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The Impact of Technological Innovations on Bank Performance in Emerging Economies

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

On a global scale, technological innovations have achieved great success in the process of economic development of national economies, especially in the banking sector. Technological innovation is largely used by the banking sector to create competitive intelligence and competitive advantage, as it helps banks improve their services and cost efficiency, as fewer employees and fewer traditional branches are needed. However, this current study focused on examining the impact of technological innovation on bank performance in 40 emerging markets from 2000 to 2021. Findings from the correlation results show that there are strong positive correlations between technological innovation and bank performance in emerging markets. Similarly, we also find the

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existence of cointegration between technological innovation and bank performance and the existence of a long-run relationship between technological innovation and bank performance in emerging markets, as implied by the results of tied tests. Our study also found from ARDL and GMM results that there are long-term significant relationships between technological innovation and emerging market bank performance. After making these discoveries, we recommended policies such as improving the technology hub of emerging markets and extending banking services to emerging markets' underbanked populations living in remote areas using technology tools to improve bank performance in emerging markets.

Keywords: Technological innovation; bank performance.

1. INTRODUCTION

Bank performance plays a critical role in fostering economic growth, especially in emerging economies. Banks serve as financial intermediaries, mobilizing savings from households and businesses, and channelling them into productive investments that drive economic activities [1]. Strong bank performance enhances the efficiency of these intermediation processes, which in turn supports the growth of sectors such as manufacturing, services, and agriculture, thereby stimulating overall economic development. One of the main ways bank performance contributes to economic growth is by improving access to credit. Efficient banks are better positioned to offer affordable loans to individuals and businesses, which spurs entrepreneurship, facilitates capital investments, and enhances productivity (Demirgüç-Kunt et al., 2015). This access to finance is especially crucial in emerging economies, where small and medium-sized enterprises (SMEs) play a key role in driving economic activity but often face credit constraints. By improving credit availability, banks enable these businesses to expand, innovate, and create jobs, which in turn boosts economic output. In addition, well-performing banks support financial stability, which is essential for sustained economic growth. A stable and efficient banking sector reduces risks such as inflation and currency fluctuations, which can negatively affect investment and consumption (King & Levine, 1993). Moreover, sound banks build trust among investors, encouraging both domestic and foreign direct investments (FDI) [2]. FDI, in particular, brings capital, technology, and expertise, further enhancing productivity and growth in emerging markets. However, given the crucial role banks play in the economy, technological innovation can bring improvement and spur the performance of banks in emerging economies. The ongoing digital transformation within the banking sector continues to shape how banks operate, making financial technology a critical determinant of success in these emerging market economies.

Technological innovations which encompass digital platforms, mobile banking, electronic payment systems, and blockchain technology, among others, are of crucial importance in transforming the global banking industry, particularly in emerging economies, where financial technology (FinTech) plays a critical role in shaping bank performance [3]. The integration of digital technologies into banking services has revolutionized how banks operate, improving efficiency, expanding financial access, and enhancing customer experiences to erode traditional banking infrastructure [4]. It has streamlined bank operations through the automation of routine tasks, improved risk management systems, and the use of artificial intelligence (AI) to enhance decision-making processes [5]. These innovations not only reduce operational costs but also improve customer satisfaction, as clients can now access services online and in real-time, reducing the reliance on physical branches [6] which results in efficiency in the banking sector and this serves as a key determinant of bank performance because banks can allocate more resources to profitable ventures and innovative products. Therefore, this underscores the benefits of technological innovation on banks. Hence, regulatory support and partnerships with technology firms can bolster bank performance in emerging economies [7] and governments and central banks in these regions recognize the potential of FinTech to spur economic development and promote innovation while ensuring financial stability.

