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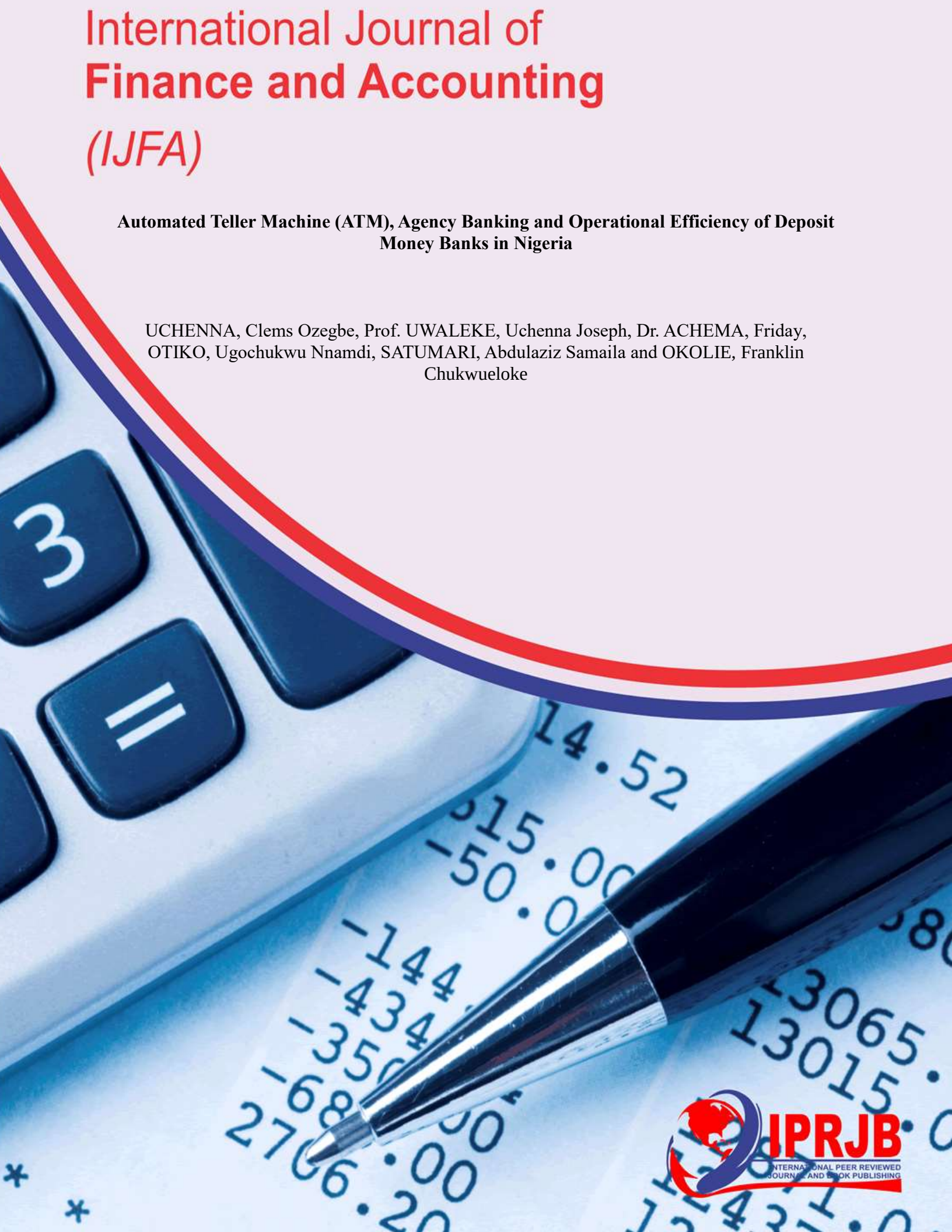

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Abstract

Purpose: The rapid advancement in technology is transforming the financial sector, positioning ATMs and agency banking as crucial innovations that significantly enhance the accessibility and efficiency of banking services. This study investigates the impact of Automated Teller Machines (ATMs) and agency banking on the operational efficiency of deposit money banks in Nigeria. The study objective was to assess the influence of Automated Teller Machines (ATMs) and agency banking on operational efficiency.

Methodology: Utilizing an ex post facto research design, the study sampled ten deposit money banks listed on the Nigerian Exchange Group (NGX) as of 31 December 2023. Secondary data were collected from the Nigeria Inter-Bank Settlement System Plc, Central Bank of Nigeria statistical bulletins, and annual reports of the selected banks for the period of 2009 - 2023. Descriptive and inferential statistical techniques, including correlation and panel regression analysis were used to analyze the effect of ATM and agency banking on operational efficiency.

Findings: The findings revealed that ATM usage has a significant positive effect on operational efficiency. Agency banking, measured through Point of Sale (POS) systems, also exhibited statistically significant effect on operational efficiency. The study concluded that technological advancements, particularly in the form of ATMs and agency banking, significantly contribute to the operational efficiency of banks in Nigeria.

Unique Contribution to Theory, Practice and Policy: The study recommended that DBMs in Nigeria should continue investing in digital banking innovations to enhance performance and maintain competitiveness.

Keywords: *ATM, Agency Banking, Operational Efficiency*

JEL Classification Codes: *G21, O33, C33*

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INTRODUCTION

The integration of technology into banking operations has profoundly transformed the global financial landscape. Innovations such as Automated Teller Machines (ATMs) and agency banking have emerged as pivotal tools in enhancing the accessibility, speed, and cost-efficiency of financial services worldwide. As highlighted by Murinde et al. (2022), these technological developments have driven the widespread adoption of digital banking solutions, urging industry stakeholders and regulators to critically examine their implications for operational performance.

