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Technology Investment and Sustainable Growth of Listed Deposit Money Banks in Nigeria

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ABSTRACT: The study examined the effect of technology investment on sustainable growth of listed deposit money banks in Nigeria. The specific objectives was to analyze the effect of technology expense ratio, digitalization rate, IT infrastructure investment, technology adoption rate and innovation rate on sustainable growth of listed deposit money banks in Nigeria. *Ex post facto* design was adopted in the study. All the thirteen listed deposit money banks made up the study population. The sample size comprised eleven listed deposit money banks in Nigeria after removing Jaiz bank and Unity bank that were yet to publish their 2024 annual reports as at the time this study was being reported. Secondary data used in the study were sourced from the banks' annual reports from 2015 to 2024. Descriptive analysis was done in addition to test of correlation, test of multicollinearity, heteroskedasticity test, test of autocorrelation, linearity test, and test of cross-sectional dependence. The Panel Estimated Generalised Least Squares was used to test the hypotheses. It was found that: technology expense ratio has a positive and significant effect on sustainable growth of listed deposit money banks in Nigeria ($\beta = 0.4678$, $p = 0.0000$); digitalization rate has a negative but non-significant effect on sustainable growth of listed deposit money banks in Nigeria ($\beta = –0.0000095$, $p = 0.4961$); IT infrastructure investment has a positive and significant effect on sustainable growth of listed deposit money banks in Nigeria ($\beta = 3.7324$, $p = 0.0000$); technology adoption rate has a negative and significant effect on sustainable growth of listed deposit money banks in Nigeria ($\beta = –0.1614$, $p = 0.0000$); innovation rate has a negative and significant effect on sustainable growth of listed deposit money banks in Nigeria ($\beta = –0.8429$, $p = 0.0000$). In conclusion, the mere presence of technological initiatives or increased expenditure does not automatically translate into sustainable growth, instead, the effectiveness of technology investment appears to hinge on strategic alignment, proper implementation, and value optimization. The study recommends that bank executives of listed deposit money banks in Nigeria should ensure consistent and well-structured investment in technological operations, as well as allocate sufficient resources to maintain and upgrade technological systems in order to strengthen operational efficiency, enhance service quality, and ensure that technology spending translates into measurable long-term financial benefits.

Keywords: Technology Investment, Sustainable Growth, Technology Expense Ratio, Digitalization Rate, IT infrastructure investment

1.0 INTRODUCTION

The rapid evolution of technology has transformed the global financial landscape,

with deposit money banks (DMBs) increasingly relying on technological innovations to enhance operational efficiency, improve service delivery, and achieve sustainable growth. In Nigeria, a developing economy with a dynamic banking sector, the adoption of financial technologies (FinTech) such as mobile banking, internet banking, automated teller machines (ATMs), and point-of-sale (POS) systems has become a critical strategy for banks to remain competitive and meet the growing demands of stakeholders. In the banking industry of today, this wave of model automation is speedily bringing about a fusion of multiple technologies such as advanced analytics, clouds application, Block Chains, Machine learning among others, thereby compelling the financial institutions to shift from its traditional processing status quo (Vassallo, 2020; Mbagwu & Obonofiemro, 2023). Sustainable growth in this context refers to the ability of banks to achieve long-term financial performance, operational stability, and stakeholder value creation while addressing environmental, social, and governance (ESG) considerations.

The Nigerian banking sector has faced significant challenges, including poor financial performance, liquidity constraints, and bank failures, as evidenced by historical crises such as the 2009 banking sector intervention by the Central Bank of Nigeria (CBN), which led to the takeover of nine banks due to mismanagement and poor return on assets (ROA) (Sanusi, 2009; Adeyemi, 2011). These challenges underscore the need for strategic investments in technology to enhance operational efficiency and financial resilience. Scholars like Ogundajo et al. (2022) have investigated the impact of financial innovation on the return on assets of listed DMBs in Nigeria, finding that product and service innovations significantly influence financial performance, though the relationship varies across innovation types. Similarly, Odum et al. (2024) examined the effect of technology-based innovations, such as expenditure on IT infrastructure, on non-interest income of DMBs in Nigeria, concluding that such investments positively impact revenue streams.

The adoption of financial technologies has been linked to improved efficiency and competitiveness in the banking sector. For instance, a study on Tanzanian banks by Modern Finance (2021) found that a high FinTech index significantly enhances bank efficiency, particularly for larger banks, though smaller banks face challenges in technology integration. In Nigeria, Ogunode and Akintoye (2023) highlighted that FinTech adoption aids financial inclusion but is hampered by issues such as poor system interoperability and rural under coverage, suggesting that technology investments must be strategically aligned to maximize impact. Furthermore, Eze et al. (2024) explored the role of disruptive technologies in enhancing electronic income for Nigerian DMBs, emphasizing the transformative potential of advanced data analytics and machine learning in fraud prevention and operational efficiency.

Sustainable growth in banking also involves balancing profitability with social and environmental responsibilities. Samson and Tukur (2024) investigated sustainable banking practices in Nigeria, finding that investments in environmental innovation, while reducing non-performing loans, may pose liquidity challenges, highlighting a trade-off between sustainability and stability. Despite the growing body of research, the literature reveals mixed findings on the impact of technology investment on sustainable growth. While some studies, such as Okoye et al. (2024), suggest that FinTech enhances bank performance by improving access to capital and operational efficiency, others, like Ogundajo et al. (2022), note that certain innovations may have a negative or insignificant effect on specific financial metrics like ROA. Moreover, there is a paucity of studies that holistically address the interplay between technology investment and

sustainable growth, particularly in the context of Nigeria's unique economic and regulatory environment. This gap is significant, as Nigerian DMBs operate in a context marked by high competition, regulatory reforms, and socio-economic challenges, necessitating a nuanced understanding of how technology investments can foster long-term growth.

This study aims to fill this gap by examining the effect of technology investment and the sustainable growth of deposit money banks in Nigeria, focusing on key performance indicators such as return on assets (ROA), return on equity (ROE), and non-interest income, alongside sustainability metrics like ESG disclosures. By building on the works of authors like Ogundajo et al. (2022), Odum et al. (2024), and Samson and Tukur (2024), this research seeks to provide empirical evidence and policy recommendations to enhance the strategic deployment of technology for sustainable banking growth in Nigeria. The banking business has seen a radical change in the recent time due to financial technology. The supply of financial services through technology known as technological investment has fundamentally changed how financial institutions operate thereby creating new opportunities for environmentally friendly banking practices. Chen, Huang and Xu (2021), and Kumari and Devi (2022) reported that the rise in technological investment of banks have enhanced financial services' accessibility, efficiency and cost-effectiveness in Sub-Sahara Africa.

Technology investment in the banking sector characterized by rapid technological advancements and innovative strategies, has revolutionized operations across sectors. This evolution is not just a prevailing trend but an imperative for achieving sustainable development in the banking industry (Kumar, Arokiaraj, Gupta, Gandra, Chatterjee & Vishwakarma, 2021). The integration of digital technologies in banking operations has led to enhanced resource efficiency, reduced carbon footprint, and increased social responsibility, aligning with the broader goals of environmental sustainability. However, this transformation is not without its challenges. The rapid integration of digital solutions raises concerns about data privacy, electronic waste, and the digital divide, which need to be proactively addressed. Banks, especially in Africa, have not accelerated their digitalization efforts in response to the COVID-19 pandemic, which has further highlighted the need for a balanced approach that leverages digital transformation to advance sustainability while addressing these challenges (Miković, 2021).

In 2012, the Nigerian Sustainable Banking Principles (NSBP) was created through a joint effort by the Central Bank of Nigeria (CBN), the Bankers' Committee, and other stakeholders. Included in these principles are Environmental and Social Risk Management, Environmental and Social Footprint, Human Rights, Women's Economic Empowerment, Financial Inclusion, E & S Governance, Capacity Building, Collaborative Partnerships, and Reporting. These guidelines form the cornerstone of sustainable banking practices in Nigeria. Specifically, financial inclusion and capacity were used as a standard for assessing how well financial technology drives sustainability in the Nigeria banking system. Thus, the banking sector is crucial in directing the economy's growth toward a sustainable future (Ojo & Akinyede, 2023), hence the justification for the study.

1.1 Statement of Problem

The Nigerian banking sector plays a critical role in driving economic development through financial intermediation, yet it faces persistent challenges such as operational inefficiencies, high non-performing loans, and limited financial inclusion, particularly in rural areas (Sanusi, 2009; Adeyemi, 2011). The adoption of financial technologies (FinTech), such as mobile banking, internet banking, automated teller machines (ATMs),

and emerging innovations like artificial intelligence (AI) and blockchain, has been touted as a solution to enhance operational efficiency, diversify revenue streams, and promote sustainable growth among deposit money banks (DMBs). However, the extent to which technology investments translate into sustainable growth—encompassing financial performance, stakeholder value, and environmental, social, and governance (ESG) considerations—remains unclear in the Nigerian context. Nigeria faces significant challenges in achieving sustainable development across various sectors, particularly in aligning linked with the United Nations Sustainable Development Goals (SDGs) While efforts have been made to implement SDGs, full domestication remains unachieved (Benjamin et al., 2024).

Empirical studies present conflicting findings on the impact of technology investment on bank performance. For instance, Ogundajo et al. (2022) found that financial innovations positively influence return on assets (ROA) in Nigerian DMBs, but the effect varies by innovation type and bank size, with some innovations yielding insignificant or negative outcomes. Similarly, Odum et al. (2024) noted that technology-driven non-interest income enhances revenue diversification but is constrained by high implementation costs and infrastructural deficits. Furthermore, Samson and Tukur (2024) highlighted that while sustainable banking practices, supported by technology, reduce non-performing loans, they may strain liquidity, posing a trade-off between sustainability and financial stability. These inconsistencies suggest a need for a more comprehensive understanding of how technology investments drive sustainable growth in Nigerian DMBs.

Several contextual challenges exacerbate this problem. Nigeria's banking sector operates in an environment marked by economic volatility, unreliable power supply, limited internet penetration in rural areas, and regulatory complexities (Ogunode & Akintoye, 2023). These factors hinder the effective deployment of technology and limit its impact on financial inclusion and sustainability. Additionally, while the Central Bank of Nigeria's (CBN) cashless policy and Sustainable Banking Principles have spurred technology adoption, the long-term implications for sustainable growth, particularly in balancing profitability with ESG metrics, remain underexplored. The lack of holistic studies that integrate financial performance indicators (e.g., ROA, ROE, non-interest income) with sustainability metrics (e.g., ESG disclosures, financial inclusion indices) creates a significant gap in the literature

The problem is further compounded by the absence of clear evidence on how technology investments can be optimized to address Nigeria's unique socio-economic challenges, such as low digital literacy, cybersecurity risks, and uneven financial access across urban and rural divides. Without a thorough investigation, Nigerian DMBs risk misallocating resources to technologies that fail to deliver sustainable growth, potentially undermining their competitiveness and contribution to national development. This study seeks to address these issues by examining the relationship between technology investment and sustainable growth in Nigerian DMBs, with a focus on identifying the factors that enhance or inhibit the effectiveness of such investments in achieving long-term financial and non-financial outcomes.

