ways. According to the World Bank (2017), financial inclusion is "a state in which all people have access to financial services offered by formal institutions and may use at least one formal account to conduct financial transactions at a reasonable cost." Broadly defined by Chen and Yuan (2021), financial inclusion is "the availability and equality of opportunities for individuals and enterprises, particularly low-income people and micro and small businesses, to access a range of appropriate financial services, such as savings, credit, payment, and risk management products" (Chen & Yuan, 2021).

Recently, the academic community has taken a keen interest in financial inclusion, with scholarly works highlighting its potential to enhance economic growth (Nkwede, 2015) and promote financial prosperity among the general population. Despite its crucial role in the development of any economy, achieving a commendable level of financial inclusion remains a global challenge (Ene, Abba, & Fatokun, 2019)

The study therefore, seek to provide answers to the research question on the impact of AI-enabled customer service on financial inclusion in South-West Nigeria? Based on this the main objective of this study is to examine the relationship between AI applications and financial inclusion in Nigeria, especially in the rural areas in the South-West of the country. .

Literature Review

The Concept of Financial Inclusion

Financial inclusion is another pivotal concept of the study. Initially, one of the major topics of discussion in the early 21st century has been financial inclusion, which has also emerged as a tool to achieve more equitable economic growth. The United Nations (UN) has incorporated it into its primary goals, specifically the Sustainable Development Goals (SDGs), aimed at enhancing global welfare based on human rights and equality (Bayero, 2015). Likewise, it has become a key objective for Central Banks in many developing countries.

The Sustainable Development Goals (SDGs) consist of a set of 17 ambitious goals that aim to address a wide range of global challenges (Runsewe, 2018; & Atkinson, 2014). While the SDGs do not specifically focus on financial inclusion, it is widely recognized that expanding access to financial services plays a crucial role in supporting the achievement of many of these goals. Greater financial inclusion can contribute to reducing poverty, promoting economic growth, improving access to education and healthcare, and empowering individuals and communities around the world. Also, a staggering amount of people across the world, especially the developing countries, are unable to access financial services that can enhance their living conditions. As revealed by the World Bank, about 50 per cent of the total population of adults in the world, with more than 70 per cent of them resident in developing and underdeveloped

countries, are unable to access established financial institutions (Ventura, 2021).

In comparison, data from Nigeria indicates that out of 84.7 million adults, 39.2 million—or 46.3 percent—are not eligible for financial services (Central Bank of Nigeria, 2011). This highlights the extent of financial exclusion in the nation. Therefore, advocating for increased financial inclusion as a strategic approach to mitigating poverty and other social issues globally; connecting rural residents with formal financial institutions; and enhancing public perception of these institutions as legitimate. As a critical issue and a major objective for developing countries, it has been extensively featured in academic studies, with scholars discussing its implications (Menyelim et al., 2021). At this juncture, various definitions and perspectives on financial inclusion are examined to guide the direction of this study.

Financial inclusion is conceptually a process that enables unbanked and vulnerable people to access financial services, including credit facilities, without restriction and for the least amount of money possible. According to Singh (2017), financial inclusion comprises unrestricted access to banking services, digital payment methods, financial literacy programs, insurance plans including health and crop insurance for people and farmers, and access to credit facilities, particularly at the micro level. In their discussion of the advantages and myriad chances provided by financial inclusion, contend that options   allow people to invest, save for the future, and borrow money from banks. Financial inclusion enables people who are not digitally savvy to make cash payments for products and services purchased. That is, without digital knowledge, they are still able to connect to a digital payment system and transfer cash without any inhibition and at an affordable rate for friends, family and other associates. Financial inclusion allows access to basic financial products and services such as bank accounts, saving products, financial advisory and education services, payment services, insurance, and the use of banking tools – online banking. Babajide, Adegboye and Omankhanlen (2015) posited that an essential feature of financial development which fosters improvement in the quantity, quality and efficiency of services that deal in financial intermediaries; and helps to garner savings from local people used to increase investments in businesses in local areas. Financial inclusion refers to the effective provision of financial goods and services to the underprivileged in society at reasonable pricing. Most low-income individuals in society are either unbanked or underbanked (FINCA, 2020). Financial inclusion, its involves providing financial services including financial counselling, credit facilities, and savings at costs that are affordable to low-income members of society.

The Concept of Digital Financial Inclusion

Digital financial inclusion is based on technology access, where non-financial organizations like telecommunications companies provide financial services, as opposed to traditional financial inclusion, which depends on the strategy of accessing monetary transactions, financial products, and services through banks and other financial firms (Mhlanga, 2020). The majority of people who were previously denied access to basic financial services are now empowered with digital financial inclusion thanks to the arrival of fintech innovations (Dauda, et al, 2023). According to Geng and He (2020), the foundation of digital financial inclusion is technology like the Internet, big data, and cloud computing, which eliminates geographical constraints and expansion costs. So, even amid the pandemic, small enterprises and people can receive efficient and affordable financing. Digital financial inclusion improves and broadens business cooperation, which in turn boosts the need for employment by making financing simpler and more affordable to effectively help underserved groups (Geng & He, 2021).

Artificial Intelligence

Artificial intelligence is an offshoot of intelligence which was originally within the domain of humans only. Intelligence serves as the basis for the clear distinction between artificial intelligence and human intelligence. The term "Intelligence" has been clearly defined and explained in the literature. It means the innate ability of humans to acquire pertinent skills and knowledge and apply them to solve human problems, both present and emerging problems in individuals' personal lives and the society at large (Finn, et al., 2016). Intelligence also borders on the use of the mental ability to think, learn and solve problems (Devin, Gupta, Darrell, Abbeel & Levine, 2017).