In Nigeria, a country with a population exceeding 200 million and a significant unbanked segment, the uptake of digital banking solutions such as ATMs and agency banking has accelerated in response to growing demands for accessible and efficient financial services (Imam et al., 2024). ATMs offer essential services including cash withdrawals, fund transfers, and bill payments, which particularly benefit urban consumers seeking convenience. Agency banking, on the other hand, serves as a channel to reach underserved rural communities by leveraging local businesses as intermediaries. These innovations are instrumental in promoting financial inclusion in a country with diverse socio-economic challenges (Kazeem, 2022).

ATMs have revolutionised customer-bank interactions by enabling 24-hour banking access and reducing dependence on physical branches, leading to improved customer satisfaction (Jegede, 2014). Agency banking complements this by expanding service coverage through non-bank agents, reducing operational costs and building local trust. However, these technologies also present challenges such as cybersecurity threats, high maintenance costs, technological obsolescence, and the need for effective regulatory oversight (Adepoju & Mohammed, 2010; Odumusor et al., 2024). Despite these constraints, the successful integration of ATMs and agency banking into service delivery models is vital for enhancing the operational efficiency of Deposit Money Banks (DMBs) in Nigeria.

Although prior studies have explored the financial performance of banks using indicators like return on assets and return on equity (Dulacha et al., 2024; Ashiru et al., 2023), there remains a paucity of empirical evidence on the direct impact of ATMs and agency banking on operational efficiency—a key internal performance metric. Moreover, differences in adoption strategies across banks and the lack of a comprehensive framework for evaluating these digital tools limit effective decision-making for both practitioners and policymakers. Notable exceptions, such as the studies by Rabiu et al. (2019) and Sporta & Muganda (2021), have touched on this area, but broader, multi-bank analyses in the Nigerian context are limited.

This study seeks to fill this gap by investigating the effects of ATM usage and agency banking on the operational efficiency of deposit money banks in Nigeria. Specifically, it aims to answer the following research questions: (1) How do ATMs influence the operational efficiency of DMBs in Nigeria? (2) What is the effect of agency banking on the operational efficiency of DMBs in Nigeria? Corresponding hypotheses are:

H_{01}: ATM adoption does not significantly influence the operational efficiency of DMBs in Nigeria.

H_{02}: Agency banking adoption does not significantly affect the operational efficiency of DMBs in Nigeria.

The findings are expected to contribute practical insights into optimising banking operations and promoting inclusive financial systems.

The remainder of this paper is structured as follows: Section 2 reviews relevant literature on ATMs, agency banking, operational efficiency, and the Nigerian banking context. Section 3 outlines the research methodology, including data sources, sampling techniques, and analytical tools. Section 4 presents the results and discusses their implications. Section 5 concludes the paper by summarising key findings, outlining limitations, and offering recommendations for future research.

LITERATURE REVIEW

Automated Teller Machine (ATM)

Automated Teller Machines (ATMs) are electronic banking outlets that allow customers to complete basic transactions without the need for a human teller. Common ATM services include cash withdrawals, balance inquiries, fund transfers, and deposits, providing round-the-clock accessibility to banking services (Anifowose & Ekperiware (2022). Globally, ATMs have become an integral part of banking systems, offering convenience and ease of access while reducing operational burdens on physical bank branches. In Nigeria, ATMs have risen in popularity as banks aim to improve service delivery and reach out to both urban and rural clients. With Nigeria's enormous geographical expanse and various degrees of banking infrastructure, ATMs play an important role in bridging service gaps, especially for those in underserved or distant locations (Jegede, 2014). ATMs reduce the need for clients to travel great distances to bank offices by providing instant, on-demand access to cash and other banking services, hence increasing financial inclusion. (Osahenvemwen and Iroh 2021). The increased deployment of ATMs in Nigeria reflects deposit money banks' (DMBs) efforts to streamline operations and improve client interactions. ATMs can help banks save money by reducing consumer foot traffic in branches and reducing dependency on in-branch staff, hence improving operational efficiency (Ahaiwe 2021). However, ATM efficiency increases are influenced by machine uptime, maintenance, and security concerns. High rates of ATM downtime, for example, can negate the gains by reducing consumer satisfaction and bank efficiency. Furthermore, despite its benefits, implementing ATMs in Nigeria is not without problems. Frequent power outages, high maintenance expenses, and security concerns about card theft pose substantial challenges (Adepoju and Mohammed, 2010). Addressing these difficulties is critical to maximizing the operational and financial benefits that ATMs provide to the Nigerian banking sector. As technology progresses, newer ATM models with improved security features and digital capabilities may help reduce these difficulties, resulting in a more robust ATM network across the country.

Empirical evidence demonstrates that increased ATM adoption significantly improves banks' operational efficiency by reducing transaction costs and enhancing earnings. Research by Otonne and Ige (2023) indicated that a 1% increase in ATM transactions could lead to an average increase of ₦4 in banks' earnings per share, highlighting the financial benefits of ATM usage. Furthermore, Glater and Swoboda (1995) found that processing a transaction through a human teller costs banks approximately $1.07, whereas completing the same transaction via an ATM costs just $0.27, representing a cost reduction of roughly 74.8%. These findings underscore the substantial cost savings associated with ATM transactions compared to traditional teller services. Such reductions

in transaction costs enable banks to allocate resources more efficiently, potentially allowing staff to focus on higher-value advisory roles rather than routine cash handling (Adewoye & Omoregie, 2013)

Agency Banking

Agency banking is a collaborative arrangement between a financial institution and a third-party agent, designed to deliver essential banking services to customers, particularly in underserved regions. This innovative model plays a crucial role in promoting financial inclusion and enhancing accessibility for individuals who may otherwise lack access to traditional banking services (Ogbebor, 2014; Mwando, 2013). Agency banking, which empowers third-party agents, successfully expands the reach of Deposit Money Banks (DMBs) into remote or rural areas where physical bank branches may be few or non-existent. Through agency banking, customers can perform a range of banking transactions, including deposits, withdrawals, and payments, conveniently and securely, without needing to visit a bank branch (Dotun & Adesugba, 2022). This flexibility not only meets the needs of customers but also enhances internal banking efficiency by lowering transaction costs, reducing congestion in banking halls, and accelerating expansion into rural markets where full-service branches would be costly and impractical. In Nigeria, the regulatory framework for agency banking is provided by the Central Bank of Nigeria (CBN) under the "Guidelines for the Regulation of Agent Banking and Agent Banking Relationships in Nigeria" (CBN, 2013). These guidelines define permissible activities for agents, outline eligibility requirements, and specify risk management protocols (Ayegbeni, 2020). Agents must be individuals or businesses with a verifiable location, capacity to render financial services, and a record of financial integrity. Banks are responsible for selecting and monitoring agents in line with these criteria (CBN, 2013).