The debate on relationship between technology investment and sustainable growth of listed deposit money banks in Sub-Sahara Africa showed little or no knowledge that exists which defines clearly the relationship between technology investment and banks sustainable growth. Despite the gains derivable from implementing ICT in modern commercial banking operations, commercial banks in Sub-Sahara Africa still face crucial challenges, difficulties and stress

in adopting and implementing ICT in their operational activities which has led to low performance level. Ogbeide, Onwumere, Agama, Humphrey, and Daniel (2023) and Ogbonna, Akwam, Okonkwo, Okaro, and Adigwe (2023) reported that recent technological investments in the banking sector have enhanced customer-focused services, improved regulations, and strengthened security, resulting in a shift from traditional to neo-banking in Nigeria. Okoro, Nnam, Joe, and Obizuo (2024) further showed that NDIC data from 2005 to 2021 reflect strong performance and expansion of Nigerian banks due to technology investment. However, most studies (e.g., Nasamu, 2020; Paul, 2024; Okeke, 2024) focused on profitability rather than sustainable growth. Therefore, this study examines the effect of technology investment on the sustainable growth of Nigerian banks.

1.2 Objectives of the Study

The main objective of this study is to examine the effect of technology investment on sustainable growth of listed deposit money banks in Nigeria and South Africa. The specific objectives of the study are to:

1. Analyze the effect of technology expense ratio on sustainable growth of listed deposit money banks in Nigeria.
2. Determine the effect of digitalization rate on sustainable growth of listed deposit money banks in Nigeria.
3. Examine the effect of IT infrastructure investment on sustainable growth of listed deposit money banks in Nigeria and South Africa.
4. Evaluate the effect of technology adoption rate on sustainable growth of listed deposit money banks in Nigeria.
5. Examine the effect of innovation rate on sustainable growth of listed deposit money banks in Nigeria.

1.3 Research Hypotheses

In order to direct the flow of this study, the following hypotheses were proposed in a null form as thus:

H_{01}: Technology expense ratio does not significantly influence sustainable growth of listed deposit money banks in Nigeria.

H_{02}: Digitalization rate has no significant effect on sustainable growth of listed deposit money banks in Nigeria.

H_{03}: IT infrastructure investment has no significant effect on sustainable growth of listed deposit money banks in Nigeria.

H_{04}: Technology adoption rate has not significantly influence sustainable growth of listed deposit money banks in Nigeria.

H_{05}: Innovation rate has no significant effect on sustainable growth of listed deposit money banks in Nigeria.

2.0 LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Technology Investment

Technology can be described as dynamic and complex strategic resources that modern digital organizations adopt and implement to enhance their operational activities and performance (Okafor et al., 2025; Dibie & Nworie, 2025; Mmadubuobi et al., 2024). Technology is a strategic tool to enhance innovativeness in banking industry specifically in the modern money deposit banking system and operations (Abu, Daniel & Kajo, 2024). Technologies are modern machinery that the banking industry uses to enhance changes in innovative strategies in competitive markets (Kiani, Yang, Ghani & Hughes, 2021) and enhances strategic growth and attain competitive strengths and advantage (Kiani, Kanwal & Wang, 2021). Technology investment (TI) has become an integral part of modern life, especially in high income countries. The ubiquity of ICT has led to its normalization in daily life, often rendering its environmental impacts invisible. However, there is a growing recognition of ICT as a potential solution to

sustainability challenges. This recognition comes with the need to address two major pitfalls: the environmental impacts of ICT itself and the risk of perceiving ICT as a neutral tool rather than a technology imbued with implicit values. Addressing these pitfalls requires a shift from an atomized and techno-biased understanding of ICT to an approach that acknowledges the broader socio material, political, and economic structures in which ICT operates (Odoyemi, Titilola, Adeola, Onyeka & Noluthando, 2024).

According to Paul (2024), in the realm of software engineering, sustainable practices are increasingly important. The environmental effects of software, such as e-waste from discarded computers due to software upgrades and the power demands of new software versions, are significant. Sustainable software engineering aims to create reliable, long-lasting software that meets user. Technology investment refers to firms that premise their financial services on a sound technology platform in a bid to invent new financial products and services which can reach a wider variety of entities, corporate and individual customers alike (Mlanga, 2019). One remarkable feature of investment in technology is its ability to ensure efficiency within the market and at same time keep transaction costs very low. Also, Kim, Park, Choi and Yeon (2023) described technology investment as a platform which provides for the intersection of technology and finance.

According to Cheng and Qu (2020), technology investment could have an effect on traditional banks through the use of technology interactions between banks and fintechs as well as between banks and companies outside of the fintech industry. Chen, Wu and Yang (2019) and Nguyen (2022), in their studies showed how investment in technology can enhance financial services by encouraging low-cost transactions, extending business models, and raising the quality of service. Investment in technology may be able to aid commercial banks in their efforts to diversify. On the other side, the disruptive-innovation theory suggests that new market entrants acquire cutting-edge technology and use them to provide services that are easily accessible and affordably priced (Nguyen, 2022). The customer hypothesis explains how FinTech businesses replace outdated banking services to satisfy client demand. According to the disruptive innovation idea, FinTech businesses compete aggressively with traditional banks by generating revenue from innovative technologies designed to give customers quick and affordable access to services.

2.1.2 Technology Expense Ratio

The term banking technology refers to the use of sophisticated information and communication technologies together with computer science to enable banks to offer better services to its customers in a secure, reliable and affordable manner and sustain competitive advantage over other banks (Floyd, Daniel & Patricia, 2024). According to Paul (2024) technology expenses are those expenses on core systems maintenance, modernization, innovation, transformative technology, data processing, equipment, software, digital initiatives, compliance, and cyber-security. Technology expense in the banking sector subsumes the activity of using advanced computer algorithms in unraveling the patterns of customer behavior by sifting through customer details such as demographic, psychographic and transactional data. This activity also known data mining, helps banks achieve their business objectives by solving various marketing problems such as customer segmentation, customer scoring, target marketing, market-basket analysis, cross-sell, up-sell, customer retention by modeling churn etc. Successful use of data mining helps banks achieve significant increase in profits and thereby retain sustainable advantage over their competitors (Usoro, 2022).

From theoretical perspective, banking technology is not a single, stand-alone discipline, but a confluence of several disparate fields such as finance (subsuming risk management), information technology, communication technology, computer science and marketing science. Banking Technology has three important dimensions. They are as follows according to the study of Ogbonna, Akwam, Okonkwo, Okaro and Adigwe (2023): (i) The use of appropriate hardware for conducting business and servicing the customers through various delivery channels and payments systems and the associated software constitutes one dimension of banking technology. The use of computer networks, security algorithms in its transactions, use of ATM and credit cards, Internet banking, telebanking and mobile banking are all covered by this dimension. The advances made in information and communication technologies take care of this dimension. (ii) On the other hand, the use of advanced computer science algorithms to solve several interesting marketing related problems such as customer segmentation, customer scoring, target marketing, market-basket analysis, cross-sell, up-sell and customer retention etc. faced by the banks to reap profits and outperform their competitors constitutes the second dimension of technology expense in the banking sector. This dimension covers the implementation of a data warehouse for banks and conducting data mining studies on customer data. (iii) Moreover, banks cannot ignore the risks that arise in conducting business with other banks and servicing their customers, for otherwise, their very existence would be at stake.

2.1.3 Digitalization Rate

Digitization in banking and financial services refers to the transformation of traditional financial activities, such as transactions, investments, and customer interactions, into digital formats. Digitalization leverages technology to improve efficiency, accessibility, and customer experience across various financial services. Digitization aims to enhance operational efficiency, reduce costs, expand financial inclusion, and improve the overall customer experience in the banking and financial services industry. The digitization of banking and finance presents an exciting opportunity to create a more efficient, inclusive, and customer-centric financial landscape. By embracing innovation and addressing its challenges, this digital revolution can reshape the ways we manage and interact with our finances (Ojo & Akinyede, 2023). According to Okoro, Nnam, Joe and Obizuo (2024), the digitization of banking and other financial services is a revolution reshaping how funds are managed. It offers a glimpse into a future filled with convenience, efficiency, and potentially, greater financial empowerment. However, challenges like cyber-security threats and the digital divide require careful consideration and solutions. The study notes also that as banks navigate this digital transformation, the key lies in leveraging technology responsibly and ensuring inclusivity. By doing so, they can unlock the full potential of digital banking and create a more accessible and secure financial landscape for everyone.

2.1.4 Information Technology Infrastructure Investment

Information technological infrastructure in business context is “a set of interrelated components that collect (or retrieve), store, and distribute information to support decision making and control in an organization”. Sailing along the same coast, Augustine, Chinwe and Emmanuel (2023) further described it as the application of communication technology and information to deal with the collection, storage, manipulation and transfer of information using electronic means. Technological infrastructure is defined as those facilities, machines, and tools that are used [at least in its basic form] to facilitate the execution of economic transactions/activities in an effective and efficient manner (Usoro, 2022). Some of the information technology infrastructure investments (i.e. devices, facilities, machines, ATM, POS and tools)

that are being used in financial institutions to facilitate operational activities are briefly identified to include: Automated Teller Machine (ATM), Point of Sales, and WEB Purchase.

2.1.5 Technology Adoption Rate

The role of technology in supporting the e-banking function has become increasingly complex. IT operations which are traditionally housed in a computer data center with user connections through terminals have become more and more dynamic and include distributed environments, integrated applications, telecommunications options, interest connectivity, and an array of computer operating platforms. As the complexity of technology has grown, banks have increased their reliance on vendors, partners, and other third parties for a variety of technology solutions and services (Ugwuanyi & Ugwuanyi, 2023). Okeke (2024) notes that banking modernization optimizes core systems, leveraging technology to streamline processes and improve efficiency. By integrating innovative solutions, banks can automate routine tasks, reduce manual errors, and accelerate transaction processing, leading to significant time and cost savings. Mgbemena and Onah (2024) reported that technology has the potential to bring about fundamental technological, social and economic changes that support innovation, efficiency, and opportunity maximization, also poses several challenges for organizations. These challenges include hyper-competition from all corners of the world, uncertainty in the nature of product and service offerings, and the absolute necessity to perceive and respond quickly to changing environments. The need for organizations to deploy assets or capabilities to match the prevailing needs of technology and other vital variables of the marketplace becomes inevitable. Hence, flexibility in technological capability is very important.