Given the above discussions which highlight technological innovation as an important catalyser of bank performance, it can be deduced that technological innovation is very crucial for bank performance due to the

ubiquitous role it plays in the improvement of bank operations, development and growth. The impact of technological innovations on bank performance in emerging economies is profound, influencing operational efficiency, profitability, and customer reach. Technological innovation plays a critical role in driving progress across various sectors, influencing economic growth, improving productivity, and enhancing the quality of life. The importance of technological innovation can be understood through its role in introducing new products, services, and processes, innovation increases productivity, reduces costs, creates new markets, improves quality of life, creation of new industries and jobs, enhancement of business processes by streamlining operations, enhancing customer experiences, and improving decision-making processes through data analytics, cloud computing, and customer relationship management (CRM) systems allow banks to make informed decisions, tailor products to customer needs, and optimize supply chain processes. Drawing from the foregoing, this study investigates the impact of technological innovation – measured with mobile banking, internet banking, automated teller machines (ATM) and electronic banking on bank performance explored through bank return on assets and bank return on equity in emerging economies. To this end, this paper stand to provide answers to the following questions. a). What are the effects of the mobile banking on bank performance in emerging economies? b). Do internet banking significantly influence bank performance in emerging economies? c). How does automated teller machines (ATMs) affect bank performance in emerging economies? d) In what ways does electronic banking influence bank performance in emerging economies?

Answering these questions requires that we employ the autoregressive distributed lag (ARDL) estimation approach and robustly check the findings using the differenced and system generalized method of moment (GMM) to estimate the impact of technological innovations – measured with mobile banking, internet banking, automated teller machines and electronic banking on banking sector performance measured with bank return on assets and bank return on equity in emerging economies. The lesson drawn from the previous studies shows that while some scholars like [8,9,10,11,12,13,14] concluded that financial innovations have significant negative influence on bank performance, other scholars like [15,16,17] discovered a positive relationship between technological innovations and bank performance in their respective studies, leading to inconsistent policy options. This has therefore resulted in incongruent policies on ways to improve bank performance in emerging economies even in the presence of various policies and economic reforms such as India's Unified Payments Interface (UPI) system, Basel III guidelines in South African banks, Kenya's Central Bank Regulatory Sandbox, Brazil's Corporate Governance Law (Lei das Sociedades Anônimas), China's investments in 5G and cloud computing, Nigeria's Risk-Based Supervision Framework, Bangladesh's SME Financing Policy, Indonesia's Banking Consolidation Plan, Turkey's Central Bank's Reduction of Reserve Requirements, and South Africa's Cybersecurity and Cyber Crimes Bill. Hence, there is a great need to re-evaluate the impact of technological innovation on bank performance through these variables, especially in emerging economies.

Our paper therefore contributed to the existing knowledge in the following. Firstly, we holistically investigate the synergy between technological innovations – measured with – mobile banking, internet banking, automated teller machines, and electronic banking on bank performance – explored by bank return on assets and bank returns on equity in emerging economies. Secondly, we estimated these variables using the panel autoregressive distributed lag (ARDL) model as the baseline model and robustly checked the findings using the panel differenced and system generalized method of moment (GMM) which can address the problem of endogeneity, serial correlations and instrument-over-identification problems which ARDL could not address. However, the rest of the study will be organized as follows, part 2 will deal with technological innovation and bank performance in emerging economies part 3 will deal with the review of related literature, part 4 will deal with methodology, part 5 will deal with empirical findings results and findings and section 6 will contain concluding remarks and possible policy recommendations.

2. TECHNOLOGICAL INNOVATIONS IN DEVELOPING ECONOMIES

Emerging economies have gracefully embraced technological advancements as a result of the emergence of the Internet, which has blackened nations in the form of conventional development, the spread of vast knowledge, and economic

prosperity [18]. Recently, the use of the Internet has increased by 70%, which has increased the number of global Internet users to 73%, the use of communication applications by 80%, and also the use of a computer [18]. However, despite widespread globalization and technological advances, financial exclusion stubbornly persists in many emerging economies, leaving vast numbers of low-income populations unbanked or underbanked [19], yet financial services are almost universally available in high-income countries in most emerging countries will become unattainable [20].

Emerging markets contain more than 1.6 billion people and 200 million small businesses that lack access to formal financial services [21]. The World Bank's most recent 2022 survey on the impact of banking on FinTech in emerging economies revealed that more than 1.6 million people do not have basic transaction accounts, cannot make or receive payments, invest in businesses, reduce their consumer spending, or finance their small businesses [19]. Fig. 1 shows technology adoption in emerging economies.