However, intelligence relies on other human senses to collect information from the outside world and an organised way of keeping the knowledge obtained from the information. Position-wise, intelligence is an integral part of the cognitive functions of humans which include memory, planning, language and so on. It is broadly divided into Human Intelligence and Artificial Intelligence. While human intelligence deals with problem-solving, reasoning and learning; artificial intelligence can copy human intelligence, executing tasks that need learning, thinking, problem and decision-making. In mainstream psychology, it is confirmed that human intelligence comprises several components which include learning, reasoning, problem-solving, perception, and language comprehension. Intelligence can align its behavior with new situations emerging around it (Osimen, et al, 2024). However, some researchers think that human intelligence has to do with only the computational strength needed to realize human objectives in the world. This includes problem-solving, quick thinking, rational thinking, taking purposeful actions, and bonding effectively with the immediate environment. With the distinction between human and artificial intelligence made, this study focuses, henceforth, on the concept of artificial intelligence, streaming together various perceptions and definitions of the concept to shed light on what it connotes, its capabilities and implications for finance, and other sectors of the economy.

stated that AI are computer system that can do the work that is routinely done by humans. And they do them with the aid of statistical techniques. elaborated on the capacities of AI that it borders on the science of enabling computers to reason, plan, learn, perceive, communicate and be mobile, moving objects from one point to the other. Like other studies, Shabbir and Anwer (2015) define AI as the ability of computers and machines to execute intellectual functions which are within the domain of human beings. These computers are meant to find solutions to problems and make necessary and accurate inferences and decisions. This position was shared by who maintained that AI has the potential to copy human beings, performing tasks such as thinking, learning, making decisions and drawing inferences. They extended AI to software or any written programme that enables robots, computers and other related to think independently.

Turan, Almalioglu, Konukoglu and Sitti, (2017) asserted that AI has to do with machines and robots which have an in-built capacity to perform tasks in a way similar to humans. According to them, AI has the intellectual strength and attitude of humans; the ability to learn, sense to make decisions and understand emerging situations. Turan, et al. (2017) stress that elements of AI such as robots can reason, decide and solve prevailing problems. To them, robots could make intelligent decisions, learn and give advice to end users of a given products and services.

Conceptual Review of Applications of Artificial Intelligence (AI) in the financial services

Artificial Intelligence (AI) is adopted in all kinds of industries ranging from manufacturing to retail and service provision Belanche, Casaló & Flavián (2019). Financial institutions are building on technologies that have been in use for years through artificial intelligence (AI) applications to improve access even to people who were previously served by formal financial institutions. AI applications in the banking industry today include automation in customer services, personalized customer service experience, enhanced security, sample recognition, and fraud detection.

Artificial Intelligence (AI) enabled   Customer Service

Customer service which has been commonly referred to as customer support, customer experience, customer relations, customer care or customer success is support provided by an organization to guide their customer before, during, and after they buy a product or service. The information technology revolution has afforded companies to choose how they interact with their customers. Customer service is a part of the broader customer retention program in customer relationship management (CRM). CRM is an interaction of processes, strategies and technologies used by companies to manage customers' engagements throughout their lifecycle. CRM has 5 retention programs namely: customer service; frequency and loyalty programs; customization; community building; and reward programs. Investing in effective and efficient customer service is important for any organization because customers have more options. Companies should treat any interactions with customers as a customer service opportunity and it has the potential to create a benefit or otherwise to the company depending on the customer service.

The Concept of Unbanked Population

Data and specific figures that demonstrate how people around the world are viewed as being unbanked are the finest ways to explain the world's unbanked population. According to the World Bank's Global Findex, there are 1.7 billion adults who are unbanked and do not have access to basic financial services. In a sense, these people do not have a reliable place to save their money; they do not have the opportunity to access or obtain small loans from financial institutions and are vulnerable to unscrupulous lenders; they are unable to build a solid credit record that can be used for financial purposes in the future; they have no clear means of receiving money, customer payments and remittances from relatives in diaspora inclusive; and lastly, they do not have access to any safe methods of payments for products and services procured. In other words, they are excluded from financial products and services and reside largely in developing countries.

Empirical Review

The essence is to review previous studies to address a research problem or answer a given research question (Gohavacyf, 2020). In a literature review, a series of research done on a subject is reviewed to provide insight into a subject of consideration (Nakano & Muniz Jr., 2018). It helps to identify possible research gaps (Qureshi, 2019). This section is therefore devoted to empirical reviews of extant studies on the core subject of this study and the review is arranged according to regions – Africa, Asia, Europe and America. In recent years, there have been emerging technologies ranging from the Internet of Things (IoT), big data, cloud computing data science, and blockchain to artificial intelligence (AI). The advancement of these technologies is deemed to provide the basis for the Fourth Industrial Revolution or Industry 4.0 (; Bloem, 2014).

However, AI forms the central force of these technologies and the anticipated Fourth Industrial Revolution. It is imperative to state that the mainstream literature is replete with findings about what artificial intelligence can do to the economy, human activities, advancement in science and technology, and more importantly, finance. Here, existing empirical studies are methodically used to highlight the consequences of AI for financial inclusion, societal challenges including poverty and unemployment, and economic growth. Therefore, this section is divided into three parts: The relationship between financial inclusion and economic growth, factors affecting financial inclusion, and the effects of AI on financial inclusion (Isibor et.al. 2023; Samuel-Hope, Omankhanlen & Osuma 2020).