2.1.6 Innovation Rate

Innovation in the banking sector is the act of creating and then popularizing new financial instruments as well as new financial technologies, institutions, and markets (Makur, 2024). It may be viewed as the design, development, and implementation of innovative financial instruments and processes, and the formulation of creative solutions to problems in finance. According to Korir (2024), innovation is one of the most important competitive weapons and generally seen as a firm's core value capability. It is considered as an effective way to improve firm's productivity due to the resource constraint issue facing a firm. According to Makur (2024), commercial banks in Kenya have continuously been innovating new products, services and governance in order to improve their financial performance. The financial sector has over time developed successfully with innovation products and services available in financial market. Some of these products are debit cards, credit cards, ATM cards, M-pesa and others which facilitate the use of electronic means of payment and sometimes substitute for the use of physical cash. Similarly, these products gain a wider recognition in financial market leading to reduction of holding amount of money. The study notes that the latest service innovation will lead to furthering of financial inclusion and innovative service offerings for all Kenyans by presenting their financial services offering on to a single platform which will make banking services more accessible, flexible convenient and more affordable. Innovation in the banking sector is seen as an improvement in the array of financial products and instruments that are stimulated by unexpected change in customer needs and preferences, tax policy, technology and regulatory impulses.

2.1.7 Sustainable Growth

According to Tutun and Som (2019), sustainable growth is a growth that could be profitably maintained for future benefits. Sustainable growth as a concept was popularized by Higgins' remarkable study in

1977, where he proposed that sustainable growth rate model should be used to explain its practical limits to growing firms. Therefore, sustainable growth rate explains if there is consistency between the sales growth with the realities of the firm and the financial market. As reported by Yusuf, Emmanuel, Akpan and Odumegwu (2020), corporate sustainable growth is all about the financial performance information and non-financial performance information that includes social and environmental activities that enable firms to grow sustainably and friendly. The study of Buffa, Franch and Rizio (2020) submitted that to ensure sustainable growth, organizations must concede the following:

i. Responsible for their social, environmental and economic impact.
ii. Being transparent in decisions and activities affecting its responsibilities.
iii. Interests of the stakeholders to be responded to.
iv. The rule of law is mandatory for all.

A firm with growth rate which deviates from sustainable growth will eventually fall into the dilemma of unsustainable growth (Buffa, Franch & Rizio, 2020). For the purpose of this study, sustainable growth will be measured as return on equity multiplied by retention ratio. This is expressed as ROE (1-DPR).

2.2 Theoretical Expository Literature

2.2.1 Technology Expense Ratio and Banks Sustainable Growth

Technological expense in the banking sector are becoming more well-known and in the spotlight on a worldwide scale, but it is unclear how these advancements will impact the banking sector and traditional business models (Chen, Wu & Yang, 2019). Two opposing theories about how technology investment affects the economy are the "innovation-growth" hypothesis and the "innovation-fragility" theory. According to Okoro et al (2024), “innovation-growth" theory, which was put forth in 2021, investment in technology has a positive influence on bank performance because their technology expense can boost banks' capacity for risk distribution and promote the efficient use of resources. The major reason for technological expense is to remedy the challenges of traditional banking. Due to strict rules, traditional banks frequently have issues when providing loans (Zhao, Li, Yu, Chen & Lee, 2022). Okoro et al (2024) note that the market share of traditional financial institutions has decreased as a result of the rise of shadow banks resulting from increase in technology expense of banks. Siam (2023) examined the impact of technology investment on performance of Jordanian commercial banks. The study found a positive relationship between technology investment and performance of commercial banks in Jordan. The study goes further to note that majority of the banks are providing services on internet through their websites and this shows that the attention is more to achieving e-banking as satisfying and fulfilling customers’ needs. Thus, the study is of the opinion that there should be a well-articulated strategy to achieve success and profits in the long run through technology investment.

2.2.2 Digitalization Rate and Banks Sustainable Growth

Digitalization rate offers the convenience of conducting most of the banking transactions at a time that suits the customer with the aid of information technology IT. The customer can access funds and transfer funds between accounts, pay bills and make purchases 24 hours a day, 7 days a week. It could be seen as the provision of retail and small value banking products and services through electronic channels (Ugwuanyi & Ugwuanyi, 2023). Such products and services can include deposit taking, lending, account management, the provision of financial advice, electronic bill payment, and the provision of other electronic payment products and services such as electronic money (Basel Committee on banking supervision, 2024). Bank digitalization rate includes systems that enable financial institutions, customers, individuals and

businesses, to access accounts, transact business, or obtain information on financial products and services through public or private networks, including the internet. Customers access banks digitalization index through e-banking services using an intelligent electronic devise, such as a personal computer (PC), personal digital assistant (PDA), automated teller machine (ATM). Private networks "closed" restrict access to participant (financial institutions, customers, merchants, and third-party service providers) bound by agreement on the terms of membership. Public networks "open" have no such membership requirements (Okeke, 2024).

Melo de Brito, Tereza and Siegel (2022) investigated the return on investment for banks digitalization index (an analysis of financial account aggregation). The study revealed a positive and significant relationship between return on investment and banks digitalization index. The primary conclusion of the investigation is that banks digitalization index is a compelling technology that should become a commodity in the sense that most important banks will provide it, and it will represent no more a differentiated competitive advantage. Siam (2023) found a positive correlation between the impacts of bank digitalization and banks profitability in Jordan. Khrawish and Al-Sa'di (2021) found a positive relationship between bank digitalization services and banks profitability in Jordan. The study goes further and noted that banks digitalization services gives an indicator of high expenses and cost associated with applying these services. However, digitalization in the banking sector in Jordan according to the study is new and changing rapidly but ensures banks profitability.

2.2.3 Information Technology Infrastructure investment and Banks Sustainable Growth

Banking has become highly ICT based and due to its inter-sectoral link, it is reaping the benefits of technological revolution as evidenced by its application in most of its operations. Osabuohien (2022) carried out an empirical analysis on the anticipated role of ICT has in enhancing the operations of selected Nigerian banks in the light of current reforms. The study reported that investment in information technology infrastructure speeds up banking operations, productivity, profitability and ensures sustainability in the banking. This is crucial in the sector's current reforms where attention is focused on the ability of banks to attract and retain customers, which is mainly feasible through efficient service delivery that depend, to a large extent, on the use of ICT. The basic Zaghol, Ramdhan and Othman (2021) assert that information technology infrastructure investment makes it possible for bank customers to use their websites without being constrained by the need for faxes, phone confirmations, original signatures, or letter-writing. It consists of using the internet (www) to perform financial transactions rather than going to the banking hall with the aid of technological gadgets like computers. This serves as a payment method in addition to considerably simplifying online shopping. Payments are made by customers using contact or contactless cards, much like mobile banking (Sarma, 2023). Online debt repayment and the purchase of airline tickets rank as the two most common internet transaction kinds. It is necessary to increase awareness of and use of cashless banking because a sizeable section of the population is ignorant of the benefits of online transactions (Siyanbola, 2023).

According to Asare and Sakoe (2024), investment in information technology infrastructure in the banking sector has led to internet banking which enhanced bank productivity as well as transaction volume, cashier productivity, customer retention, service delivery, client services, and all other elements of bank services which ensures banks sustainable growth. By cutting operating expenses for banks and enabling them to run with fewer employees and faster, more efficient services, electronic banking

has increased the number of people in Ghana who have access to financial services. The study notes that the users can carry out services including money transfers, airtime top-ups, balance checks, password resets, and bill payments through the Internet banking platforms. Services for online banking offer benefits and drawbacks. Thus, the study is of the opinion that investment in information technology infrastructure could ensure banks sustainable growth. However, consumers and marketers must be aware of changing banking practices, security risks, logistical difficulties, a break in personal ties, and the transforming financial landscape.

Baccelli (2021) investigated whether investment in information technology (IT) {hardware, software and other IT services} influences the performance of European banks and found a relationship between total IT investment and improved bank profitability or efficiency indicating the existence of a profitability paradox. However, the impact of different types of IT investment (hardware, software and services) on banks' performance is heterogeneous. The study notes that the sustainability of European commercial banks under review depends on its investment in information technology infrastructure. Investment in IT services from external providers (consulting services, implementation services, training and education, support services) appears to have a positive influence on accounting profits and profit efficiency, while the acquisition of hardware and software seems to reduce banks' performance. Mittal and Dhingra (2021) evaluated the impact of computerization on the performance of Indian banks in terms of their profitability and productivity. After defining input and output parameters, the study found that investment IT ensures efficiency in banks productivity and profitability among the Indian firms.

2.2.4 Technology Adoption Rate and Banks Sustainable Growth

Far reaching changes in computers and communications technology have altered our way of life. It is this change which has also fundamentally altered the way in which banking is being performed. The basic functions of banking have remained the same but the way in which banking services are provided has altered (Rangarajan, 2021). Rangarajan (2021) itemized the evolution of technology adoption in banking as follows:

Firstly, it started off with computerization of a few key functions and departments in principal branches through adoption of what he called advanced ledger posting machines. These systems were designed to take care of the accounts related functions of the banks which were at the heart of banking operations and which had assumed great significance in terms of the need for accuracy and control. Secondly, the next progress was towards branch automation. This enabled setting up of “Single Window Service” facilities which were focused on the customers.

Thirdly, there was the emergence of network-based operations which were aimed at providing interbank connectivity. Fourthly, an important stage in the evolution of the user-friendly technology arrived with the deployment of ATMs and the adoption of Core Banking Solution which radically transformed the way banking was done by bankers and customers.

The introduction of these various technology products has had a beneficial impact on both banks sustainability and customers. Lin (2023) investigated whether the technology adoption (TA) can create economic value and competitive advantage. In contrast to past research, which generally assumed that technology adoption investment leads to IT capability that in turn leads to competitive advantage, this study examines technology adoption directly. The results of this study indicate that both technology adoption and human capital investment contribute directly to the overall value-creation performance of banking firms. Further, the study suggests

that technology adoption and human capital investment can have a negative interactive effect on the firm's value creation. The study goes further to note that firm's technology adoption should be seen as an integral tool for creating economic value and business sustainability instead of a business infrastructure that makes business operations efficient. The results of this study support the technology acceptance model adopted in the present study as a theoretical foundation.

Kabiru, Mohd and Norlena (2022) investigated the moderating effect of technology adoption in the relationship of business process reengineering (BPR) factors and the organizational performance. BPR factors are operationalized by change management, BPR strategy alignment, customer focus, management commitment, technology adoption and adequate financial resources. The technology adoption includes IT knowledge, IT operations and IT objects. The results of the study show that technology adoption moderated the relationship between BPR factors such as change management, customer focus, management commitment and overall organizational performance of the bank. Furthermore, the result revealed that technology adoption moderated the relationship between management commitment, customer service and management performance.

2.2.5 Innovation Rate and Banks Sustainable Growth

Innovation, characterized by the introduction of new financial products, services, technologies, and processes, has significantly impacted the banking industry. With no other considerations taken into account, technology continues to outperform its marginal costs. According to Hu and Xle (2022), innovation has improved substantially efficiency, productivity, and overall success in the banking sector. Furthermore, a perfect positive association was found between financial innovation and bank profitability. Innovation technologies encompass a wide range of advancements, including the development of online banking, mobile payment systems, blockchain technology, and algorithmic trading. Scholars have highlighted that these innovations have reshaped how banks operate and engage with customers (Pea-Assounga & Yao, 2021). Amin (2023) demonstrated that the adoption of digital banking technologies can enhance operational efficiency, reduce costs, and improve customer satisfaction. Similarly, Tufano (2023) found that banks embracing innovative solutions often experience improvements in transaction speed and accuracy. Innovation has a direct impact on customer engagement and satisfaction. Shahid, Islam, Malik and Hasan (2022) discussed how mobile banking apps have transformed the way customers interact with their banks, leading to increased customer loyalty.