However, without massive investment in digital infrastructure, an emerging market would rarely develop, despite widespread technology adoption. This could happen because the world's 25 least connected countries are all in emerging economies – 21 in Africa and 4 in the rest of the world [18]. Lack of access to technological innovation hinders economic growth as people will also be financially disconnected. It has also exposed many SMEs to financial struggle and consequently led to market failure and insolvency despite policies initiated by the International Telecommunication Union (ITU), the World Bank and other multilateral and regional bodies such as the Digital World Bank. Moonshot Initiative - a $25 billion fund to support developing economies, especially in Africa, the situation has been getting worse recently and has even hit the performance of companies and banks hard [18].

Bank performance is the primary goal of any bank, and emerging market banks are no exception. Bank performance refers to the manner or manner in which the bank's resources are used in a manner that enables it to achieve its objectives [22]. As a very important economic entity, banks play an important role in mediating between savers and spenders. Banks largely control the economy over the supply of money in circulation and are the main drivers of economic progress [22]. Fig. 1 shows the best and worst-performing banks in emerging economies in 2021. It shows that countries such as Vietnam, Poland, Israel, Puerto Rico, Saudi Arabia, Czech Republic, Georgia, United Arab Emirates, South Arica and Slovenia are the best. -performing banks in emerging economies; while Nigeria, Slovakia, Malaysia, China, Egypt, Colombia, Chile, Brazil, Turkey and Peru are the worst-performing banks in emerging economies in 2021.