Furthermore, the implementation of agency banking is linked to increased customer acquisition and retention, as it provides a more accessible banking experience. As a result, DMBs can improve their market share and profitability by capturing a larger customer base (Innocent & Nwankwo, 2016). In addition, agency banking helps address several barriers that hinder individuals from accessing conventional banking services, such as geographical distance, lack of identification, and limited financial literacy, thereby fostering greater financial inclusion (Ogbebor, 2014; Dotun & Adesugba, 2022).

Despite its benefits, the implementation of agency banking in Nigeria faces several challenges, such as security risks, technology reliability, and regulatory concerns. Notably, agent fraud such as cash diversion and unauthorised charges, can erode customer trust and pose financial risks to banks. Liquidity constraints - where agents run out of cash or float - can interrupt service delivery, especially in rural areas. Furthermore, reconciliation delays between agent transactions and central bank systems can cause financial reporting errors and customer dissatisfaction (Ayadi, et al., 2023). Agents are often located in high-traffic, sometimes insecure areas, raising risks of theft and fraud that banks must address to safeguard customer transactions. Also, issues such as network failures and limited infrastructure can disrupt agent services, impacting the reliability of banking access (Agu et al., 2016). Ensuring robust technological support and clear regulatory oversight is therefore essential for maintaining the trust and efficiency of agency banking channels in Nigeria

Operational Efficiency

Operational efficiency in banking refers to the effective management of resources to minimise costs and maximise service delivery quality and speed, thereby enhancing the overall performance of financial institutions. It is the ability of a bank to deliver products and services to its customers in the most cost-effective manner possible while still ensuring the high quality of its products, services and support (Berger & Humphrey, 1997). It is a critical metric that reflects a bank's ability to deliver services in a cost-effective manner while maintaining customer satisfaction and competitive advantage (Oino, 2018). Globally, banks have been increasingly focused on improving operational efficiency due to rising competition, regulatory demands, and the evolving expectations of digitally savvy customers. Operational efficiency enables banks to optimise their financial and human resources, streamline processes, and ultimately drive sustainable profitability.

In the Nigerian banking sector, operational efficiency is especially important given the unique challenges and complexities of the market. Factors such as high service costs, diverse socio-economic backgrounds, and varying levels of digital infrastructure pose unique challenges for deposit money banks (DMBs) striving to balance cost control with service expansion. Empirical evidence shows that Nigerian bank customers often face long wait times, especially in urban branches, with average queue times reportedly exceeding 25 minutes during peak hours (CBN, 2021). In addition, infrastructure-related costs remain high, particularly in maintaining power supply and connectivity, which are critical for ATM and agency banking operations (Agwu, 2018; Gololo & Ibrahim, 2018). Enhancing operational efficiency enables these banks to reduce overhead expenses, improve transaction processing times, and increase the accessibility and affordability of their services (Agwu, 2018).

Technological innovations such as ATMs and agency banking have had a direct and measurable impact on operational efficiency in Nigerian banks. By shifting routine transactions to automated or agent-based platforms, banks can alleviate in-branch congestion and reduce the workload on their in-branch staff, allowing them to focus on higher-value services. According to Anifowose and Ekperiware (2022), banks with extensive ATM coverage experience fewer over-the-counter (OTC) transactions, which helps to reduce personnel costs and improve customer experience. For instance, agency banking allows banks to reduce branch dependency in underserved areas, significantly lowering overhead costs and increasing accessibility without the need for full-fledged branches (Munyengabe & Gabriel, 2018). A study by Otonne and Ige (2023) found that a 1% increase in ATM transaction volume was associated with a ₦4 increase in banks' earnings per share, highlighting the efficiency and profitability of self-service technologies. Similarly, the use of ATMs and digital banking platforms helps to lower transaction costs and provides customers with 24/7 access, enhancing convenience and operational productivity (Anifowose & Ekperiware, 2022; Nigatu, Belete & Habtie, 2023).

Despite these advantages, achieving and maintaining operational efficiency in Nigeria's banking sector is complex, with obstacles such as infrastructure limitations, security risks, and fluctuating economic conditions. Power outages, network downtimes, and the high cost of technology maintenance often affect the continuity and reliability of these services. Furthermore, security challenges, including fraud and cyber threats, necessitate ongoing investment in advanced cybersecurity measures and reliable transaction monitoring systems (Gololo & Ibrahim, 2018).

Theoretical Review

The study is underpinned by the Resource-Based View (RBV) Theory. The other theories such as the Technology Acceptance Model (TAM) and Diffusion of Innovation Theory are supporting theories. These theories complement each other in explaining the adoption, diffusion, and strategic use of technological innovations in the banking sector, addressing interconnected aspects of the study.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), introduced by Davis (1989), is one of the most influential theories for understanding user adoption of technology. TAM posits that two main factors determine a user's acceptance of technology: perceived usefulness (PU) and perceived ease of use (PEOU). PU refers to the degree to which a person believes that using a particular system would enhance their performance, while PEOU refers to the degree to which a person believes that using the system would be free of effort. In banking, TAM has proven particularly useful in examining the factors that drive customers to adopt mobile and online banking, especially in emerging economies like Nigeria, where factors such as technological literacy and infrastructure can vary widely across customer segments (Ayo et al., 2016).