Conversely, Walker and Milne (2020) highlighted the importance of addressing potential privacy concerns associated with innovative technologies. A study by Dash and Paul (2021) found that innovative technologies adoption have a positive and significant impact on bank performance in UAE. The study showed that overall innovation and technology adoption in the UAE banking sector contributes to competitiveness and performance. Similarly, revealed that green innovation increases financial performance and economic growth. Several other scholars also confirmed that green innovation improves financial performance (Mehraj, Jayadevappa, Haleem, Parveen, Madduri, Ayyagari & Dhabliya, 2021). In the short term, however, this link may not be apparent because of high initial investment costs and the impact of environmental and social aspects on organizational change acceptability. A study by Nazaritehrani and Mashali (2020) revealed that online banking reduces bank operational expenses which ensure its sustainable growth. According to Amin (2023), great customer satisfaction and retention are linked to the availability of

financial innovation services and user-friendliness. The study added that financial innovation services lead to a substantial association between customers' loyalty and satisfaction. Furthermore, Rahi, AbdGhani and Hafaz (2020) argued that some banks have implemented financial innovation to save costs while increasing customer service and satisfaction. Consequently, the study notes investment in financial innovation determines banks sustainability. Similarly, Pea-Assounga and Wu (2022) found that innovative technologies have significant and positive effects on customer satisfaction. The study went further to argue that innovative technologies is beneficial for bank clients and facilitates them to access their accounts and make transactions all across the world which ensures banks sustainable growth in Italy.

2.3 Theoretical Framework

2.3.1. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), posits that technology adoption is driven by Perceived Usefulness (PU) (the belief that a technology enhances performance) and Perceived Ease of Use (PEOU) (the belief that a technology is user-friendly). These factors influence users' behavioral intentions to adopt and use technology, which is critical for its successful implementation. In Nigerian money deposit banks, TAM explains how employees and customers perceive and adopt technologies such as mobile banking, internet banking, and automated teller machines (ATMs). High PU and PEOU can enhance technology adoption, leading to improved operational efficiency, customer satisfaction, and financial inclusion, which contribute to sustainable growth. This study uses TAM to investigate how user perceptions of technology investments drive their adoption and impact growth metrics like profitability and customer retention.

Agwu and Carter (2014) examined mobile banking adoption in Nigeria and found that PU and PEOU significantly influenced customers' acceptance of mobile banking platforms, leading to increased financial inclusion and bank performance. Their study supports the relevance of TAM in explaining technology adoption in Nigerian banks.

Okeke and Okeke (2019) studied internet banking in Nigeria and confirmed that PU and PEOU positively affected customer adoption, which improved service delivery and bank profitability, aligning with sustainable growth objectives. Olatokun and Ojo (2014) investigated ATM adoption in Nigeria and found that ease of use was a critical determinant of customer acceptance, directly impacting banks' operational efficiency and customer base expansion. These studies validate TAM's applicability in the Nigerian banking context, showing that technology acceptance drives outcomes like customer satisfaction and financial performance, which are key to sustainable growth.

2.3.2. Diffusion of Innovations Theory (DOI)

The Diffusion of Innovations Theory, proposed by Rogers (1962), explains how innovations spread within a social system based on five attributes: relative advantage, compatibility, complexity, trialability, and observability. The theory also categorizes adopters into groups (e.g., innovators, early adopters) based on their adoption speed. DOI is relevant for understanding how technological innovations, such as fintech solutions, blockchain, and AI-based systems, are adopted by Nigerian banks and their customers. Technologies that offer relative advantages (e.g., cost efficiency), are compatible with existing systems, and are less complex are more likely to be widely adopted, enhancing competitiveness and market expansion. This study applies DOI to explore how the attributes of technology investments influence their diffusion and contribute to sustainable growth through improved service delivery and operational efficiency.

Eze and Chiejina (2017) studied the diffusion of mobile banking in Nigeria and found that relative advantage and compatibility significantly influenced adoption rates, leading to increased customer reach and bank profitability. Their findings highlight DOI's relevance in explaining technology diffusion in Nigerian banks. Akinyemi and Mushunje (2020) examined fintech adoption in African banks and found that trialability and observability accelerated diffusion, enabling banks to expand services to underserved populations, a key factor in sustainable growth. Kolodinsky et al. (2004), in a broader context, confirmed that technologies with low complexity and high relative advantage were adopted faster in banking, improving operational efficiency and market competitiveness, which is applicable to Nigeria's evolving banking sector. These studies demonstrate that DOI's attributes explain the adoption of banking technologies in Nigeria, supporting sustainable growth through enhanced market penetration and operational improvements.

2.3.3. Resource-Based View (RBV)

The Resource-Based View (RBV), developed by Barney (1991), argues that a firm's competitive advantage stems from resources that are valuable, rare, inimitable, and non-substitutable (VRIN). Technology investments, such as advanced IT infrastructure and cybersecurity systems, are strategic resources that can differentiate banks in a competitive market.

RBV provides a framework to evaluate how technology investments serve as strategic resources that drive sustainable growth in Nigerian banks. Investments in unique technologies (e.g., AI-driven analytics, secure digital platforms) can enhance efficiency, customer trust, and market positioning, contributing to long-term sustainability. This study uses RBV to analyze how technology investments, as VRIN resources, create competitive advantages and support growth metrics like profitability and operational resilience.

Odeh and Okoye (2019) investigated IT investments in Nigerian banks and found that robust IT infrastructure (a VRIN resource) improved operational efficiency and customer trust, leading to sustained financial performance. Their study supports RBV's role in linking technology to sustainable growth. Barney et al. (2011), in a global context, confirmed that firms leveraging unique technological resources gained competitive advantages, a finding applicable to Nigerian banks investing in proprietary systems like AI or blockchain. Adeniran and Ojo (2021) studied cybersecurity investments in Nigerian banks and found that inimitable security systems enhanced customer confidence and reduced financial losses, contributing to long-term sustainability.

These studies underscore RBV's relevance in the Nigerian banking sector, showing that strategic technology investments create competitive advantages that drive sustainable growth.

2.3.4 Integration of Theories and Empirical Insights

The integration of TAM, DOI, and RBV provides a holistic framework for understanding how technology investments drive sustainable growth in Nigerian money deposit banks. TAM explains individual-level acceptance through PU and PEOU, supported by studies like Agwu and Carter (2014), which link user acceptance to improved bank performance. DOI extends this by examining the diffusion process, with studies like Eze and Chiejina (2017) showing how technology attributes accelerate adoption and market expansion. RBV emphasizes the strategic role of technology, with studies like Odeh and Okoye (2019) demonstrating how VRIN resources enhance competitiveness and sustainability. In the Nigerian context, this integrated framework

suggests that sustainable growth is achieved when technology investments are:

Perceived as useful and easy to use (TAM), encouraging adoption by employees and customers. Widely diffused due to favorable attributes (DOI), expanding market reach and operational efficiency. Leveraged as strategic resources (RBV), creating competitive advantages that ensure long-term sustainability. For example, a bank's investment in a mobile banking platform must be user-friendly (TAM, supported by Okeke and Okeke, 2019), compatible with local needs to ensure diffusion (DOI, supported by Eze and Chiejina, 2017), and unique to provide a competitive edge (RBV, supported by Odeh and Okoye, 2019). This synergy drives sustainable growth through enhanced profitability, customer satisfaction, and operational resilience.

2.4 Empirical Review

Bamidele, Soyebo, and Olaiya (2024) investigated the effect of emerging technology adoption on the financial performance of Deposit Money Banks (DMBs) in Nigeria using monthly data from 2012 to 2019 and the Fully Modified Ordinary Least Squares (FMOLS) regression method. Their findings revealed that web payments, mobile money, Automated Teller Machines (ATMs), and Point of Sale (POS) terminals have positive long-run effects on bank performance, implying that technology adoption enhances operational efficiency and service delivery. Similarly, Mgbemena and Onah (2024) examined how technology adoption influences profitability in Nigerian banks using multiple regression analysis. Their results showed that ATM and POS usage significantly improve Return on Equity (ROE), whereas web-based and mobile transactions were not statistically significant, suggesting uneven effects of digital channels on profitability.

In a related study, Yusuf, Ologunwa, and Obamuyi (2024) explored how financial technology affects the financial performance of DMBs in Southwest Nigeria using an ex-post facto research design. The study found that digital banking tools such as ATMs, mobile banking, internet banking, and POS terminals significantly enhance returns on assets, equity, and net income. They further reported that a 1% rise in ATM transactions increases return on assets by 0.18%, while a 1% increase in mobile banking boosts it by 0.29%. Similarly, Okoro et al. (2024) examined the impact of ATM, POS, and internet banking transactions on liquidity ratios and bank performance using regression analysis. Their findings indicated that ATM and POS transactions positively influence performance, while internet banking has a negative effect, suggesting operational inefficiencies or security challenges in digital platforms.

Odoyemi et al. (2024) conducted a qualitative review of sustainable IT practices in Nigerian banking from an environmental perspective. They observed that while some banks adopt green IT initiatives such as paperless operations and energy-efficient data centers, overall adoption remains low due to poor infrastructure, limited awareness, and weak regulatory frameworks. Nonetheless, they noted that sustainable IT enhances cost efficiency and corporate image. Likewise, Okeke (2024) studied the effect of Information and Communication Technology (ICT) on the performance of listed consumer goods firms in Nigeria between 2013 and 2022 using regression analysis. The results showed that funding for ICT hardware and software negatively and insignificantly affected Return on Capital Employed (ROCE), implying that excessive investment in ICT without corresponding productivity gains may diminish firm returns.

Paul (2024) examined the effect of artificial intelligence (AI) investments on the performance of Nigerian DMBs from 2012 to 2022. Using Ordinary Least Squares (OLS), the study found that software book value negatively and significantly affects ROE, while software expenses are insignificant.

However, AI investments collectively influence bank performance, indicating that while AI holds potential, its benefits depend on proper integration and utilization. Similarly, Abu, Daniel, and Kajo (2024) assessed ICT usage among Nigerian banks through quantitative methods. Their findings showed that ICT and digitalization significantly enhance strategic decisions, competitiveness, and customer satisfaction, confirming ICT's vital role in modern banking operations.

Ojoh and Akinyede (2023) focused on financial technology and bank sustainability using survey data from 385 bank users. Their analysis revealed that fintech adoption significantly drives sustainability, financial inclusion, and capacity building in Nigerian banks. Likewise, Augustine, Chinwe, and Emmanuel (2023) analyzed the effects of DMBs' technological infrastructure investments on performance using regression analysis. The results demonstrated that such investments significantly improve net interest income, e-business income, and customer deposits, though their impact on net profit after tax was positive but insignificant.