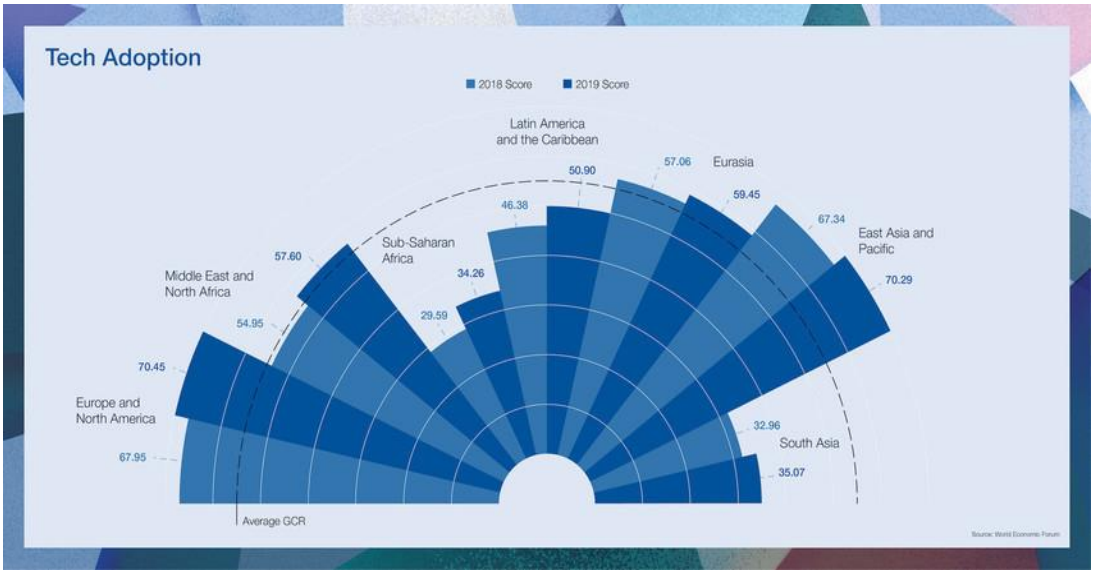

Fig. 1. Technology adoption in emerging economies
Source: World Economic Forum

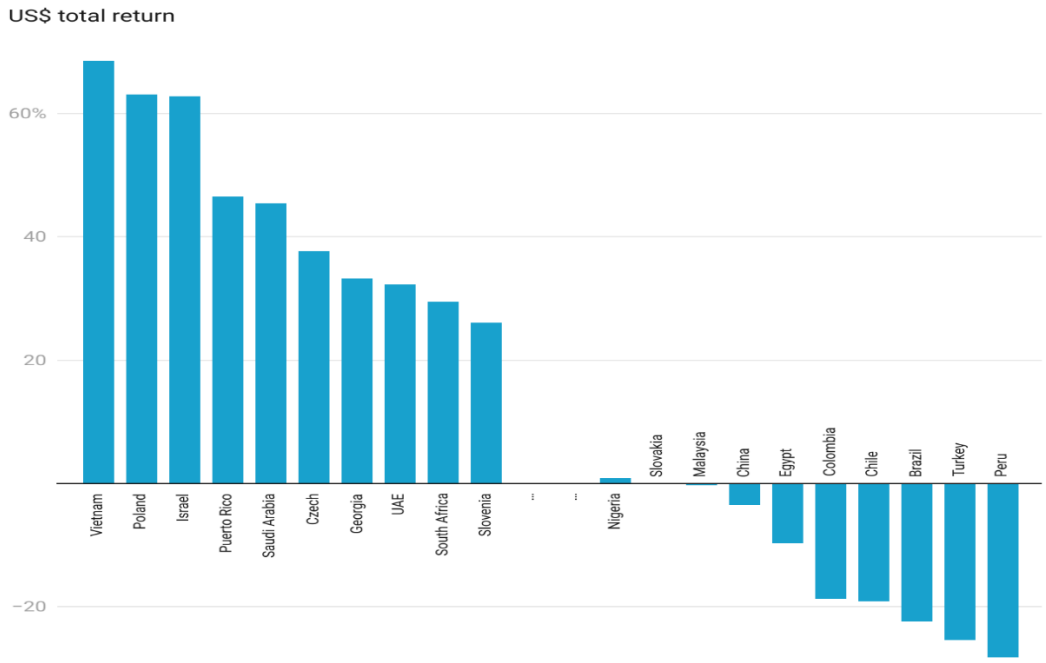

Fig. 2. The best and worst performing banking sectors of emerging economies in 2021 (total return in USD)

Source: Chart initiated by Rahul Shah and Rohit Kumar from Bloomberg, Tellimer Research. Note: This is calculated using Median Performance for banks with market capitalization > US$1bn and only markets with 2 or more such banks have been included in the chart

The result in Fig. 1 means that emerging market economies still lack proper penetration of technological innovation, especially in the banking sector, and there is little research work focusing on emerging market economies in this area coherently. We will base our research on examining the impact of technological innovation on bank performance in emerging market economies, with a strong emphasis on the causes of poor performance by emerging market banks, the importance of well-performing emerging market banks, ways to improve emerging market bank performance, better ways to harness technological innovation in emerging markets, and government action to address technical innovation barriers in emerging markets.

3. REVIEW OF RELATED LITERATURE

This section focused on a discussion of the related theoretical and empirical literature. Over time, the urgent need to digitize banks in emerging markets has become paramount as banks in the region have underperformed compared to their counterparts in other regions. Today, emerging markets have not only embraced the use of technology but have become global innovators in many fields, now at the forefront of the latest technological developments, from mobile banking and shopping to robotics, autonomous vehicles, healthcare and more [23]. For example, just a few years ago making a bank deposit meant a trip to your local bank branch where you stood in line and waited for a bank teller to process your transaction. Today, Poland is considered a leader in online banking technology, with one bank there offering features such as 30-second loan approval via mobile phone, as well as alerts offering personalized advice and discounts based on a user's behaviour and location. In the same vein, a Turkish bank won a global innovation award in 2017 for its agricultural smartphone app that helps farmers share data and information and get real-time advice, and even acts as a platform for equipment rentals [24].

The Internet has become a centre of technological innovation, and banks in emerging markets, like every other economic region in the world, rely on it to improve their performance. According to Internet Live Stats, as of 2016, China, India, the United States, Brazil, and Japan represented the largest Internet user base in the

world with a total of 1.72 billion. The three emerging markets on the list have a total of 1.32 billion users. This means that 1.32 billion users have access to goods, services and information. Therefore, we think e-commerce is still very much a penetration growth story that resonates across multiple markets as consumers increasingly use multiple devices for online transactions. Therefore, an influx of scholars has contributed to the investigation of the relationship between technological innovation and bank performance, both in individual country studies and panel studies. Since there are no specific theoretical and empirical overviews of emerging market economies, this study looks at the theoretical and empirical literature that is related in the following paragraphs.