Determinants of Financial Inclusion

Many scholars have studied the factors determining the level of financial inclusion in Nigeria. Abdu, Buba, Adamu, and Muhammad (2015) show that education, income and gender were significant factors that determine financial inclusion in Nigeria. These scholars found that males and highly educated individuals have a high propensity to own bank accounts. Similarly, reports that rural dwellers are mostly financially excluded due to their level of education which does not expose them to the need and importance of banking

Similarly, Anyanwu et al. (2018) relatively support this finding in their study. They found that men are more financially included than their women counterparts and the reasons given rest on the low income, socio-cultural constraints and low financial literacy. It is evident that of the unemployed population in Nigeria, women make up the larger group. This is based on the socio-cultural constraints that tend to discourage women from wealth accumulation to focus on their gender role of home management and caregiving

Another important factor affecting financial inclusion is geography. Some rural communities in southwest Nigeria have a low level of financial inclusion, according to a study by Oluwatayo (2014). According to the study, rural financial intermediation is costly because rural areas are naturally dispersed geographically, there are few financial transactions, and rural earnings are frequently erratic and unreliable. With the argument that metropolitan centres have a concentration of financial institutions and infrastructures, Lyons et al. (2017) support the priority of urbanization as a factor of financial inclusion. They point out that metropolitan areas frequently provide profits for financial institutions, which prompted the development of financial infrastructure to cater to this rapidly expanding clientele. The study of Anyanwu et al. (2018), which asserts that there are few financial institutions in rural areas, supports this position. Internet connection is also emphasized as a factor in financial inclusion in research and Nwafor and Yomi (2018). This is because it makes transactions easier by linking client accounts to the databases of financial institutions.

Adeleke and Alabede (2021) identify a scarcely discussed determinant of financial inclusion which is identity verification. As a part of the requirement for account opening, traditional banks request means of identification and address confirmations among other requirements. However, rural dwellers do not have these requirements, thus dissuading them from opening accounts (Ibor et al. 2017). With the introduction of the biometric verification number (BVN), rural dwellers can open accounts with some financial institutions to access financial services. The BVN was implemented in Nigeria to ensure customer safety, prevent identity theft, avoiding losses due to the compromise of personal identifying numbers, eliminating fraud, and integrating illiterate people into the banking system.

Impact of AI on Financial Inclusion

Numerous studies, including those by Kshetri (2021), Mhlanga (2021), Ozili (2021), Mhlanga (2020), and Wayne et al. (2020), have highlighted the role of AI in financial inclusion, showing a range of positive impacts. Major benefits of AI adoption in financial inclusion encompass personalized customer services, fraud detection, financial advisory, and improved backend processes. According to Kshetri (2021), fintech companies are leading the adoption of AI applications to address financial exclusion. In this context, financial institutions utilize AI to analyze, evaluate, and refine customer data, thereby determining the creditworthiness of potential borrowers who lack collateral.

Mhlanga (2021) confirms that AI and machine learning significantly impact credit risk assessments by utilizing alternative data sources, such as public data, to address issues of information asymmetry, adverse selection, and moral hazard. This allows lenders to perform comprehensive credit risk analyses on potential borrowers, evaluate customer behavior, and determine their ability to repay loans, thereby enabling disadvantaged individuals to access credit. Additionally, Mhlanga (2020) notes that the financially excluded groups are often considered high risk due to the absence of effective methods to estimate their creditworthiness with available data, thus highlighting the relevance of AI in credit rating.

AI has encouraged banks to implement help desks and customer support, which has a greater influence on improving efficiency and lowering the cost of customer assistance (Mhlanga, 2020). Banks are providing a virtual assistant on the internet **(EVA).** For instance, Leo is a banking chatbot of UBA helping customers to carry out a series of financial transactions such as bill payments, money transfers, airtime purchases, check account balance and other functions. Leo is active and interfaces with customers on social media platforms: WhatsApp, Facebook Messenger, and Apple business chat (Kshetri, 2021). This allows customers to get responses to their complaints, and information on products and services without visiting a physical branch; this level of efficiency cannot be matched by a human agent, yet it is cost-effective. In the end, AI ensures that, over time, responses to unusual inquiries are ready-made as opposed to the existing quo, where advisors must immediately consult experts, chatbots can respond to clients in real-time more quickly than human workers.

Financial institutions using AI applications have been able to achieve customised financial offerings **to** uncover unknown correlations, obscure patterns, market trends, and customer preferences. These have made it possible for innovative products that target the unbanked population and outstanding customer service. The ability to identify fraudulent transactions is a further effect of AI usage (Kshetri, 2021). To detect fraud, AI-powered technology enables computers to mimic, expand upon, and amplify the cognitive processes of a human analyst at a pace and scale that is unmatched by humansThe lower rungs of the financial inclusion pyramid can now participate in the formal financial sector because of AI's capacity to provide this level of security to online finance (Mhlanga, 2020).

In Nigeria, there is a palpable scarcity of studies on the implications of AI for financial inclusion in mainstream journals. identified Nigeria as a major player in the West African market with a population above 200 million. However, its level of financial inclusion is below par and unappealing. These scholars advocated for the use of technologies, AI a prime example, to foster financial inclusion in the country. Similarly, it was predicted that within the next five years, financial technology might overtake agriculture as the country's second-largest economic industry. Lastly, these studies reviewed have shown that AI can deputise human beings in certain

roles, develop new financial products and services and stimulate new ways to deliver financial services to end-users seamlessly. For instance, the use of USSD, *737*Number and other related codes chatbox for online customer services, the use of POS and ATM for payment and withdrawals, automated online banking services, and so on are faint representations of the capabilities of AI in financial services. With these perceptions, it is believed that AI, if harnessed properly, can help the government and other stakeholders in the financial or banking industry to achieve financial inclusion in which everyone, regardless of distance, level of literacy and location, will be able to access financial services.