Ugwuanyi and Ugwuanyi (2023) found that information technology expenditure negatively, though insignificantly, influences bank profitability, suggesting that high IT spending may not always yield immediate financial benefits. Similarly, Okonkwo, Obinozie, and Echekoha (2023) reported that e-banking and ATM investments did not significantly improve bank performance, indicating that returns from technology-driven services depend on operational efficiency and customer adoption.

Nwosu, Ubi, and Fred (2022) examined banking innovation and sustainable development in Nigeria from 2005 to 2020 using the ARDL approach. Their findings revealed that banking innovation—measured by POS, ATM, and mobile banking—positively and significantly contributes to sustainable development as reflected in the Human Development Index. Correspondingly, Ola-Olatinwo, Uwaleke, and Ibrahim (2022) explored the influence of digital financial services on banks' financial performance using the ARDL technique. The study found that fintech significantly affects Return on Assets (ROA), Return on Equity (ROE), and non-interest income but not interest income, suggesting a partial effect of digital services on profitability.

Bilkisu and Kabiru (2021) examined the impact of IT investment on banks' financial performance from 2016 to 2020 using panel regression. Results showed that IT investments significantly influence ROA, ROE, and Earnings per Share (EPS), though the effect on Net Profit Margin (NPM) was insignificant. However, IT investments had an unexpected negative sign across performance indicators, implying short-term cost implications. Onuorah and Okoh (2021) found that ICT investment positively and significantly affects deposit base, profitability, and asset size, though it has no effect on loan-deposit ratios.

Gambo (2020) established that technological innovation—comprising ATMs, mobile, and internet banking—significantly enhances commercial banks' performance. Similarly, Aggreh, Malgwi, and Aggreh (2020) employed longitudinal analysis and found that ICT investments do not influence financial performance in the short term, though they may yield benefits in the long run. Collectively, the reviewed studies demonstrate a consistent pattern: technological investments generally improve banks' operational efficiency, profitability, and sustainability, though outcomes vary based on implementation strategy, infrastructure readiness, and integration effectiveness.

Chukwukaelo, Onyeiwu, and Amah (2020) investigated how different electronic channels influence the profitability of Deposit Money Banks (DMBs) in Nigeria. Using panel regression and the generalized

method of moments (GMM), their study found that electronic channels significantly and positively affect banks' return on equity (ROE), implying that technology adoption improves profitability. Similarly, Akani and Obiosa (2020) assessed the effect of financial innovation—specifically automated teller machines (ATMs), electronic funds transfers (EFT), internet banking, mobile banking, and ICT investment—on DMB profitability between 2009 and 2017. Their regression results revealed that while ATMs and EFT have negative relationships with ROE, internet and mobile banking, alongside ICT investment, positively influence bank profitability.

Meshack, Charles, and Mercy (2020) examined the dynamic impact of ICT investments on Nigerian banks between 2010 and 2017 using a longitudinal design. Their findings indicated that ICT investments do not yield immediate returns but show significant positive effects in subsequent years, suggesting a lagged relationship between technological investment and financial performance. Usman (2020), analyzing ATM, POS, and internet banking operations in Nigeria, found that while POS usage significantly enhances financial inclusion, internet banking and ATMs have insignificant effects.

In another study, Nasamu (2020) employed multiple regression on data from 2008–2019 to evaluate the effect of banking innovations on the financial performance of listed commercial banks. The results revealed that ATMs, internet banking, and mobile banking all have significant and positive impacts on financial performance, highlighting the profitability of digital innovations. Earlier, Chukwukaelo, Onyeiwu, and Amah (2019) found similar evidence that electronic banking channels—ATMs, POS, internet banking, and mobile banking—positively and significantly affect ROE in Nigerian DMBs.

Expanding beyond Nigeria, Binuyo and Aregbeshola (2023) explored ICT's influence on South African banks (2000–2022) and found that ICT adoption improves return on assets and capital employed, mainly through cost efficiency. Likewise, Oladunjoye and Tshidzumba (2023) used principal component analysis to establish a strong and direct link between technology adoption and financial market performance in Nigeria and South Africa. Ogbonna et al. (2023) also reported that fintech significantly enhances the performance of financial institutions across Sub-Saharan Africa.

In related contexts, Nkosi (2022) confirmed that technological investment significantly improves South African banks' productivity and financial outcomes, while Jean et al. (2024) found in Congo that financial innovation positively influences employee and customer satisfaction as well as bank performance. Conversely, Malit and Muendo (2023) discovered that ICT investment costs negatively affect Kenya's insurance sector, as financial gains may not immediately follow.

Further evidence from Zhao et al. (2023) indicated that fintech adoption across European banks (2015–2021) strengthens capital adequacy, asset quality, management efficiency, and liquidity. Mahboub (2022) also found that mobile and card banking significantly enhance Lebanese banks' performance, while ATMs and POS terminals have insignificant effects. Similarly, Daniel and Tabitha (2022) revealed that digital innovations—mobile, internet banking, ATMs, and EFT—positively affect profitability and return on assets of Kenyan banks.

Supporting these findings, Peter, Yaw, and Ussiph (2020) showed that IT significantly improves the operational efficiency of Ghanaian banks, with 78.82% of branches performing efficiently. Likewise, Matevu and Kerongo (2020) established that technological innovations substantially

enhance the financial performance of Kenyan banks. Finally, Mabrouk (2019), examining Arab nations, found that both product and process financial innovations have positive and significant impacts on banking performance.

2.6 Gaps in Knowledge

From the a priori expectations, most studies on technological investments in Sub-Sahara Africa (Nasamu, 2020; Bilkisu & Kabiru, 2022; Binuyo & Aregbeshola, 2022; Usoro, 2022; Nwankwo & Okoli, 2023; Ojo & Akinyede, 2023; Ugwuanyi & Ugwuanyi, 2023; Ogbonna, Akwam, Okonkwo, Okaro & Adigwe, 2023; Odoyemi, Titilola, Adeola, Onyeka & Noluthando, 2024; Jean, Hongxing, Grace, Prince, and Jonathan, 2024; Okoro, Nnam, Joe & Obizuo, 2024; Okeke, 2024; Paul, 2024; Abu, Emmanuel & Kajo, 2024; Floyd, Daniel & Patricia, 2024; etc) focused on corporate performance other than corporate sustainable growth which reflects the firm's sustainability level from the investors' perspective. Also, none of these studies in the Sub-Sahara Africa limited technological investments to banks' sustainable growth to the best of our knowledge. More so, there is no known study that have examined the cross-sectional effect of technological investments on sustainable growth using listed deposit money banks in Nigeria and South Africa as a reference point based on the available literature. Hence the need for the present study to examine the relationship which exists between technology investments and sustainable growth of listed deposit money banks in Nigeria and South Africa.

Also, most of the research findings in Sub-Sahara Africa demonstrated a positive and substantial link between technological investment and corporate performance (Emmanuel, Luther-King & Bongani, 2018; Matevu & Kerongo, 2019; Peter, Yaw & Ussiph, 2019; Meshack, Charles & Mercy, 2020; Onuorah & Okoh, 2021; Odum, Odum & Chukwu, 2021, Ogbeide, Onwumere, Agama, Humphrey & Daniel, 2023; Yusuf, Ologunwa & Obamuyi, 2024; Bamidele, Soyebo & Olaiya, 2024; etc). It therefore becomes necessary to evaluate how technological investments in the banking sector interacts with banks' sustainable growth which is a more intricate version of corporate performance using the entire listed deposit money banks in Nigeria and South Africa as a reference point. Thus, will enable banks to fulfill their responsibility for social, ecological and environmental protection and also identify and optimize more clearly the sustainability of their operations and activities.

3.0 Methodology

The research design used in this study is *Ex Post Facto* Design. It is a design that predicts the effect of one variable (independent variables) on the other variable (dependent variable). It is alternatively referred to as causal comparative design (Elom et al., 2025; Adeyemi & Ajinbola, 2019). *Ex Post Facto* design was adopted because the data to be used cannot be manipulated or controlled. The study used secondary data and was sourced from the Nigerian Exchange Group (NGX) Factbook and Audited Annual Reports and Accounts of the listed deposit money banks available at the website of the NGX. The study covers the period of ten (10) financial years (2015-2024). The population for this study consists of the 13 money deposit banks (MDBs) listed on the Nigerian Stock Exchange (NSE) as of the period covered by the study (2015–2025). These banks represent the major players in Nigeria's commercial banking sector, making them suitable for analyzing the relationship between technology investment and sustainable growth. However, two banks were excluded from the study due to the unavailability of their financial reports for the final year of the study period. The sample size for this study consists of 11 money deposit banks selected from 13 MDBs listed in Nigeria Stock Exchange for analysis. The sample size comprised eleven listed deposit money banks in Nigeria after removing Jaiz bank and Unity bank that were yet to publish

their 2024 annual reports as at the time this study was being report.

The study used panel data covering a period of 10 years (2015-2024). This is a period at which Nigerian Code of Corporate Governance (NCCG) and CBN Corporate Governance Guidelines (CCGG) were introduced and referred to by the listed banks in Nigeria.

Data to be generated from the study was collated and analyzed using Panel Regression Model (Hausman Test) operated with E-Views 12. Thus, that helped examining the effect of our explanatory variables (TER, DR, ITII, TAR & IR) on dependent variable (SG). Descriptive analysis was done in addition to test of correlation, test of multicollinearity, heteroskedasticity test, test of autocorrelation, linearity test, and test of cross-sectional dependence. The Panel Estimated Generalised Least Squares was used to test the hypotheses.

Ho (null hypothesis) was accepted if the P-value is greater than the 5% significant adopted as a standard and was rejected where the P-value is less than the 5% significant adopted. i.e. where $P > 5\%$, we accepted null hypothesis and where $P < 5\%$, we rejected null hypothesis. The dependent variable in this study is sustainable growth and it was proxied and measured using sustainable growth rate. This is in harmony with the works of Taiwo, Johnson, Aderemi and Tajudeen (2023) etc. Also, the independent variable was proxied using technology expense ratio (TER), Digitalization rate (DR), IT Infrastructure investment (ITII), technology adoption rate (TAR) and innovation rate (IR) while firm size on the other hand was measured using the log of firm size.

Table 3.1 Measurements of the Variables

Variables	Measurement	Sources	A Priori Expectations
Independent Variabl			
Technology Investment:			
Technology Expense Ratio (TER)	The ratio of technology expenses to total operating expenses	Chen, Wu and Yang (2019), Zhao, Li, Yu, Chen and Lee (2023)	It is expected to have a positive effect.
Digitalization Rate (DR)	The ratio of Digital Revenue to Total Digital Capital Expenditures	Fan, Yang and Tajul Ariffin Masron(2024)	It is expected to have a positive effect.
IT Infrastructure Investment (ITII)	Information Technology (IT) Capital Expenditures divided by Total Capital Expenditures	Onuorah and Okoh (2021), Ugwuanyi and Ugwuanyi (2023), Okeke (2024), Paul (2024)	It is expected to have a positive effect.
Technology Adoption Rate (TAR)	Revenue from Electronic Transactions dividend by Total Operating Cost	Odoyemi, Titilola, Adeola, Onyeka and Noluthando (2024),	It is expected to have a positive effect.