Disruptive innovation theory: According to Christensen's [25] disruptive innovation theory, industry leaders are displaced by new entrants when new entrants introduce disruptive innovation to which industry leaders are unable or unwilling to respond. The theory predicts that industry leaders are forced out of the industry and new entrants enter the market. OECD, Oslo Manual [26] defines disruptive innovation as an innovation that has a significant impact on the market and the economic activity of companies in this market. Any type of innovation can be disruptive. Kenya's banking industry has felt the effects of disruptive innovations from mobile money transfer telcos, notably Safaricom's M-Pesa. MShwari, a product of Safaricom and CBA Bank, stands out as the biggest disruptive innovation along with Mpesa in Kenya in the last decade. Statistics from Safaricom ltd indicate that Mshwari was officially launched on 27 November 2012 and attracted 70,000 subscribers on the first day of its operational launch. It attracted 1 billion Kenyan shillings in deposits in one month – a level that took traditional banks in Kenya many months or even years to reach – by April 2013 it had more than 3 million customers. M-Pesa 2013 gained 10.2 million customers. To meet this challenge, banks have engaged in innovation [27]. The disruptive theory is relevant in that it explains the type of technological innovation that banks adopt. Technological, marketing and managerial innovations are disruptive because they are eliminating traditional banking.

Theory of innovation diffusion: Innovation is critical to business growth, it is the stimulus that drives industry performance through the adoption of the medium through which banking processes are carried out using technology. This theory explains an individual's intention to adopt technology as a way of performing a traditional activity; this theory was developed by Roger [28]. The critical factors that determine the adoption of innovation at the general level are the following: relative advantage, compatibility, complexity, trialability and observability (Rogers, 1995). Gerrard and Cunningham [29] in Moga [30] tested the theory of electronic banking adoption. The nominalized factors are complexity, trialability and observability [30]. Banks have developed a way to make the banking business easier and more enjoyable for their clients, unlike brick-and-mortar banking with long queues and lots of paperwork without adopting technology that makes it more stressful and cumbersome with the interbank transaction process more. With the use of sophisticated technology, the interbank transaction is easy and it is much safer and more convenient to transact through internet-connected ATMs, computers, vending machines, mobile banking etc. mediums for your tax payment processes through an online banking platform such as PAYE collection, stamp duty processing, water and electricity bills and other government revenue funds that can be easily and quickly collected and processed.

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Diffusion is a special type of communication that deals with the spread of messages that are perceived as new ideas [28]. This idea is seen by the individual as new and something that is brought into the system to facilitate the interaction of people in that society. With each passing day, developments in technology are changing the way we see, think and relate to each other in society, these innovations have been able to help make things easier for human communication, transportation, banking, security, etc. Communication of new ideas is the basis for the spread of innovation, that is, that communication is a process in which participants create and share information to achieve mutual understanding [28]. For example, due to the way and complexity of business, business owners can come up with innovations that will help their business and also allow the business to reach a wider audience, a client can come to the business owner with a problem, or The need and business innovation can be recommended as a solution to the problem as banks have introduced internet banking and the use of ATMs to reduce the banking queue and reduce the processing

time of customers' request. The four main elements of diffusion theory as proposed by Rogers in his work are; innovation, Communication channels, Time and social system. Rogers [28] defined innovation as an idea, practice or object that is perceived as new by an individual or other unit of adoption. As far as human behaviour is concerned, it does not matter whether an idea is "objectively" new, as measured by the length of time since its first use or discovery. Newness in innovation may not only include new knowledge, someone has known about the innovation for some time, but has not yet developed a favourable or unfavourable attitude toward it, nor has he accepted or rejected it [28]. In the banking industry, the innovation in creating technology that aids banking activities has helped tremendously in providing easy banking inside and outside the banking halls. This provided sophisticated means of conducting banking operations using smart cards, mobile phones and the use of ATMs to reduce long queues in banking halls and reduce waiting time. Time is the third element of diffusion theory and it is an important element in the diffusion process. Most other behavioural science research is timeless in the sense that the time dimension is simply ignored. Time is an obvious aspect of any communication process, but most (non-diffusion) communication research does not explicitly address it [28].