Recent Nigerian empirical studies have reinforced the relevance of TAM in explaining digital banking adoption. For instance, Bello, Ladan, and Ibrahim (2024) utilised the TAM framework to examine agency banking adoption in the Nigerian banking industry and found that perceived usefulness and perceived ease of use were significant predictors of adoption among bank customers. Similarly, Umar, Isah, and Nuhu (2024) reported that both PU and PEOU strongly influenced agent banking service acceptance among rural entrepreneurs in Adamawa State, underscoring TAM's continued applicability in understanding technology adoption in Nigeria's financial sector. These studies highlight the ongoing relevance of TAM in the Nigerian context, while also showing the importance of integrating local realities.

However, TAM has faced significant critiques. Critics argue that TAM is overly simplistic and fails to consider important social, cultural, and environmental factors that influence technology adoption. It often neglects external variables, such as social influence, technological infrastructure, and security concerns, which are critical in a developing economy like Nigeria. Furthermore, TAM assumes that users act rationally and predictably when deciding to adopt technology, which may not always be the case in real-world situations (Bagozzi, 2007). In Nigeria, for instance, issues like trust, security concerns, and the reputation of financial institutions may heavily influence the adoption of digital banking services—factors not adequately addressed by TAM. To address these gaps, extended models like TAM2 and the Unified Theory of Acceptance and Use of Technology (UTAUT) have been developed to include additional determinants like social influence and facilitating conditions (Venkatesh & Davis, 2000; Rondan-Cataluña et al., 2015)

Diffusion of Innovation Theory

Rogers' Diffusion of Innovation Theory (2003) explains how new ideas, products, or technologies are adopted over time within a social system. It outlines five categories of adopters: innovators, early adopters, early majority, late majority, and laggards. The rate of adoption depends on factors such as relative advantage, compatibility, complexity, trialability, and observability. In the Nigerian

banking context, this theory has been useful in analysing how digital banking innovations such as ATM and agency banking are accepted and diffused among both banks and customers (Kazeem, 2022; Ahaiwe, 2021). Empirical evidence suggests that ATM adoption has been more concentrated in urban centres where there is better electricity and security infrastructure, while rural areas still experience limited access due to frequent machine downtimes and logistical challenges (Otonne & Ige, 2023). Similarly, agency banking has seen significant uptake in rural communities, with studies showing that it has become a preferred channel in areas lacking physical bank branches, particularly in the northern and southeastern regions of Nigeria (Bello et al., 2024; Umar et al., 2024). These patterns indicate differing rates and motivations for adoption across regions, shaped by infrastructural and demographic conditions.

Despite its popularity, Diffusion of Innovation Theory has limitations. It is often criticised for its linear approach to adoption, implying a one-size-fits-all model that may not accurately capture the complexities of technology adoption in diverse cultural contexts. It assumes that all individuals will follow the same stages of adoption without considering unique socio-economic and cultural factors that may affect adoption differently in various groups. For example, in Nigeria, rural and urban populations may have distinctly different adoption rates due to disparities in infrastructure, digital literacy, and access to banking agents or ATM services. The theory also assumes that innovations are always beneficial, overlooking potential negative effects or resistance due to cultural preferences and existing traditional systems (Greenhalgh et al., 2004). Furthermore, Rogers' model is criticised for focusing on individual decision-making while neglecting organisational and structural factors that can influence the adoption process.

Resource-Based View (RBV)

The Resource-Based View (RBV), proposed by Barney (1991), argues that firms achieve a sustainable competitive advantage through the acquisition and effective utilization of valuable, rare, inimitable, and non-substitutable resources (VRIN). RBV has been particularly relevant in studying banking, where technological resources like ATM and agency banking platforms are considered strategic assets that can enhance operational efficiency and customer service, thus providing a competitive edge (Mostafa & Fatemeh, 2014).

RBV, however, has faced its own set of critiques. One major criticism is its limited focus on internal resources without sufficient emphasis on the dynamic external environment and the firm's ability to adapt. Recent literature has highlighted the importance of dynamic capabilities—the firm's capacity to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments which were largely absent in the original RBV framework (Teece, 2018; Peteraf & Barney, 2015). Critics argue that RBV assumes resources are static and that firms can rely solely on these resources for sustained competitive advantage, ignoring factors like market changes, technological advancements, and competitor actions (Mostafa & Fatemeh, 2014).

In the Nigerian context, for example, banks face external challenges like regulatory changes, cybersecurity risks, and socio-economic instability, which can impact the effectiveness of even the most well-developed technological resources. In this light, the integration of dynamic capabilities with RBV offers a more comprehensive understanding of how Nigerian banks can continuously renew and adapt their technological resources to sustain competitiveness.

In addition, RBV is often criticized for its lack of clear guidelines on how resources should be effectively utilised to create a competitive advantage, leading to potential implementation challenges. Furthermore, the VRIN criteria are considered overly restrictive; not all resources that contribute to a firm's success are non-substitutable or rare, as the model suggests. This limits the theory's applicability, particularly in rapidly changing industries like banking, where technological resources can quickly become obsolete.

TAM, Diffusion of Innovation Theory, and RBV each offer valuable insights into technology adoption and resource utilisation in the banking sector; however, the study is anchored on Resource-Based View theory (RBV).

Empirical Review

Several empirical studies have examined the effects of ATM and agency banking on operational efficiency in various contexts, including Nigeria.

Dulacha et al. (2024) investigated the relationship between agency banking convenience and the financial performance of commercial banks in Isiolo County. Using a descriptive survey of 173 employees across Kenyan Cooperative Bank, KCB, and Equity Bank, they found a strong positive correlation between agency banking convenience and financial performance. Recommendations included leveraging digital platforms and expanding accessibility. However, the study's reliance on a convenience sample and its limited technological focus suggested room for further refinement.