Theoretical Review

The creation of artificial intelligence is a new form of technological innovation meant to enhance productivity and better the quality of life across the globe. Different schools of thought express **their positions on financial inclusion. In other words, some theories explain financial inclusion from different viewpoints. At this point, some of the extant theories on innovation, which is the base of AI, are:**

- Theory of Dynamic Capabilities by David Teece, Gary Pisano and Amy Shuen (1997)

- Theory of Organizational Learning by Chris Argyris (1967)

- Disruptive Innovation Theory by Clayton Christensen (1995)

- Innovator's Solution Theory by Clayton Christensen (2003)

- Public good theory of financial inclusion by Peterson Ozili (2020)

- Dissatisfaction theory of financial inclusion by Peterson Ozili (2020)

- Vulnerable group theory of financial inclusion by Peterson Ozili (2020)

Methodology

This study adopted pragmatists' research paradigm using a mixed-methods design to generate data for descriptive analysis to produce socially useful knowledge (Morgan, 2014, Maarouf, 2019). Thus, the study involved the collection of both quantitative and qualitative data through a sequential exploratory design, an approach to combining quantitative and qualitative data collection and analysis in a sequence of phases (Maarouf, 2019). Hence, quantitative (survey) and qualitative (In-depth interview) were conducted. Then, the two sets of results were used to draw inferences.

Quantitative Design (survey)

The quantitative method of survey was pertinent in this study to assess the impact of AI-enabled customer service on financial inclusion; examine the effect of AI-enabled credit and savings on financial inclusion as well as investigate the impact of AI-enabled fraud detection on financial inclusion in South-West Nigeria.

Qualitative Design (In-depth Interview)

This study further employed the qualitative method of In-depth interviews to gain adequate information and deeper insight into the moderating effect of the challenges of adopting AI applications on financial inclusion. An in-depth interview is essential as it enables the interviewer to go deeper into the interviewee''s thoughts and emotions. In contrast to a

questionnaire, when the respondents are constrained by answer alternatives or forced to paraphrase his or her opinions, even in an open-ended question, employing this approach gives the interviewee the chance to express themselves freely.

Quantitative Population (Survey)

The quantitative population of this study comprises employees of both international and national licensed banks in Southwest Nigeria. The Southwest states include Lagos, Oyo, Osun, Ekiti, Ogun, and Ondo. The choice of these states is based on the high concentration of banks in this geopolitical zone. This zone also boasts a wide array of financial institutions such as microfinance banks, mortgage banks, development banks, finance houses, discount houses, pension managers, insurance companies, and Bureau de Change, more so than other regions in the country.

International licensed banks include Access Bank, First Bank, First City Monument Bank, Fidelity Bank, Guaranty Trust Bank, Union Bank, United Bank for Africa, and Zenith Bank (Akamo, 2021). National licensed banks consist of Unity Bank, Wema Bank, Eco Bank, Heritage Bank, Citi Bank, Keystone Bank, Polaris Bank, Titan Trust Bank, Sterling Bank, Standard Chartered Bank, and Stanbic IBTC (Akamo, 2021).

International licensed banks are organized by the Central Bank of Nigeria to conduct banking operations within Nigeria as well as maintain offshore banking activities in chosen jurisdictions. Conversely, national licensed banks are exclusively authorized to operate banking businesses across all states within the federation of Nigeria.

Qualitative Population Survey and In-depth Interview

The population for the in-depth interview includes stakeholders of both international and national licenced banks, Fintech firms as well as the Department of Computer Science in Universities of Southwest Nigeria. This methodology allowed the researcher to elicit information from experts in the fields of Finance, Banking and Information Technology to explain how best AI Applications can help to achieve financial inclusion among rural dwellers and draw out possible challenges of AI applications in rural areas.

Quantitative Sample Size (Survey)

Considering the geographical composition of the survey population, the researcher selected a total of 360 respondents from the six states of Lagos, Ogun, Oyo, Ondo, Ekiti, and Osun. The selection of 360 respondents as the sample size follows guidelines for choosing a sample size for multivariate studies. The authors have suggested that a sample size of "50 is very poor; 100 is poor; 200 is fair; 300 is good; 500 is very good; and 1000 is excellent." The questionnaires were distributed among 360 randomly selected midlevel employees of both international and national licensed banks in the Southwest states.

Qualitative Sample Size (In-depth Interview)

In-depth interviews formed the second qualitative part of this study. It was conducted with senior management employees of selected international and national licensed banks, senior management employees of Fintech firms in Nigeria and Head of Departments of computer science departments of selected Universities. "There is inconsistency as regards the minimum of interviews to be conducted; however, a significant number of articles, book chapters, and books recommend five to 50 participants as adequate". Creswell (2014) adds that these

interviews must be one-on-one and it needs to be conducted with individuals who are not hesitant to speak and have relevant contributions to the discourse. On this premise, four (4) senior management employees of the Information Technology division in international and national licenced banks were interviewed. Furthermore, 6 heads of computer science departments in universities in each state of the Southwest were interviewed.

In addition, 5 key stakeholders of Fintech in Nigeria were interviewed. The selected fintech firms were Paystack, Flutter Wave, Paga, Piggy Vest, and Interswitch (Bolade, 2021). They were selected according to the volume of transactions completed via their platforms. The in-depth interview sought to examine stakeholders' knowledge in the field of Finance, Banking and Information Technology to explain how best AI Applications can help to achieve financial inclusion among rural dwellers and draw out possible challenges of AI applications in rural areas.

Sampling Techniques

Kothari (2002) outlines two types of sampling, namely probability sampling and nonprobability sampling, where the first involves selecting a random sample from a list and the other on the availability of respondents or purposiveness. Hence, for the quantitative aspect, the probability method of sampling was applied while for the qualitative part, the probabilistic method was employed.