The technology acceptance model (TAM): Among the information acceptance models, the technology acceptance model (TAM) is the most appropriate for this study. TAM is another adaptation of TRA specifically tailored for modelling user acceptance of information systems [31]. TRA suggests that social behaviour is motivated by an individual's attitude toward performing that behaviour. However, it does not specify which particular beliefs would be important in a particular situation. TAM assumes that the actual use of technology can be predicted by the user's intention and attitude toward use, which in turn are influenced by the technology's perceived ease of use and perceived usefulness. TAM accepts a well-established causal chain as follows:

Belief > Attitude > Intention > Behaviour

Based on certain beliefs, a person forms an attitude towards certain objects, based on forms of intention, and how to behave towards the given object. The intention to behave is the only determinant of actual behaviour. Davis adopted TRA by developing two key beliefs that account for information system use in particular. The first of these beliefs is perceived usefulness, defined as “the degree to which a person believes that using a particular system would improve their job performance [31]. The second is perceived ease of use, defined as “the extent to which a person believes that using a particular system would be effortless [31].

Empirical literature: Zhang et al. [32] examined the effect of fintech innovations on bank performance in China. Using a panel data approach, they found that fintech development significantly improves bank profitability, with mobile banking services contributing to cost efficiency. Lee, Park, & Choi [33] analyzed the role of artificial intelligence (AI) in improving risk management in South Korean banks. Their results indicate that AI-driven analytics reduce loan defaults and enhance credit decision-making. Singh & Ghosh [9] explored the relationship between digital banking and operational efficiency in Indian banks. Their findings show that digital banking adoption leads to higher customer satisfaction and reduced transaction costs. Mohammed & Abdullahi [10] studied the adoption of blockchain technology in Nigerian banks. They concluded that blockchain reduces transaction times and fraud, thus improving bank trust and customer retention. Alvarez, Gonzalez, & Navarro [34] examined the impact of technological innovation on financial inclusion in Latin America. They found that mobile banking and fintech platforms significantly enhance access to banking services in rural areas. Santos et al. [35] conducted a study on Brazilian banks, focusing on the role of cloud computing in enhancing operational flexibility. Their results show that cloud adoption leads to lower IT costs and faster innovation cycles. Khan & Malik [17] analyzed the impact of digital financial services on bank profitability in Pakistan. Their study concluded that the adoption of fintech platforms positively influences return on assets (ROA) and return on equity (ROE). Manasseh et al. [3] found that digital financial innovation significantly impacts financial system development in the long run. As such, the evidence revealed that automated teller machines (ATMs), point of sale (POS), mobile payments (MP) and mobile banking are significant and contribute positively to financial system development in the long run, while mobile money (MM) and Internet banking (INB) are insignificant but exhibit positive and inverse

relationship with financial development respectively.

Adeola & Evans [36] explored the role of technological innovation in improving banking sector resilience in Africa. They found that digital transformation reduces operational risks and enhances service delivery, particularly during crises like COVID-19. Garcia & Fernandez [14] examined the role of big data analytics in Spanish banks. The study found that data-driven decision-making increases loan portfolio quality and customer retention. Rizvi & Naqvi [11] investigated the effects of technological disruption on bank performance in Southeast Asia. The study showed that banks investing in digital infrastructure experience faster growth in customer base and profit margins. Ahmad & Iqbal [37] studied the influence of internet banking on customer loyalty in Bangladesh. They found that easy-to-use platforms improve customer engagement and long-term profitability. Cheng & Lau [38] explored the impact of contactless payments on bank liquidity management in Hong Kong. Their findings revealed that the shift to digital payments improves cash flow management and liquidity ratios. Fernandez & Lopez [39] investigated the role of machine learning in fraud detection in Argentine banks. Their empirical findings suggest that machine learning algorithms significantly reduce fraud cases and operational losses. Rahman et al. [40] conducted a study on the role of mobile banking in enhancing financial literacy in Indonesia. They concluded that mobile banking platforms contribute to better financial decision-making among low-income groups. Smith & Johnson [41] examined the use of AI in customer service automation in South African banks. They found that AI-powered chatbots improve customer satisfaction and reduce operational costs.