Assoumou et al. (2024) analyzed the effects of financial innovations, including ATMs, POS systems, internet banking, and mobile banking on the performance of commercial banks in Cameroon. Their regression analysis highlighted significant positive impacts of ATMs and mobile banking, while POS systems and internet banking showed no measurable effects. Similarly, Njitor et al. (2023) found that financial innovations like credit cards, internet banking, ATMs, and mobile transactions positively correlated with bank performance.

Al-Sahlani (2023) explored the impact of financial technologies, including Mobile Money Operations (MMO), ATMs, Point of Sale (POS) systems, and Point of Contact (POC), on bank performance in Iraq from 2018 to 2022. Using secondary data from the Iraq Stock Exchange and the Central Bank, the study revealed that MMO significantly enhanced bank performance due to high transaction volumes. ATMs and internet banking also positively influenced bank performance, though POC and POS systems had minimal effects. Despite these findings, the study's limited sample size and its focus on the Iraqi context restrict its applicability to Nigeria's unique banking environment.

Awan and Parveen (2023) investigated financial innovations in Pakistan from 2013 to 2019, including ATMs, credit cards, and internet banking. Their econometric analysis revealed a positive link between these technologies and bank profitability, with recommendations focusing on increasing internet banking usage. The findings, while insightful, may not directly translate to the Nigerian context due to differing regulatory and operational landscapes.

Omole et al. (2023) focused on the impact of fintech services on the financial performance of Nigerian deposit money banks from 2018 to 2022. They identified positive relationships between fintech adoption and various financial health metrics. Recommendations emphasized enhancing

user experiences through mobile and online banking, but limitations such as small sample sizes and incomplete data were noted.

Ashiru et al. (2023) studied the influence of mobile banking, online banking, and ATMs on Nigerian banks between 2012 and 2021, identifying POS as having the greatest positive effect, followed by ATMs and mobile banking. While secondary data supported the findings, the study's limited sample size and duration necessitated further research.

Sporta and Muganda (2021) examined agency banking's role in improving the operational efficiency of Kenyan commercial banks between 2014 and 2018. Employing descriptive statistics and panel data analysis, they found agency banking significantly enhances operational efficiency. The authors recommended aligning digital strategies with operational models and fostering collaborations with technology firms to maximize benefits. Nonetheless, they noted the need for deeper analysis of factors influencing agency banking efficacy.

Ejinkonye and Okonkwo (2021) investigated the role of financial technologies - ATMs, online banking, mobile banking, and POS transactions on deposit mobilization in Nigerian banks between 2009 and 2018. Their OLS regression analysis identified significant effects from ATMs, while other innovations exhibited positive but statistically insignificant impacts. Despite robust methodology, the outdated timeframe and lack of external economic considerations limited the study's applicability.

Nwankwo et al. (2021) discovered that ATM transactions improved Nigerian banks' performance, while POS and mobile banking had weaker and negative effects, underscoring the need for broader, more extensive studies.

Rabiu et al. (2019) examined e-banking's effects on operational efficiency at Diamond Bank Plc's Bauchi branch. Their findings pointed to significant efficiency gains but were constrained by a narrow focus and small sample size.

Orji et al. (2018) used the Seemingly Unrelated Regression Equation (SURE) model to analyze the effects of e-banking innovations - ATMs, mobile banking, and POS transactions on six selected Nigerian banks. Their findings underscored the positive impact of these innovations, although limited sample size and insufficient data on the study period were highlighted as drawbacks.

These empirical studies collectively underscore the transformative potential of financial innovations like ATMs and agency banking in enhancing operational efficiency and financial performance. However, differences in study contexts, methodological limitations, and technological adoption levels highlight the need for more insight and comprehensive research tailored to Nigeria's banking environment.

Research Gap

The review reveals several critical research gaps that justify this study. First, a period gap is noticeable, especially in Nigerian studies, which largely cover data only up to 2018 to 2023. This study spans from 2009 to 2023, allowing a more updated analysis of ATM and Agency banking impacts on operational efficiency. In addition, while many studies examine a broad range of financial innovations, few focus specifically on electronic payment channel – ATM and Agency banking's effect on operational efficiency in Nigerian banks. By narrowing this focus, this study

provides clearer insights into these particular technologies. Moreover, past studies, such as those by Dulacha et al. (2024); Assoumou et al. (2024); Al-Sahlani (2023); Awan and Parveen (2023); Omole et al. (2023); Ashiru et al. (2023); Ejinkonye and Okonkwo (2021); Nwankwo et al. (2021); and Orji et al. (2018) often used return on asset, return on equity, and deposit mobilization, but none has considered operational efficiency as a measure of performance. This study addresses this by examining the effect of these banking innovation variables on operational efficiency across multiple banks in Nigeria, using a more comprehensive dataset to enhance reliability and provide a holistic view of ATM and Agency banking's role in operational efficiency in Nigeria. The works of Rabiu et al. (2019); and Sporta and Muganda (2021) are the only studies that have been found to have empirically investigated the effect of e-banking and agency banking on operational efficiency of banks.

METHODOLOGY

This study employed an ex post facto research design, which involves examining existing data where the researcher has no direct control over the variables, as these variables readily available. The area of the study is Nigeria, while the population is the twelve (12) Deposit Money Banks listed on the NGX as of 31st December 2023. The study sample comprised Ten (10) Deposit Money Banks listed on the Nigerian Exchange Group (NGX) as of 31st December 2023. The sample was selected using the purposive sampling technique. The study utilized secondary data from Nigeria Inter-Bank Settlement System Plc (NIBSS), CBN Statistical Bulletins and the Annual Reports of the selected listed Deposit Money Banks for the period 2009 - 2023. Data were analyzed using both descriptive and inferential statistical techniques. Descriptive statistics were used to determine the centralization and dispersion of study variables. The mean, standard deviation, lowest and maximum values were used to present the data (Katarzyna 2020). To test the hypotheses, multiple regression analysis was employed, which is a statistical method used to assess the relationship between a single dependent variable and multiple independent variables (Sekaran & Bougie, 2010). The study utilized panel regression analysis to leverage its strengths in controlling for omitted or unobservable variables that could compromise causal inference in observational studies (Halaby, 2004). This panel data approach is well-suited to the cross-sectional and time-series nature of the data, aligning with methodologies employed in studies conducted by Agyemang et al., 2023 in China and Guerrero Escamilla & Vargas 2021).