Quantitative Sampling Techniques

Given the large population for this study, a multi-stage sampling technique was employed to reduce the population to a manageable size. According to Chauvet (2015), this technique is effective when the population is spread across a heterogeneous area. It involves dividing the population into sub-populations, referred to as strata, and using a hierarchical structure of units within each stratum (Jain & Hausman, 2004). In the first stage of stratification, the researcher divided the six Southwest states—Oyo, Ogun, Lagos, Ekiti, Osun, and Ondo—into three senatorial districts each.

In the second stage, one local government was randomly selected from each of the senatorial districts, totaling six local governments. These selected local governments include Ibadan Northeast, Ijebu East, Surulere, Akure North, Iwo, and Oye.

In the third stage of stratification, the researcher used a simple random lottery method to select three wards from each local government. The selected wards from each state are: from Oyo state Ibadan Northeast: Monatan, Orita Bashorun, and Iyankangu.From Ogun State: Ijebu East: Ogbere, Ikija, and Ajebandele. Oyo state::Surulere: Yaba/Ojuelegba, Coker, and Ikate.Ondo state: Akure North: Ayetoro, Isale Oba I, and Moferere.Osun state: Iwo: Isale Oba I, Molete II, and Gidigbo I.Ekiti state: Oye: Ilupeju I, Ire, and Ayede North

In the fourth stage, two banks, representing international and national licensed banks, were randomly selected from each ward, making a total of 36 banks. Finally, at the last stage, 10 respondents were selected using a systematic sampling technique in each of the randomly selected banks.

Qualitative Sampling Techniques (Survey Respondents)

For the in-depth interview, a simple random sampling technique was employed in selecting 4 banks representing international and national licensed banks. The selection was done out of the

International licenced banks which include Access Bank, First Bank, First City Monument Bank, Fidelity Bank, Guaranty Trust Bank, Union Bank, United Bank for Africa, and Zenith Bank (Akamo, 2021). Additionally, the nationally licensed banks consist of Unity Bank, Wema Bank, Eco Bank, Heritage Bank, Citi Bank, Keystone Bank, Polaris Bank, Titan Trust Bank, Sterling Bank, Standard Chartered Bank, and Stanbic IBTC (Akamo, 2021).

In all, Zenith Bank and Union Bank were randomly selected in the internationally licensed category, while Heritage bank as well as Sterling Bank were randomly selected in the nationally licensed category. Expert sampling which is a type of purposive sampling technique was further employed in selecting senior managers in the Information technology division of the selected bank.

In addition, a purposive sampling technique was used in selecting five (5) Financial Technological companies to participate in the in-depth interview. The selected Fintech companies include Paystack, Flutter Wave, Paga, Piggy Vest, and Interswitch. They were selected according to the volume of transactions completed via their platforms (Bolade, 2021). The product managers of each fintech company were therefore engaged in the in-depth interviews. Lastly, for the in-depth interview, a purposive sampling technique was employed in selecting the heads of department of computer science department of 6 randomly selected universities in each Southwest state. The selected Universities are Caleb University (Lagos State), Olabisi Onabanjo University (Ogun State), Federal University of Oye-Ekiti (Ekiti State), Bowen University (Osun State), Adekunle Ajasin University (Ondo State) and University of Ibadan (Oyo State).

Research instruments	Respondents
Questionnaire	Staff of banks
In-depth interview guide	Senior banking managers (IT Division)
In-depth interview guide	Product managers
In-depth interview guide	Head of Departments

Table 3- 1   Representation of the Measurements of Artificial Intelligence

Research Instrument

In obtaining data from the selected respondents, this study employed copies of the questionnaire and interview guide all fully developed for the study. The questionnaire is an important instrument for obtaining information from people about their perceptions, attitudes and behaviours, hence its usefulness in this study. The questionnaire contains a series of questions with key constructs on artificial intelligence-enabled customer service and financial inclusion. The researcher alongside three research assistants administered the questionnaire that was self-completed.

The interview guide was further used in eliciting information from key informants at the randomly selected international and national licenced banks, Fintech companies as well as higher institutions of learning. The use of the in-depth- interview for these categories of respondents was considered feasible as it has a blend of why and how questions that may lead to totally unforeseen issues and give deeper insight into artificial intelligence-enabled customer service and financial inclusion.

Data Collection Procedure

Premised on the completion of the pilot study, the data collection exercise took place within the premises of selected financial institutions in which their interested employees were served a copy of the questionnaire to complete. The researcher approached each employee at his or her desk, seeking his or her permission to participate in the data collection exercise. The data collection exercise was done during work hours when employees are disposed to filling a questionnaire and granting pre–arranged interviews. Upon the receipt of the consent of randomly selected respondents, employees were attended to one after the other. Each randomly selected customer was handed a questionnaire to complete. And two respondents were not brought together nor attended to simultaneously. The researcher did her best to provide each respondent with a writing pen and a convenient space to complete the questionnaire, indicating their levels of agreement to the questionnaire without any external influence. Each respondent, on average, spent 15 minutes completing the questionnaire.

In the same vein, the interviewees, who are reputable people in the financial and educational sector were urged to answer some well-tailored questions to collate the needed data for the study. Also, selected rural dwellers were organised into different groups to express their opinions about issues bordering on financial products and services to improve financial inclusion among them. As a further measure to protect the privacy of the data obtained from the respondents, they were not asked to submit their names. Hence the anonymity of the respondents was protected. All completed questionnaires and responses from interviews were filed and kept for data processing and editing before analysing it.

Model Specification

The objectives of this research are outlined in the model presented below. In this model, financial inclusion is depicted as a function of various AI application components, such as AI-enabled personalized banking and automation, AI-enabled credit and saving, AI-enabled fraud detection, and AI-enabled customer service. In other words, financial inclusion is the dependent variable, while the components like AI-enabled personalized banking and automation, AI-enabled credit and saving, AI-enabled fraud detection, and AI-enabled customer service are the independent variables. Through an extensive review of extant studies on the subject of artificial intelligence and financial inclusion, Mhlanga (2020) built a model that reflects Financial Inclusion as a function of AI. This model was modified to include these four applications of the Artificial Intelligence of the unbanked population.