Innovation Rate (IR)	R&D spending divided by total operating expenses	Jean, Hongxing, Grace, Prince and Jonathan (2024)	It is expected to have a positive effect
Control Variable:			
Firm Size (FZ)	Measured as a natural logarithm of total asset	Frances and Nworie (2025)	It is expected to have a positive effect.
Dependent Variable			
Sustainable Growth	ROE(1-DPR)	Taiwo, Johnson, Aderemi and Tajudeen (2023)	

Source: Researcher's Compilation (2025)

In line with the previous researches, the study adapted and modify the Models of Oladunjoye and Tshidzumba (2023) and Okeke (2024) in examining the relationship between technology investment and sustainable growth of listed deposit money banks in Nigeria. This is shown below as thus:

Oladunjoye and Tshidzumba (2023): $\mathbf{FMP = \beta_0 + \beta_1 TECH + \mu}$
Okeke (2024): $\mathbf{ROCE = \beta_0 + \beta_1 FICTH + \beta_2 FICTS + \beta_3 FSZ + \mu}$
Where:
FMP = Financial Market Performance
TECH = Technology Adoption
ROCE = Return on Capital Employed

FICTH = Funding for ICT Hardware
FICTS = Funding for ICT Software
FSZ = Firm Size
Thus, to ascertain the effect of technology investment on sustainable growth of listed deposit money banks on the NGX, the study adopt the following models in a bid to provide answers to the null hypotheses of the study.

The modified functional model for the study is expressed as:
SG = *f* (TER, DI, ITII, TAR, II & FZ)……..……...i

The general econometric model used for the study is specified as thus;
Model:
$SG_{it} = \beta_0 + \beta_1 TER_{it} + \beta_2 DR_{it} + \beta_3 ITII_{it} + \beta_4 TAR_{it} + \beta_5 IR_{it} + \beta_6 FZ_{it} + \varepsilon_{it}$ ii
Where;
SG = Sustainable Growth
TER = Technology Expense Ratio
DR= Digitalization Rate
ITII = IT Infrastructure Investment
TAR = Technology Adoption Rate
IR = Innovation Rate
FZ = Firm Size (Control Variable)
μ = Stochastic Term

$\beta_1 - \beta_6$ = Coefficient of Regression Equation
β_0 = Constant coefficient (intercept) of the model
'*A Priori*' is given as: $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 > 0$

4.0 DATA ANALYSIS

4.1 Descriptive Analysis

Table 4.1 shows the descriptive statistics for each variable used in the study.

Table 4.1 Descriptive Analysis of Data

	SG	TER	DR	ITII	TAR	IR	FZ
Mean	0.107823	0.059210	17.00441	0.001922	0.131449	0.001330	9.327908
Median	0.097700	0.031252	1.741686	0.001362	0.074802	0.000000	9.459073
Maximum	0.525817	1.757986	731.5853	0.012945	5.543256	0.023084	10.63651
Minimum	-0.174979	0.000000	0.000000	9.36E-07	0.000000	0.000000	7.880253
Std. Dev.	0.096332	0.173874	92.91989	0.001945	0.527450	0.004275	0.698794
Skewness	1.186266	8.738716	6.797088	2.438143	9.958719	3.485875	-0.500697
Kurtosis	6.787740	84.70637	48.90301	12.17144	102.6186	14.65337	2.360451
Jarque-Bera	91.55612	31998.05	10504.49	494.5118	47302.59	845.1954	6.470809
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.039344
Sum	11.86048	6.513119	1870.486	0.211470	14.45937	0.146349	1026.070
Sum Sq. Dev.	1.011514	3.295323	941117.5	0.000412	30.32416	0.001992	53.22608
Observations	110	110	110	110	110	110	110

Source: Eviews 10 Statistical Output (2025)

As shown in Table 4.1, the sustainable growth (SG) of the listed deposit money banks in Nigeria recorded a mean value of 0.1078, indicating that on average, the banks achieved an annual growth rate of about 10.78% within the period of 2015–2024. The minimum value of –0.1749 suggests that some banks experienced negative growth in certain years, while the maximum value of 0.5258 implies that a few banks attained a sustainable growth rate as high as 52.58%. The standard deviation of 0.0963 shows moderate dispersion around the mean, suggesting that sustainable growth among banks was relatively consistent. The positive skewness (1.1863) indicates a right-tailed distribution, meaning that most banks recorded growth rates below the mean, with a few achieving exceptionally high growth. The kurtosis value of 6.7877, being greater than 3, suggests a leptokurtic distribution, implying the presence of outliers. Although the Jarque-Bera probability (0.0000) indicates deviation from normality, the large sample size (n = 110) satisfies the Central Limit Theorem, which assures that the sampling distribution of the mean approximates normality, thus validating the reliability of the statistical analysis.

From Table 4.1, the technology expense ratio (TER) has a mean of 0.0592, implying that about 5.92% of total operating expenses of Nigerian deposit money banks were spent on technology-related costs during the study period. The minimum value of 0.0000 shows that some banks reported negligible or no technology spending in certain years, while the maximum value of 1.7579 reflects that a few banks allocated a disproportionately large share of their operating costs to technology. The standard deviation of 0.1739 suggests considerable variability in technology spending patterns among banks. The high positive skewness (8.7387) and kurtosis (84.7064) indicate that the distribution is extremely right-skewed and leptokurtic, implying the presence of extreme outliers. Although the Jarque-Bera probability of 0.0000 rejects normality, the large sample of 110 observations allows reliance on asymptotic properties under the

Central Limit Theorem, supporting further parametric analysis.

According to Table 4.1, the digitalization rate (DR) shows a mean value of 17.0044, indicating that on average, digital revenue accounted for a moderate proportion of total digital capital expenditure, though with significant variation. The maximum value of 731.5853 and minimum of 0.0000 reflect wide disparities among banks, suggesting that some banks have achieved advanced digital transformation, while others remain at early stages. The standard deviation of 92.9199 confirms this wide dispersion. The skewness of 6.7971 and kurtosis of 48.9030 signify a highly non-normal distribution with extreme positive outliers. The Jarque-Bera probability (0.0000) supports this, indicating statistical non-normality. Nevertheless, with 110 observations, the Central Limit Theorem justifies proceeding with inferential analysis, as the sampling distribution of the mean tends toward normality.

As presented in Table 4.1, the IT infrastructure investment (ITII) variable has a mean value of 0.001922, signifying that only about 0.19% of total capital expenditures were allocated to IT infrastructure across the banks. The maximum value of 0.0129 and minimum of approximately 0.0000 demonstrate that IT investment levels remain relatively low across the sector, with minor differences among banks. The standard deviation of 0.001945 indicates low variability, suggesting a generally consistent but limited investment in IT infrastructure. The positive skewness (2.4381) and high kurtosis (12.1714) suggest that a few banks invested substantially more in IT than others, creating a right-skewed and leptokurtic distribution. Despite the Jarque-Bera probability of 0.0000 indicating non-normality, the robustness of the results is ensured by the sample size of 110, consistent with the Central Limit Theorem.

Table 4.1 shows that the technology adoption rate (TAR) has a mean of 0.1314, suggesting that revenue from electronic transactions accounts for approximately 13.14% of total operating costs, indicating a growing reliance on digital platforms among Nigerian banks. The minimum value of 0.0000 implies that some banks had little or no electronic transaction revenue in certain years, whereas the maximum of 5.5433 reveals that a few banks generated significantly higher electronic revenues relative to costs. The standard deviation of 0.5275 reflects substantial variability in adoption rates across banks. The high skewness (9.9587) and kurtosis (102.6186) reveal a highly skewed and peaked distribution, confirming the presence of outliers. Although the Jarque-Bera probability (0.0000) rejects normality, the relatively large dataset (n = 110) supports the validity of inferential analysis through the Central Limit Theorem.

From Table 4.1, the innovation rate (IR) has a mean of 0.00133, indicating that R&D spending constitutes only about 0.13% of total operating expenses among Nigerian deposit money banks. The maximum value of 0.0231 and minimum of 0.0000 suggest that most banks invest minimally in research and development, with only a few allocating meaningful resources toward innovation. The standard deviation of 0.0043 points to limited variation in innovation spending. However, the skewness (3.4859) and kurtosis (14.6534) indicate a highly right-skewed and peaked distribution, implying that few banks stand out with relatively higher R&D intensities. Although the Jarque-Bera probability of 0.0000 signals non-normality, the sufficient sample size ensures that the mean estimates remain consistent and reliable under the Central Limit Theorem.

Table 4.1 reveals that firm size (FZ), measured as the natural logarithm of total assets, has a mean of 9.3279, indicating that most of the banks in the sample are relatively large financial institutions. The minimum value of 7.8803 and maximum of 10.6365

suggest notable variation in asset size, reflecting both medium-sized and very large banks within the sample. The standard deviation of 0.6988 demonstrates moderate dispersion around the mean, implying a reasonably balanced distribution of bank sizes. The skewness value of –0.5007 indicates a slight left skew, showing that a few banks are much larger than the average. The kurtosis of 2.3605, which is close to 3, implies near-normality of the data. The Jarque-Bera probability of 0.0393, though marginally significant, combined with the sample size of 110, supports the assumption of approximate normality based on the Central Limit Theorem.

4.2 Model Diagnostics

Five model diagnostics were conducted in this study to establish the suitability of the regression estimates. The tests include: test of multicollinearity, heteroskedasticity test, test of autocorrelation, linearity test, and test of cross-sectional dependence.

4.2.1 Test of Linearity

The Ramsey RESET test assessed whether the linear regression model is correctly specified or if non-linear relationships between the dependent and independent variables exist but are omitted from the model.

Table 4.2 Test of Linearity

Ramsey RESET Test
Equation: UNTITLED
Specification: SG TER DR ITII TAR IR FZ C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.821127	102	0.0715
F-statistic	3.316505	(1, 102)	0.0715
Likelihood ratio	3.519707	1	0.0606

Source: Eviews 10 Statistical Output (2025)

The Ramsey RESET test, as presented in Table 4.2, was conducted to determine whether the functional form of the regression model is correctly specified or whether any non-linear relationships between sustainable growth (SG) and the explanatory variables were omitted. The test returned a probability value of 0.0715, which is greater than the conventional 5% significance level. This implies that the null hypothesis of correct model specification cannot be rejected, confirming that the relationship between SG and its predictors is appropriately captured in a linear form. Therefore, the model does not suffer from omitted variable bias due to non-linearity, and the assumption of linearity in the regression model is upheld.

4.2.2 Test of Autocorrelation

Autocorrelation test evaluated whether the residuals (errors) from a regression model are correlated over time, which can violate regression assumptions and bias standard errors.