Model Specification:

The econometric model adopted in this study is stated below:

$$OEFit = \beta_0 + \beta_1 ATM_{it} + \beta_2 POS_{it} + \beta_3 FSZ_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

OEF = Operational Efficiency (Dependent variable)

ATM = ATM transaction representing ATM (Independent Variable)

POS = POS representing Agency banking (Independent Variable)

FSZ = Firm Size (Control Variable)

B0 = Intercept

β_1- β_3 = Coefficients of the estimate

ε_{it} = Error term of the estimate for bank *i* at time *t*, accounting for unexplained variations in operational efficiency

i represents the individual firm (cross-sectional unit) in the sample (e.g., different Deposit Money Banks).

t represents time, indicating the specific time period (e.g., year) during which the observations were recorded.

Table 1: Variables Definition and Measurement

Variable	Description	Source
Automated Teller Machine (ATM)	Volume of ATM transactions	Abdullai and Nyaoga (2017
Agency Banking (POS)	Volume of transactions processed through POS apps	Sporta & Muganda (2021).
Firm Size (FSZ)	Natural log of Total Assets	Oyelade (2019)
Operational Efficiency (OEF)	Ratio of Proft after taxes to Total Assets	Lotto & Papavassiliou (2019).

Source: Researcher's Compilation (2023)

FINDINGS

Descriptive Statistics

The descriptive statistics were computed for the dataset in this section using the key parameters. The results revealed important information about the distribution and central tendency of the data.

Table 2: Descriptive Statistics

	ATM	POS	FSZ	OEF
N	15	15	15	15
Missing	0	0	0	0
Mean	7.44	1.21	2.65	5287
Median	590238934	63715	2.65	5287
Standard deviation	5.60	2.65	0.0686	825
Minimum	60133610	918	2.53	3995
Maximum	1914220419	9.85	2.75	6579
Skewness	0.865	2.88	-0.202	1.40
Std. error skewness	0.580	0.580	0.580	0.580
Kurtosis	-0.141	8.79	-1.14	-1.20
Std. error kurtosis	1.12	1.12	1.12	1.12
Shapiro-Wilk W	0.909	0.534	0.961	0.964
Shapiro-Wilk p	0.130	< .001	0.714	0.755

Source: Jamovi Output

Key: ATM = Automated Teller Machine; POS = Point of Sale; FSZ = Firm Size; OEF = Operational Efficiency.

The descriptive statistics in Table 2 provides insights into the characteristics of the study variables. For ATMs, the average usage level is recorded at 7.44, with a standard deviation of 5.60, which indicates that there is considerable variation in ATM usage across the banks. The range is notably wide, spanning from a minimum of 60,133,610 to a maximum of 1,914,220,419, suggesting that some banks have significantly higher ATM usage. The skewness value of 0.865 suggests a moderate right skew, meaning that a few banks report much higher ATM usage than others. However, the Shapiro-Wilk test shows a p-value of 0.130, which does not indicate significant deviation from normality. Therefore, the ATM variable distribution appears to be approximately normal.

The POS variable displays an average usage level of 1.21, but it has a much higher relative variability with a standard deviation of 2.65. This high level of variability, along with a skewness value of 2.88, shows that POS data is highly skewed to the right. The kurtosis value of 8.79 further suggests that the distribution is peaked with extreme values. The Shapiro-Wilk p-value for POS is less than 0.001, indicating a significant deviation from normality. This non-normal distribution implies that POS usage across banks is uneven, with a few banks likely contributing to disproportionately high usage values.

For Firm Size (FSZ), the average value is 2.65, with a low standard deviation of 0.0686, indicating very little variation in firm size across the banks. This consistency is also reflected in the skewness of -0.202, which suggests a nearly symmetrical distribution. The kurtosis value of -1.14 points to a distribution that is fairly flat, indicating no extreme values. The Shapiro-Wilk test results in a p-value of 0.714, suggesting no significant deviation from normality. Thus, FSZ data is roughly normal and relatively consistent across the banks.

Operational Efficiency (OEF) records a mean of 5287, with a standard deviation of 825, showing moderate variability across the banks. The skewness value of 1.40 suggests a mild right skew, meaning that a few banks are more operationally efficient than others. The kurtosis value of -1.20 indicates a slightly flatter distribution than a normal one, and the Shapiro-Wilk test yields a p-value of 0.755, which suggests no significant deviation from normality. This means that OEF data is roughly normal, allowing for further parametric analyses.

Overall, the variables ATM, FSZ, and OEF are approximately normally distributed, meeting the assumptions for potential parametric testing. However, the POS variable shows a high degree of skewness and kurtosis, indicating that it does not follow a normal distribution.

Correlation Matrix

The correlation matrix is a square matrix that displays the correlation coefficients between each pair of variables in a dataset.

Table 3: Correlation Matrix

		ATM	POS	FSZ	OEF
ATM	Pearson's r	—			
	df	—			
	p-value	—			
POS	Pearson's r	0.422	—		
	df	13	—		
	p-value	0.117	—		
FSZ	Pearson's r	0.861	0.627	—	
	df	13	13	—	
	p-value	< .001	0.012	—	
OEF	Pearson's r	0.866	0.666	0.998	—
	df	13	13	13	—
	p-value	< .001	0.007	< .001	—

Source: Jamovi Output

The correlation matrix in Table 3 shows the relationships between Automated Teller Machines (ATM), Point of Sale (POS), Firm Size (FSZ), and Operational Efficiency (OEF) in Nigerian Deposit Money Banks.