The scholar, Mhlanga (2020), arrived at the point through documentary and conceptual analysis of peer-reviewed papers, seasoned reports and other reliable documents on the subject of AI and financial inclusion. Hence the model is viable and reliable to attain the stated objectives of this study. The variables are, therefore, functionally expressed as:

FINC   = f (AIECS)

The regression format of the above function is written as:

FINC   = α_0 + α_4 AIECS + μ_t.

Where: $\alpha_1 <> 0$; $\alpha_2 <> 0$; $\alpha_3 <> 0$; $\alpha_4 <> 0$; $\alpha_6 <> 0$

FINC; Financial Inclusion of the Unbanked Rural Dwellers.

AIIECS; AI-Enabled Customer Service

μ; *Error term*

α_0; Constant term,

α_1; Coefficient of *AIIECS*

μ_t; Error term.

Methods of Data Presentation and Analysis

The process of data analysis is spelt out in this section. Firstly, upon the completion of the questionnaires by the selected respondents who are employees of various banks, the data collected was properly edited and transcribed into digits. The researcher examined all the completed questionnaires carefully to ensure that they were properly filled. Then, the details of the completed questionnaires were retrieved and transcribed into codes using mathematical digits from 1 to 5. Furthermore, the codes were written into an Excel sheet in preparation for a comprehensive analysis. This was done because the study employed the Statistical Package for Social Sciences (SPSS). The software comprehends and uses information in numbers. Econometrics and statistical tools such as frequency, descriptive statistics, regression analysis, confirmatory factor analysis and were used to assess and estimate each objective of the study. Frequency was used to assess the demographic of the respondents' using percentages.

Regression Analysis

The use of regression analysis is to estimate the impact of AI-enabled Customer Service on Financial Inclusion. Through it, the nature of the impact of AI applications was determined, whether positive or negative. All these statistical tools are integrated in the software used for the study. Regression analysis was conducted in the course of this study using an ordinary regression approach. This estimation technique is particularly recommendable for categorical response data sets as used in this study. The regression was first applied to determine significant component extracts of AI constructs that significantly explain financial inclusion. The analysis is selecting the factor scores generated from the principal components analysis earlier conducted. The selection is based on the most significant generated factor score that best explains financial inclusion at a significant level. This process is simply referred to as a stepwise method of regression analysis. Thus, the final factor scores that exhibit a significant effect on financial inclusion were analyzed and reported by the study.

The analysis of variance shows the statistical significance of the model based on the F-statistic result while the Durbin-Watson result is used to ascertain whether there are issues of serial autocorrelation among the variables. Durbin Watson's score of 1.5 to 2.4 is assumed to be recommendable to establish the absence of autocorrelation. The closer the value is to 2 the better the level of unbiased estimates arising from serial autocorrelation. On the contrary values below the minimum benchmark of 1.5 are considered to be predominantly negative autocorrelation while values above 2.4 are considered to be more positive autocorrelation. Autocorrelation is established when the parameter estimates are biased as a result of the influence of the endogenous variable in which case the estimates are expected to be independent of the influence of the error terms from the explained variable.

The individual effect of the factor scores in explaining financial inclusion is captured by the coefficient table. The T-statistic contained in this section helps to determine whether the individual factor scores are significant predictors of financial inclusion. The level of significance is determined at 1%, 5% and at most 10% level of significance. In this study, the standardized

Beta coefficients are used which captures regression weights after normalization of the reference variable. Hence the parameters are estimated at intercept and means level. The outcomes of the analysis were put in tabular and chart form starting with the demographics of the entire respondents. Tables and charts were used to help the end users of the outcomes of the study to comprehend them. Lastly, the narrative technique was adopted in analysing the responses received from the interviewee's respondents. The responses obtained from the interviewees were transcribed and their contributions were extracted and presented in a readable format without altering their opinions.

Data Analysis and Interpretation

Analysis of the Challenges of Adopting AI Applications in Rural Areas

Table 4.1 shows the challenges that may impair the adoption of AI applications in rural areas in the country. The use of AI applications in rural areas will encounter challenges that may frustrate financial institutions from deploying these applications. So, the combined use of mean and standard deviation helps to indicate the order of severity of each problem in rural areas.

Items	Mean	Std Deviation
The initial cost of deploying AI is huge.	1.47	0.500
AI relies on an iteration process to learn specific actions and it takes time.	1.73	0.453
At the initial phase of deployment, AI can complicate banking operations.	2.05	0.842
A shortage of experts in the field of AI can stall its deployment.	1.62	0.486
There is no clear regulatory framework for its deployment in rural areas.	1.39	0.551
The level of literacy of the end users matters	4.06	0.566
Enough human resources are required to educate rural dwellers about its usage.	4.15	0.443
There is no infrastructure to aid its deployment	2.06	1.300
AI will need to understand local languages to work effectively.	4.19	0.618
AI may alter conventional banking operations and processes.	1.33	0.491

Table 4.1: Descriptive Statistics of the Challenges of Adopting AI Applications in Rural Areas

Source: Field Survey, 2024

From Table 4.1, the main challenge facing the adoption of AI applications in rural areas is the understanding of local languages to enable them to function effectively. It has a mean value of 4.19 and a standard deviation of 0.618. This challenge is followed by the need for a large number of human resources who will first educate rural dwellers on the use of AI applications. This challenge has a mean value of 4.15 and a standard deviation of 0.443. This challenge is followed by another critical challenge in the form of the level of literacy of the AI application users with

a mean value of 4.06 and standard deviation of 0.566. Next to the challenge of literacy is the challenge of lack of infrastructure to support the deployment of AI applications in rural areas for rural dwellers. It has a mean value of 2.06 and a standard deviation value of 1.300.