Table 4.3 Test of Autocorrelation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.966907	Prob. F(2,101)	0.3837
Obs*R-squared	2.066566	Prob. Chi-Square(2)	0.3558

Source: Eviews 10 Statistical Output (2025)

As shown in Table 4.3, the Breusch-Godfrey Serial Correlation LM Test was employed to assess the presence of autocorrelation in the residuals of the regression model. The probability value of 0.3837 exceeds the 0.05 threshold, leading to the acceptance of the null hypothesis that there is no serial correlation among the residuals. This result indicates that the errors are independently distributed over time, satisfying a key classical regression assumption. Consequently, the model's estimated coefficients and standard errors can be considered efficient and unbiased, reinforcing the reliability of subsequent statistical inferences.

4.2.3 Test of Multicollinearity

The Variance Inflation Factor (VIF) test checked for multicollinearity, which occurs when independent variables are highly correlated with each other, potentially inflating standard errors and weakening the model's reliability. A VIF value above 10 typically signals serious multicollinearity.

Table 4.4 Test of Multicollinearity

Variance Inflation Factors
Date: 08/22/25 Time: 00:20
Sample: 1 110
Included observations: 110

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
TER	0.030906	17.53539	1.569827
DR	7.41E-09	1.111388	1.075055
ITII	17.66118	2.229133	1.122404
TAR	0.003283	16.30853	1.534663
IR	3.271568	1.102616	1.004427
FZ	0.000149	221.2214	1.223438
C	0.013324	225.9199	NA

Source: Eviews 10 Statistical Output (2025)

Table 4.4 presents the results of the Variance Inflation Factor (VIF) test, which examines whether high correlations exist among the independent variables that could distort regression estimates. The VIF values for all variables—TER (1.57), DR (1.08), ITII (1.12), TAR (1.53), IR (1.00), and FZ (1.22)—are all well below the critical threshold of 10, suggesting the absence of serious multicollinearity. This implies that each independent variable contributes unique information to the model and that the estimated coefficients are not inflated by redundancy among predictors. Therefore, the regression results are considered stable and interpretable.

4.2.4 Test of Cross-sectional Independence

Test of Cross-sectional Independence is crucial in panel data analysis to determine whether residuals are correlated across entities (in this case, banks). Cross-sectional dependence can bias standard errors and affect inference.

Table 4.5 Test of Cross-sectional Independence

Residual Cross-Section Dependence Test
Null hypothesis: No cross-section dependence (correlation) in residuals
Equation: Untitled

Periods included: 10
Cross-sections included: 11
Total panel observations: 110
Note: non-zero cross-section means detected in data
Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	91.14315	55	0.0016
Pesaran scaled LM	3.446114		0.0006
Pesaran CD	2.868648		0.0041

Source: Eviews 10 Statistical Output (2025)

According to Table 4.5, the Pesaran Cross-sectional Dependence (CD) test was performed to check whether residuals across different banks are correlated, which is important in panel data analysis. The reported probability value of 0.0041 is below the 5% significance level, leading to the rejection of the null hypothesis of no cross-sectional dependence. This finding suggests that the residuals of the banks are correlated, implying that shocks or policy changes affecting one bank may spill over to others within the Nigerian banking system. While this interdependence reflects the interconnected nature of financial institutions, it also implies that the model should account for such cross-sectional effects—perhaps by using robust standard errors or panel-corrected estimators—to ensure accurate inference. To address this, the study used Period Seemingly Unrelated Regression analysis in the panel estimation in order to correct for the cross-sectional dependence observed in the model.

4.2.5 Panel Heteroskedasticity

Test of Heteroskedasticity as show in Table 4.6 helped to check whether there was a non-constant variance in the error terms across observations, which can distort test statistics and confidence intervals.

Table 4.6 Test of Heteroskedasticity
Panel Cross-section Heteroskedasticity LR Test
Null hypothesis: Residuals are homoskedastic
Equation: UNTITLED
Specification: SG TER DR ITII TAR IR FZ C

	Value	df	Probability
Likelihood ratio	60.98183	11	0.0000

Source: Eviews 10 Statistical Output (2025)

As indicated in Table 4.6, the Panel Cross-section Heteroskedasticity Likelihood Ratio (LR) test assessed whether the variance of the error terms is constant across banks. The probability value of 0.0000 is statistically significant, leading to the rejection of the null hypothesis of homoskedasticity. This result confirms the presence of heteroskedasticity in the panel data model, meaning that the variability of residuals differs across observations. Such non-constant variance can bias standard errors and lead to unreliable hypothesis testing. Therefore, the study should employ heteroskedasticity-robust standard errors to correct for this problem and ensure valid statistical inference. To address this, the study used Period Seemingly Unrelated Regression analysis in

the panel estimation in order to correct for the panel heteroskedasticity observed in the model.

4.3 Test of Hypotheses

The result of the panel estimated generalised least squares is shown below in Table 4.7. This approach was used because of the cross-sectional dependence and panel heteroskedasticity observed in the baseline panel regression.

Table 4.7 Test of Hypotheses

Dependent Variable: SG
Method: Panel EGLS (Period SUR)
Date: 08/22/25 Time: 00:26
Sample: 2015 2024
Periods included: 10
Cross-sections included: 11
Total panel (balanced) observations: 110
Linear estimation after one-step weighting matrix
Period SUR (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TER	0.467828	0.046584	10.04258	0.0000
DR	–0.0000095	0.000014	-0.683027	0.4961
ITII	3.732398	0.349700	10.67313	0.0000
TAR	-0.161396	0.014307	-11.28093	0.0000
IR	-0.842891	0.194322	-4.337598	0.0000
FZ	0.061779	0.002939	21.02037	0.0000
C	-0.482088	0.026722	-18.04077	0.0000

Weighted Statistics

R-squared	0.851409	Mean dependent var	2.271225
Adjusted R-squared	0.842753	S.D. dependent var	3.556552
S.E. of regression	0.971567	Sum squared resid	97.22610
F-statistic	98.36267	Durbin-Watson stat	1.950783
Prob(F-statistic)	0.000000		

Source: Eviews 10 Statistical Output (2025)

The regression results are presented in Table 4.7 to show the effect of each independent variable on sustainable growth (SG), as well as the overall model validity.

Table 4.7 presents the results of the panel EGLS model, which examined the effect of various technology investment variables on the sustainable growth of listed deposit money banks in Nigeria. The model validity statistics show that the coefficient of determination (R-squared = 0.8514) and adjusted R-squared (0.8428) are both high, indicating that approximately 85% of the variations in sustainable growth (SG) are jointly explained by the independent variables—technology expense ratio, digitalization rate, IT infrastructure investment, technology adoption rate, innovation rate, and firm size.

The F-statistic (98.3627) with a corresponding probability value of 0.0000 confirms that the overall model is statistically

significant at the 5% level. This means the set of explanatory variables collectively has a significant effect on the sustainable growth of banks during the 2015–2024 period. The Durbin-Watson statistic (1.95) is approximately equal to 2, suggesting the absence of autocorrelation in the residuals, thereby reinforcing the reliability of the model. The constant term (C = –0.4821, p = 0.0000) is negative and statistically significant, implying that when all independent variables are held constant, sustainable growth would decrease by approximately 0.48 units. This negative constant indicates that without the contribution of technology investments and firm size, the banks' growth would be unsustainable or decline over time.

The coefficient for firm size (FZ = 0.0618, p = 0.0000) in Table 4.8 is positive and significant at the 5% level, implying that a one-unit increase in firm size (measured as the natural logarithm of total assets) increases sustainable growth by 0.0618 units, all else held constant. This positive effect means that larger banks, with greater asset bases, tend to experience more sustainable growth due to their capacity to spread technological costs, access better funding, and exploit economies of scale. Therefore, firm size positively enhances the sustainability of growth in Nigeria's deposit money banks.

4.3.1 Test of Hypothesis I

H_{01}: Technology expense ratio does not significantly influence sustainable growth of listed deposit money banks in Nigeria.

The first hypothesis (H_{01}) proposed that the technology expense ratio does not significantly affect the sustainable growth of listed deposit money banks in Nigeria. As shown in Table 4.8, the coefficient of TER (0.4678, p = 0.0000) is positive and statistically significant at the 5% level. This implies that a one-unit increase in the ratio of technology expenses to total operating expenses will, on average, increase sustainable growth by 0.4678 units, holding other variables constant. The positive and significant effect suggests that banks that commit more of their operating expenses to technology achieve better sustainable growth, likely due to efficiency gains, improved service delivery, and enhanced competitiveness. Hence, the null hypothesis (H_{01}) is rejected, and it is concluded that the technology expense ratio exerts a positive and significant effect on the sustainable growth of listed deposit money banks in Nigeria.

4.3.2 Test of Hypothesis II

H_{02}: Digitalization rate has no significant effect on sustainable growth of listed deposit money banks in Nigeria.

The second null hypothesis (H_{02}) stated that the digitalization rate has no significant effect on the sustainable growth of listed deposit money banks in Nigeria. The coefficient of DR (–0.0000095, p = 0.4961), as reported in Table 4.8, is negative but statistically insignificant at the 5% level. This means that for every one-unit increase in the digitalization rate, sustainable growth decreases marginally by 0.0000095 units, an effect too small to be meaningful. The insignificance indicates that, during the study period, digitalization efforts—measured as the ratio of digital revenue to total digital capital expenditures—did not translate into measurable gains in sustainable growth. This could suggest that although digital transformation is ongoing, it may require more time, better integration, or complementary managerial strategies to yield sustainable outcomes. Therefore, the null hypothesis (H_{02}) is accepted, confirming that digitalization rate has no significant effect on the sustainable growth of listed deposit money banks in Nigeria.

4.3.3 Test of Hypothesis III

H_{03}: IT infrastructure investment has no significant effect on sustainable growth of listed deposit money banks in Nigeria.

The third null hypothesis (H_{03}) assumed that IT infrastructure investment has no significant effect on sustainable growth. Table 4.8 shows that ITII (3.7324, p = 0.0000) has a positive and statistically significant coefficient at the 5% level. This implies that a one-unit increase in the ratio of IT capital expenditures to total capital expenditures will lead to an average increase of 3.7324 units in sustainable growth, holding other factors constant. The magnitude of this coefficient demonstrates that investments in IT infrastructure contribute substantially to sustainable growth, likely through enhanced operational efficiency, service reliability, and innovation capacity. The significant effect also highlights the critical role of digital infrastructure as a foundation for technological advancement in the banking sector. Accordingly, the null hypothesis (H_{03}) is rejected, affirming that IT infrastructure investment has a positive and significant effect on the sustainable growth of listed deposit money banks in Nigeria.

4.3.4 Test of Hypothesis IV

H_{04}: Technology adoption rate has not significantly influence sustainable growth of listed deposit money banks in Nigeria.