ATM and OEF show a strong positive correlation ($r = 0.866$, $p < 0.001$), suggesting ATM usage significantly enhances operational efficiency. Similarly, **POS and OEF** have a positive correlation ($r = 0.666$, $p = 0.007$), indicating that agency banking positively impacts operational efficiency, reinforcing the value of POS for bank performance. **FSZ and OEF** are highly correlated ($r = 0.998$, $p < 0.001$), indicating larger banks generally have higher operational efficiency, possibly due to greater resources or structural advantages.

These results support the study's hypotheses that both ATM and agency banking boost bank operational efficiency, with firm size playing a critical role.

Regression

Regression analysis was conducted to test the impact of online banking and mobile banking on operational efficiency. The result is shown in Table 4.

Table 4: Model Fit Measures

				Overall Model Test			
Model	**R**	**R^2**	**Adjusted R^2**	**F**	**df1**	**df2**	**p**
1	1.000	0.999	0.999	3747	3	11	< .001
Note. Models estimated using sample size of N=15							

Source: Jamovi Output

The model fit measures in Table 4 indicate that ATM, POS, and FSZ possess a very high level of explanatory power in predicting Operational Efficiency (OEF). The model's R value is 1.000, signifying a perfect linear relationship between the predictors and OEF. The R^2 value of 0.999 suggests that 99.9% of the variance in OEF is explained by these three variables, demonstrating

an excellent fit. The Adjusted R^2 is also 0.999, confirming that the model remains highly predictive even after accounting for the number of predictors. The F-statistic of 3747, with a p-value of <0.001, shows that the model is statistically significant, meaning that ATM, POS, and FSZ collectively have a substantial impact on operational efficiency.

Table 5: Model Coefficients – OEF

Predictor	Estimate	SE	t	p
Intercept	-23235	698	-33.28	< .001
ATM	9.61	2.86	3.36	0.006
POS	2.44	3.95	6.19	< .001
FSZ	10734	271	39.54	< .001

The model coefficients table provides insights into the influence of each predictor—ATM, POS, and FSZ—on the operational efficiency (OEF) of Deposit Money Banks.

The **intercept** value of -23235 ($p < 0.001$) is significant, though primarily serves as a baseline for the model. Each predictor's **estimate** reflects its contribution to OEF:

ATM has an estimate of 9.61, with a t-value of 3.36 and a p-value of 0.006, indicating a statistically significant positive effect on OEF. This means that increased ATM usage is associated with an increase in operational efficiency, albeit with a modest effect size.

POS has a significant estimate of 2.44 ($p < 0.001$), showing a stronger positive effect on OEF than ATM, suggesting that agency banking contributes more prominently to operational efficiency.

FSZ has an estimate of 10734 with an exceptionally high t-value of 39.54 ($p < 0.001$), indicating a substantial and highly significant impact on OEF. This suggests that as bank size increases, operational efficiency improves considerably.

Test of Hypotheses

The test of the hypotheses revealed significant impacts of ATM and agency banking adoption on the operational efficiency of Deposit Money Banks in Nigeria.

For **Hypothesis 1 (H01)**, which posits that "*ATM adoption does not have a positive significant influence on the operational efficiency of Deposit Money Banks in Nigeria*," the p-value of 0.006 indicates a significant effect, confirming that ATM usage enhances operational efficiency. Based on this result, H01 is rejected.

Similarly, **Hypothesis 2 (H02)** posits that *"Agency banking adoption does not have a significant effect on the operational efficiency of Deposit Money Banks in Nigeria"*. However, with a p-value of less than 0.001 for POS (proxy for agency banking) showing a statistically significant positive effect, H02 is also rejected.

Discussion

The findings of this study both align with and diverge from previous research regarding the influence of digital banking innovations—particularly ATMs and agency banking—on bank operational efficiency and performance. This study demonstrates significant positive impacts of ATMs and POS systems on operational efficiency in Nigerian banks, consistent with several studies conducted in different regions, although some notable contrasts exist.

In agreement with the studies conducted by Dulacha et al. (2024) and Sporta and Muganda (2021), which also highlighted strong positive correlations between agency banking and operational efficiency, this study confirms that POS systems (used here as a proxy for agency banking due to their widespread deployment at agent locations)[1] significantly contribute to bank efficiency. It is important to note, however, that agency banking encompasses a broader range of services beyond POS transactions, including cash deposits and withdrawals, bill payments, and account opening, which may not be fully captured by this proxy. *A methodological note explaining this proxy is provided in the footnote.* Dulacha et al. noted that agency banking enhanced bank performance in Kenya, suggesting that increased accessibility and digital platform integration lead to improved financial outcomes. Similarly, Sporta and Muganda advocated for banks to invest in digital strategies to achieve greater efficiency through agency banking.

The results of this study are also consistent with those of Assoumou et al. (2024), who found that ATMs positively impacted Cameroonian banks, while POS systems showed no significant effect. This divergence regarding POS efficacy may be explained by differing regulatory environments, levels of user education, and infrastructural disparities between Nigeria and Cameroon. In Nigeria, relatively more developed agent networks and stronger regulatory support may have facilitated higher POS adoption and integration into banking operations, whereas Cameroon's agent banking sector might be at a nascent stage with limited reach and customer awareness.

Additionally, Omole et al. (2023) and Orji et al. (2018) found positive correlations between e-banking services (including ATMs and POS) and the performance of Nigerian banks, further supporting this study's findings that ATMs are particularly influential.