Also, another challenge facing the deployment of AI applications is the possible complications of banking operation which has a mean value of 2.05 and standard deviation value of 0.842. Next to this is the challenge of AI having to rely on the iteration process which usually takes time to understand and learn specific courses of action. It has a mean value of 1.73 and a standard deviation of 0.453. Another challenge is the shortage of experts in the field of AI. It can stall the deployment of AI applications. It has a mean value of 1.62 and a standard deviation value of 0.486. Next to it is the challenge of the huge initial cost outlay of deploying AI in rural areas which has a mean value of 1.47 and standard deviation value of 0.500. The next challenge is the lack of clear regulatory framework for the deployment of AI applications in rural areas. It has a mean value of 1.39 and a standard deviation of 0.551. Lastly, the least challenge of AI applications in the rural areas is the possibility of AI altering conventional banking operations and processes and it has a mean value of 1.33 and a standard deviation of 0.491.

Overall, the main critical challenges of deploying AI applications in rural areas are the understanding of local languages to enable it to function effectively; the need for a large number of human resources who will first educate the rural dwellers on the use of the AI applications; and lastly, the level of literacy of the AI application users. It is essential to consider these challenges in the deployment of AI applications because it helps the stakeholders to make provisions for eliminating the problems.

Assessing the Impact of AI Applications on Digital Financial Inclusion in Nigeria

In this section, the study objectives are analysed through pertinent statistical techniques regression analysis, correlation coefficient, descriptive statistics and narrative technique. These statistical techniques were chosen to measure specific objectives. Firstly, the regression analysis was used to estimate the impact of AI applications on financial inclusion in Nigeria vis – a – vis hypothesis testing. Secondly, the correlation co-efficient is used to analyse the degree of relationship between AI applications and digital financial inclusion stating whether they are positively related, negatively related or not related at all. The degree of the relationship was meant to further affirm the impact of the AI applications on financial inclusion. Thirdly, descriptive statistics is used to estimate the challenges of adopting AI applications in rural areas locations and communities. Through it, the challenges were ranked in the order of seriousness and capabilities to frustrate the adoption of AI applications in rural areas in Nigeria. Lastly, the narrative technique is used to analyse the responses of the interviewees to the series of interviews granted and the group discussions held at various communities and locations in the South West of Nigeria. The details of each analysis are offered below and discussed extensively.

	FINC	AIECS
FINC	1	
AIECS	0.091	1

Table 4.2: Summary of Correlation Matrix

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

As it is stated in the literature, Shrestha and Basnet (2018) stated that correlation coefficient is the measurement of the degree of relationship between two or more variables. Its value is estimated as a range from – 1 to + 1. The coefficient can be positive, negative, neutral, strong, fair and weak (Shrestha and Basnet, 2018). Table 4.8 reveals the degree of association between AI applications and financial inclusion. Specifically, findings reveal that that there is a positive relationship between the AI-enabled Customer Service and Financial Inclusion with the r – value of 0.091 but it is poor and non-significant. That is, any increase in the AI-enable customer service influences financial inclusion positively and vice versa.

The overall results show that all the AI applications have a positive relationship with financial inclusion and can increase it. However, all the relationships with financial inclusion are poor and only one AI application has a significant relationship with financial inclusion. It implies that AI applications have the capabilities to increase financial inclusion but it is not sustainable in the long run. Any change in the prevailing conditions and policies can greatly cause changes in financial inclusion.

AI Enabled Customer Service

In this study, AI-enabled customer service is measured using several items: AI handling of customer routine inquiries (AIECS_1), AI providing online guidance for customer applications (AIECS_2), AI's capability to answer questions about individual customer accounts (AIECS_3), AI notifying customers about downtime during operation hours and days (AIECS_4), AI communicating new banking applications, products, and services (AIECS_5), AI facilitating the communication and transfer of customer complaints (AIECS_6), AI regularly generating and sending seasonal greeting messages (AIECS_7), AI guiding customers on banking procedures such as account opening (AIECS_8), AI assisting in the loan application process (AIECS_9), and AI generating follow-up messages to check on customers with incomplete applications (AIECS_10).

	Rotated Component Matrix					Communalities
	1	2	3	4	Initial	Extraction
AIECS_1	.936	.024	-.012	-.081	1.000	.883
AIECS_2	.954	.013	-.019	-.101	1.000	.921
AIECS_3	.652	.030	-.414	-.311	1.000	.693
AIECS_4	.091	.013	-.778	.068	1.000	.619
AIECS_5	-.151	-.054	-.299	.814	1.000	.777
AIECS_6	-.202	-.104	.383	.771	1.000	.793
AIECS_7	-.053	.019	.794	.094	1.000	.642
AIECS_8	-.022	.504	.524	-.335	1.000	.642
AIECS_9	.018	.917	.011	-.137	1.000	.859
AIECS_10	.038	.917	-.020	.049	1.000	.846
Initial Eigen values (Cum%)	28.752	51.352	66.278	76.748	10.000	7.675
Measure of Sampling Adequacy						
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.						0.635

	Approx. Chi-Square	1424.179
Bartlett's Test of Sphericity	df	45
	Sig.	.000
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 4 iterations.		

Table 4.3 Factor Analysis of AI-Enabled Customer Service

Source; Researcher's estimate with SEM, 2024

The KMO test in Table 4.3 was conducted on AI-enabled customer service, yielding an estimated score of 0.635. The Chi-square distribution was 1424.179, and the sphericity test was significant at the 1 percent level with a degree of freedom (df=45). These results indicate that the sample is suitable for factor analysis, with a significant portion of the original variables' variance accounted for by the components. The principal components analysis (PCA) of AI-enabled customer service, as shown in Table 4.3, includes the initial and extracted communalities, the rotated component matrix, and the KMO and Bartlett's sphericity test for sample adequacy.