The fourth null hypothesis (H_{04}) posited that the technology adoption rate does not significantly influence sustainable growth. As reflected in Table 4.8, the coefficient of TAR (–0.1614, p = 0.0000) is negative and statistically significant at the 5% level. This indicates that a one-unit increase in the technology adoption rate—proxied by revenue from electronic transactions relative to total operating cost—reduces sustainable growth by 0.1614 units on average, holding other variables constant. The negative effect implies that rapid adoption of electronic technologies may initially increase operational costs or disrupt traditional business models, thereby dampening short-term growth. However, in the long run, such effects may normalize as systems mature and efficiencies are realized. Based on the significant p-value, the null hypothesis (H_{04}) is rejected, and it is concluded that technology adoption rate has a negative and significant effect on the sustainable growth of listed deposit money banks in Nigeria.

4.3.5 Test of Hypothesis V

H_{05}: Innovation rate has no significant effect on sustainable growth of listed deposit money banks in Nigeria.

The fifth null hypothesis (H_{05}) stated that the innovation rate has no significant effect on sustainable growth. The coefficient of IR (–0.8429, p = 0.0000) in Table 4.8 is negative and significant at the 5% level, indicating that a one-unit increase in the ratio of R&D expenditure to total operating expenses leads to a 0.8429-unit decrease in sustainable growth, ceteris paribus. This finding suggests that while innovation efforts are essential, the short-term financial burden of R&D may outweigh immediate returns, thereby reducing sustainable growth temporarily. It is also possible that the Nigerian banking sector's innovation initiatives are still at an early stage, with benefits yet to fully materialize. Consequently, the null hypothesis (H_{05}) is rejected, implying that innovation rate has a negative and significant effect on the sustainable growth of listed deposit money banks in Nigeria.

4.4 Discussion of Findings

The positive and significant effect of technology expense ratio on sustainable growth of listed deposit money banks in Nigeria (β = 0.4678, p = 0.0000) suggests that higher spending on technological operations enhances long-term growth and efficiency in the banking sector. This indicates that financial resources allocated to technology-related activities, such as digital infrastructure, system maintenance, and software upgrades, contribute to greater operational stability and financial sustainability. This outcome aligns with the findings of Bamidele, Soyebo and Olaiya (2024), who reported a significant positive relationship between emerging technology adoption and banks' performance, and

Yusuf, Ologunwa and Obamuyi (2024), who found that automated and electronic banking tools significantly improved financial performance. Similarly, Chukwukaelo, Onyeiwu and Amah (2020) revealed that electronic channels significantly enhanced profitability in Nigerian banks, while Binuyo and Aregbeshola (2023) observed in South Africa that ICT improves return on assets and capital efficiency. These studies support the notion that prudent technology expenditure translates into improved operational performance and long-term sustainability.

The negative but non-significant effect of digitalization rate on sustainable growth ($\beta = –0.0000095$, $p = 0.4961$) implies that while digital expansion is underway, its measurable contribution to growth remains limited, possibly due to uneven adoption or inefficiencies in digital infrastructure. Early-stage digital transformation may entail high implementation costs, limited customer adaptation, or transitional disruptions that offset immediate benefits. This result is consistent with Okeke (2024), who found that funding for ICT hardware and software had an insignificant effect on firm performance, and Aggreh, Malgwi and Aggreh (2020), who observed that ICT investment does not immediately affect financial outcomes. Usman (2020) also found that internet banking and ATMs had insignificant effects on financial inclusion, while Mahboub (2022) reported similar insignificance of digital channels in Lebanese banks. These studies collectively suggest that digitalization, though strategically important, may take time to yield measurable returns in sustainability metrics.

The positive and significant effect of IT infrastructure investment on sustainable growth ($\beta = 3.7324$, $p = 0.0000$) shows that strengthening technological systems directly promotes the long-term financial health of Nigerian banks. This highlights the centrality of digital infrastructure—such as data centers, networks, and core banking systems—in improving productivity, service reliability, and customer satisfaction. The result agrees with Augustine, Chinwe and Emmanuel (2023), who found that investments in technological infrastructure significantly enhance net interest income. Furthermore, Chukwukaelo, Onyeiwu and Amah (2020) confirmed the profitability benefits of e-banking channels, while Nkosi (2022) found that technological advancement significantly boosted South African banks' performance. The consistency across these studies reinforces the conclusion that IT infrastructure investment is a strong driver of sustainable growth and competitiveness.

The negative and significant effect of technology adoption rate on sustainable growth ($\beta = –0.1614$, $p = 0.0000$) suggests that while adopting new technologies is necessary for modernization, it may initially reduce banks' growth due to high implementation costs, learning curves, and integration challenges. These transitional frictions can temporarily weaken performance until efficiency gains are realized. This finding contrasts with Mgbemena and Onah (2024), who reported that technology adoption positively affects profitability, and Gambo (2020), who found that technological innovation promotes bank performance. However, it aligns with Akani and Obiosa (2020), who discovered that some e-banking innovations like ATMs and EFTs had negative relationships with return on equity, and Paul (2024), who found that software-related expenses negatively impact profitability. The result suggests that banks may experience short-term strain from adopting new technologies before achieving full operational benefits.

The negative and significant effect of innovation rate on sustainable growth ($\beta = –0.8429$, $p = 0.0000$) indicates that frequent or aggressive innovation may initially hinder sustainable growth, possibly due to high R&D costs, implementation failures, or mismatches between innovations and market readiness. This finding contrasts with studies such as Nwosu, Ubi and Fred (2022) and

Mabrouk (2019), who found that innovation enhances sustainable development and bank performance. However, it resonates with Okoro et al. (2024), who observed that certain digital tools, like internet banking, negatively affect performance, and Aggreh, Malgwi and Aggreh (2020), who emphasized the lag between innovation investment and profitability. The finding thus suggests that while innovation is vital for future competitiveness, its immediate financial benefits may be constrained by cost pressures, adaptation lags, and operational disruptions within Nigerian banks.

5.0 CONCLUSION

The findings from the study highlight the complex and multifaceted role of technology investment in shaping the sustainable growth trajectory of listed deposit money banks in Nigeria. The significant positive effects recorded for technology expense ratio and IT infrastructure investment demonstrate that channeling operational and capital resources into technological development enhances long-term growth performance through improved efficiency, digital service expansion, and stronger institutional capacity. This shows that when banks allocate resources toward building robust technological foundations, they tend to experience enduring competitive advantages that translate into financial sustainability. However, the negative and significant effects observed for technology adoption rate and innovation rate indicate that the transition toward digital systems and innovation-driven operations may initially impose cost burdens, operational disruptions, or adjustment challenges that dampen short-term growth prospects. Such outcomes highlight the transitional dynamics that accompany technological transformation, especially within a developing financial environment where digital maturity is still evolving. The insignificant effect of digitalization rate suggests that while banks are expanding digital channels, the returns from such investments may not yet be strong enough to influence sustainable growth, possibly due to uneven adoption levels or infrastructural constraints. Collectively, these outcomes portray the Nigerian banking sector as one undergoing a gradual technological evolution, where the benefits of digital and innovative initiatives are emerging but not yet fully realized. The results also reflect the critical interplay between financial capacity, institutional readiness, and technology-driven strategies in determining how effectively banks convert technological expenditure into sustainable performance outcomes, emphasizing that growth responses to technology investment can vary across both short and long horizons within an evolving financial ecosystem.

Recommendation

In line with the findings of the study, it was suggested that:

1. Technology Expense Ratio: Bank executives of listed deposit money banks in Nigeria should ensure consistent and well-structured investment in technological operations, as the findings show that such expenditure contributes meaningfully to sustainable growth. Allocating sufficient resources to maintain and upgrade technological systems can strengthen operational efficiency, enhance service quality, and ensure that technology spending translates into measurable long-term financial benefits.

2. Digitalization Rate: The management of listed deposit money banks should develop a more strategic implementation plan for digitalization initiatives by aligning digital technologies with customer needs and staff capacity. Since the current level of digitalization has not significantly enhanced sustainable growth, efforts should focus on improving digital literacy among employees and customers to ensure full utilization of digital banking platforms and improve the return on digital investments.

3. IT Infrastructure Investment: The Board of Directors of listed deposit money banks should sustain and expand their capital

expenditure on IT infrastructure, as such investment has been shown to significantly strengthen sustainable growth. Continuous improvement in digital infrastructure, such as secure networks, robust data centers, and advanced banking software, will enhance service delivery, support innovation, and maintain competitive advantage in an increasingly technology-driven financial environment.

4. Technology Adoption Rate: The Central Bank of Nigeria (CBN) should create supportive regulatory frameworks and capacity-building programs that assist banks in managing the transition costs and operational challenges associated with new technology adoption. Since rapid adoption may initially hinder sustainable growth, policies that facilitate smoother integration—through training, phased implementation, and technological support—can help banks realize long-term benefits without financial strain.

5. Innovation Rate: Research and development (R&D) departments within listed deposit money banks should strengthen the evaluation and feasibility assessment of new innovations before implementation. Given that excessive or misaligned innovation has been shown to reduce sustainable growth, banks should focus on innovations that align closely with their operational goals, customer expectations, and market realities to ensure that innovation spending yields both strategic and financial returns.

Contribution to Knowledge

This study contributes to the literature by addressing notable gaps in prior research, which largely focused on the relationship between technological investments and general corporate performance, rather than sustainable growth—a more comprehensive and investor-centered metric of firm longevity. Unlike existing studies from Sub-Saharan Africa, which predominantly explore technology's effect on profitability or operational efficiency, this research uniquely examines the effect of technological investments on the sustainable growth of listed deposit money banks in Nigeria. By incorporating cross-sectional analysis and focusing specifically on sustainability as an outcome variable, the study advances knowledge by revealing how technology spending and infrastructure development interact with long-term growth objectives within the Nigerian banking context. This approach deepens understanding of how banks can better align technological strategies with their environmental, social, and governance (ESG) obligations while offering a nuanced view of sustainability from a financial markets perspective.

Limitations of the Study

A key limitation of this study is its restricted focus on only listed deposit money banks in Nigeria, which may not fully reflect the experiences or practices of unlisted banks, microfinance institutions, or other financial service providers within the country. The exclusion of Jaiz Bank and Unity Bank due to unavailability of their 2024 financial reports reduced the coverage of the entire banking sector and may limit the generalization of findings. The study also covered a ten-year period (2015–2024), which, while useful for observing trends, may not be long enough to capture deeper or more gradual impacts of technology investments on sustainable growth.

Moreover, the analysis relied heavily on secondary data from financial statements and reports, which may not fully capture qualitative aspects such as employee capacity, customer satisfaction, or internal innovation processes. Lastly, the study was limited to five specific indicators of technology investment, and may not reflect the full range of technological initiatives banks are undertaking.

5.Suggestions for Further Studies

Future studies could explore a broader range of financial institutions, including

microfinance banks and non-listed banks, to compare how technology investments impact sustainable growth across different segments of the banking sector. It would also be useful to expand the time period to include more years, allowing for a deeper analysis of long-term trends and changes in technology adoption. Additionally, future research could look into other factors that might influence sustainable growth, such as employee training, customer experience, or the role of regulatory changes. Finally, studies could consider qualitative methods like interviews or case studies to gain a more comprehensive understanding of how technology investments are implemented and perceived by bank management and staff.

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