However, contrasts emerge when comparing the results of this study with those of Jegede (2014), who reported only marginal performance improvements from ATMs in Nigeria due to high fraud risks that limited their operational effectiveness. Jegede's findings may reflect earlier challenges in ATM security, which have been mitigated in recent years through enhanced security protocols, biometric authentication, and regulatory reforms, allowing ATMs to now contribute more significantly to operational efficiency. Similarly, Nwankwo et al. (2021) found that ATM transactions positively influenced performance but reported weak impacts from POS and mobile banking. The stronger effects of POS observed in this study suggest that agency banking may have evolved significantly and is now playing a more prominent role in enhancing efficiency within Nigeria's banking sector. This shift could also be attributed to increased user education campaigns, improved agent training, and expansion of network infrastructure in rural and underserved areas, which have collectively boosted adoption rates and trust in agency banking services.

This study reinforces findings from various contexts indicating that ATMs and agency banking contribute positively to operational efficiency in banks. The variations, such as those observed in Jegede's and Nwankwo's works, may reflect regional differences and the evolving roles of security, infrastructure, regulatory frameworks, and user education in the effectiveness of these

[1] In this study, POS (Point of Sale) systems are used as a proxy for agency banking due to their integral role as one of the primary transaction channels at agent locations. However, it is acknowledged that agency banking encompasses a broader range of services beyond POS transactions, including cash deposits and withdrawals, bill payments, and account management activities. The use of POS as a proxy is justified by data availability and its prevalence as a measurable indicator of agency banking activity within Nigerian banks.

innovations. This study thus supports the notion that technological advancements in banking have a positive impact on operational outcomes, with ATM and agency banking innovations proving beneficial for Nigerian banks.

CONCLUSION AND RECOMMENDATIONS

This study has provided valuable insights into the influence of digital banking innovations, particularly ATMs and agency banking, on the operational efficiency and performance of Nigerian banks. The findings indicate that both ATMs and POS systems significantly enhance operational efficiency, aligning with previous research while also highlighting the evolving nature of these technologies in the Nigerian banking landscape. The positive correlations established between agency banking, as represented by POS systems, and bank performance echo the findings of earlier studies from different regions, reinforcing the notion that accessibility and digital integration are critical to financial success. Moreover, the study's results underscore the substantial role of ATMs in enhancing efficiency, suggesting that recent advancements in security and technology have mitigated earlier concerns regarding fraud and operational limitations.

However, the variations observed when comparing this study's results with earlier research, particularly in the cases of Jegede (2014) and Nwankwo et al. (2021), highlight the dynamic nature of banking technologies and their effectiveness. These contrasts underscore the need for continuous evaluation of digital innovations to ensure they meet the changing demands of the banking sector and consumer expectations.

Overall, this research concluded that technological advancements, particularly in the form of ATMs and agency banking, significantly contribute to the operational efficiency of banks in Nigeria.

The study recommends that Nigerian banks should ensure:

(1) Continued Investment in Financial Innovations: Deposit Money Banks (DMBs) in Nigeria should prioritize sustained investment in financial technologies such as ATMs, mobile banking, online banking, and agency banking to improve operational efficiency and remain competitive in the digital era.
(2) Enhancing Security and Fraud Prevention: Strengthen security measures for ATMs and online banking to address fraud concerns and build customer trust, thereby increasing adoption rates and service efficiency.
(3) Expanding Agency Banking Networks: DMBs should increase the reach of their agency banking networks, especially in underserved and rural areas, to enhance financial inclusion and operational efficiency.
(4) Collaborating with FinTech Firms: Collaborate with technology providers and FinTech companies to develop user-friendly platforms and innovative solutions that improve service delivery and customer satisfaction.
(5) Leveraging Data Analytics: Implement advanced data analytics to monitor the performance of financial innovations and identify areas for improvement, ensuring resources are allocated effectively.

(6) Customer Education and Awareness: Launch educational campaigns to increase awareness and understanding of digital banking tools among customers, reducing resistance to adoption and maximizing the benefits of these technologies.
(7) Regulatory Compliance and Policy Advocacy: Ensure compliance with regulatory standards for digital banking and advocate for policies that encourage innovation while safeguarding the interests of customers and stakeholders.
(8) Integration of Emerging Technologies: Explore and integrate emerging technologies such as artificial intelligence (AI), blockchain, and machine learning into existing systems to enhance efficiency, security, and customer experience.
(9) Periodic Assessment of Technological Impact: Conduct regular evaluations of the impact of these innovations on performance metrics to refine strategies and align them with evolving market demands.
(10) Capacity Building for Staff : Invest in training and capacity building for bank employees to effectively manage and leverage these innovations, ensuring smooth implementation and operation.
(11) Focus on Cost Efficiency: Optimize the cost structure associated with implementing and maintaining financial technologies to ensure long-term sustainability and profitability.
(12) Promotion of User-Centric Designs: Develop user-friendly interfaces and platforms to enhance customer experience and drive adoption of digital banking services.

While these recommendations offer a strategic roadmap for enhancing operational efficiency through digital banking innovations, their successful implementation in Nigeria requires careful consideration of contextual challenges. Nigerian banks often face infrastructural constraints, such as inconsistent power supply and limited internet connectivity, particularly in rural areas, which can hinder the expansion and effectiveness of agency banking networks and other digital services. Additionally, socio-economic factors like varying levels of digital literacy among customers necessitate robust education and awareness campaigns to ensure meaningful adoption. Regulatory frameworks, although improving, remain complex and sometimes restrictive, requiring banks to actively engage with policymakers to navigate compliance while fostering innovation. Furthermore, resource limitations, including budget constraints and skills shortages within bank staff, may impact the pace and quality of implementation. Therefore, banks must adopt a phased and adaptive approach, prioritising investments based on regional needs and leveraging partnerships with FinTech firms and community stakeholders to overcome these hurdles. Emphasising continuous staff training and leveraging data analytics will also be critical to monitor progress and address emerging challenges effectively. This pragmatic approach will increase the likelihood of achieving sustainable gains from financial technology innovations in Nigeria's dynamic banking environment.

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