The initial and extracted communalities reveal the variance in the original variables of AI-enabled customer service attributed to all the components and the variance explained by each component. The initial eigen solution indicates that AIECS_2 (0.921) has the highest variance extraction in its component. The extracted variances show that AIECS_3 (0.693), AIECS_4 (0.619), AIECS_7 (0.642), and AIECS_8 (0.642) were below the 70 percent loading coefficient, while the other variables were satisfactorily loaded. However, since the rotated component matrix provides a more even distribution of the variances across the components, it is used to explain the results of the factor analysis in this study.

The rotated component matrix, which allows for a more even distribution of the extraction communalities, shows that the first component is highly correlated with AIECS_2 (0.936) and is uncorrelated with the other three components. The second component is highly correlated with AIECS_9 (0.917); however, AIECS_9 is less correlated with the third component than AIECS_10, even though both variables exhibit the same proportion of variance in component 2. The third component is highly correlated with AIECS_7 (0.794), while the fourth component is strongly correlated with AIECS_5 (0.814).

This suggests that further analysis on AI-enabled customer services can focus on AIECS_2, AIECS_9, AIECS_10, and AIECS_5. These components account for 76.748 percent of the total variance in the AI ECS construct indicator.

The Impacts of AI Applications on Financial Inclusion

Professional Views:

Here, interviewees' opinions seem diverse. To achieve financial inclusion through the deployment of AI applications, some interviewees expressed what AI applications could be used for in rural areas while some held the opinion that AI applications do not apply to financial inclusion. Specifically, interviewees stated that AI applications can be used in rural areas to create access to financial services especially access to credit facilities; create e-branches in rural

areas instead of fully functional physical branches; create financial products accessible and appealing to rural dwellers especially through phones, chatbots and in multiple languages. In other words, AI applications can be used to address the issue of lack of access to financial products and services and thereby connect them to financial products and services.

Discussion of Findings

Overall, the findings emanating from the analysis of the volume of data obtained from the study participants are diverse. Using a mixed method, findings elicited from the quantitative data are not largely different from the findings elicited from the qualitative data. Both methods affirmed that AI applications have positive impacts on financial inclusion. In this study, the banks' text communication to customers on their financial status; ATM installations within the communities; possession of personal debit cards for withdrawals and payments; the rate of persons keeping money at home; the increase in the loans granted in the community were determined to be most relevant indicators of financial inclusion.

The results further indicate that there exists a significant positive relationship between financial inclusion and AI applications. Therefore, the null hypothesis was rejected as the analysis showed that AI-enabled customer service has a significant impact on financial inclusion in South-West Nigeria,

The interviews provided more insights into the core objective of the study and the responses obtained from them are analysed into separate themes: The responses from both the professionals and academics were consistent. The interviewees stated that AI applications can improve financial inclusion in rural communities through the granting of credit facilities; establishment of e-branches; and development of new financial products accessible and appealing to rural dwellers, especially using phones, chatbots and multiple languages.

In summary, the emergence of AI and its applications has been transformative for many industries and societies, particularly those that adopted it early on. AI applications have driven the evolution of business operations, spurred breakthroughs in specific sectors, improved productivity, and mitigated environmental problems by reducing reliance on harmful processes and tools. AI's adaptability extends to almost every aspect of life and various endeavors. Despite the significant potential of AI applications, pressing issues still require immediate attention, such as financial exclusion. Many individuals, especially rural dwellers and small and medium enterprises in developing countries, remain financially excluded. They are finding it difficult to gain access to financial products and services that can ameliorate their perilous situations. The financial sectors in developing economies have tried to include the unbanked / under bank without much success. Similarly, in Nigeria, data revealed that out of 84.7 million adults, 39.2 million of them, that is, 46.3 per cent of the total Nigerian adults, are excluded from financial services adult (CBN, 2011). Nigeria has identified its need to remain financially inclusive to achieve a considerable level of financial equity and overall development. The issue of financial exclusion has thus been a major economic challenge that has attracted the attention of various governments over the past six decades.

Conclusion

The study yielded a broad spectrum of findings. It revealed that AI-enabled customer service and AI-enabled credit service were the most influential AI applications in promoting financial inclusion. The study empirically demonstrated that AI-enabled online guidance for customer applications is the most effective tool for AI-driven financial inclusion. Additionally, it

identified a significant positive relationship between AI-enabled customer service and financial inclusion, suggesting that improvements in AI-enabled customer services will enhance the performance of financial inclusion initiatives by financial institutions.

Recommendations

Based on the findings of the study, the following viable and relevant recommendations are proposed:

Firstly, the study has shown that AI applications significantly impact digital financial inclusion. Therefore, AI applications should be developed following comprehensive market surveys and research to uncover the needs of the general public or specific societal segments the applications aim to serve. This need-based approach ensures that AI applications fulfil their intended purposes effectively and satisfactorily.

Additionally, financial institutions should establish a framework for research and the development of specialised financial products that cater to financially excluded groups.

The study also revealed that the adoption of AI applications in rural areas encountered challenges bordering on understanding local languages; the availability of many human resources who will first educate the rural dwellers; and the level of literacy of the end users. It is therefore suggested that education, awareness, and campaigns should always precede the deployment of AI applications in any part of the country

Also, financial institutions should invest in building AI-enabled platforms in local languages that will respond to customers' routine enquiries, help customers complete loan applications, and share personalised information on savings and credit options. These will ease some of the challenges to be encountered and the rural communities will respond better to solutions in their local languages.

Acknowledgement:

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