Kassim & Hussein [42] analyzed how mobile banking impacts loan accessibility in East African banks. Their study concluded that mobile lending platforms significantly increase loan access, particularly for SMEs. Liu & Wong [43] explored how the integration of fintech solutions impacts bank competitiveness in Singapore. The study found that banks leveraging fintech partnerships outperform traditional banks in terms of customer acquisition and market share. Obeng & Asare [13] studied digital transformation in Ghanaian banks and found that banks that digitized their services saw a substantial increase in profit margins and operational efficiency. Dlamini & Ndlovu [12] investigated the role of financial technology in improving financial inclusion in Southern Africa. Their results showed that mobile money services have a positive effect on reducing the unbanked population. Wang et al. [44] analyzed the influence of cloud computing on bank cost structures in China. Their findings suggest that cloud adoption reduces overhead costs and improves IT agility. Jones & Blake [45] examined the impact of digital wallets on customer retention in Mexican banks. They concluded that digital wallets enhance customer convenience and loyalty. Gonzalez & Perez [46] explored the role of cryptocurrency adoption in emerging market banks, finding that banks incorporating crypto services attract a younger demographic and increase transaction volumes. Ahmed & Mustafa [47] conducted a study on the impact of fintech innovation on risk management in Middle Eastern banks. Their results indicate that fintech solutions enhance risk assessment capabilities.

Smith, Green, & Anderson [48] explored the influence of blockchain technology on interbank settlements in African banks. They found that blockchain reduces settlement times and enhances transparency. Patel & Desai [49] examined the impact of digital banking on operational efficiency in Indian public sector banks. Their findings show that digital adoption significantly improves cost-to-income ratios. Girma & Hailu [50] studied mobile banking and financial inclusion in Ethiopian banks, concluding that mobile banking plays a crucial role in extending financial services to underserved populations. Martinez & Torres [51] explored the role of fintech partnerships in improving bank innovation capabilities in Latin America. Their results indicate that fintech collaborations enhance product innovation and market responsiveness. Wang & Li [52] investigated the impact of AI on credit risk management in Chinese banks. They found that AI-driven credit scoring models improve accuracy in lending decisions. Mahmoud & Said [53] examined the role of technological innovation in improving customer experiences in Egyptian banks. Their results show that digital banking platforms lead to higher customer satisfaction and loyalty. Owusu & Boateng [54] analyzed the impact of digital financial services on rural banking in Ghana. They concluded that digital platforms significantly enhance banking outreach in rural areas. Hassan & Ahmed [55] explored how AI-driven data analytics impact loan approval times in Nigerian banks. Their findings indicate that AI reduces

loan processing times and improves customer satisfaction. Alam & Rahman [56] studied the impact of mobile payment systems on financial inclusion in Bangladesh. They concluded that mobile payment platforms significantly reduce financial exclusion. Mokhtar & Ismail [57] analyzed the role of fintech in improving customer acquisition in Malaysian banks. They found that banks leveraging fintech tools see faster customer base growth. Garcia & Martinez [14] examined the effect of digital banking channels on customer loyalty in Latin American banks. Their results indicate that omnichannel strategies improve customer retention.

Kumar & Rao [8] studied how technological innovation influences banking sector stability in India. Their findings suggest that digital banking reduces operational risks and improves overall sector stability. Chowdhury & Haque (2023) explored the role of fintech in expanding financial access in Bangladesh. They found that fintech platforms significantly reduce transaction costs and increase banking outreach. Zhu & Zhang [58] analyzed the effect of AI on fraud detection in Chinese banks. Their results indicate that AI-driven fraud detection systems reduce financial crime and enhance trust in banking services. Nelson & Thompson [59] studied the impact of blockchain on cross-border transactions in emerging markets. They concluded that blockchain reduces transaction costs and settlement times. Ali & Khalid [60] examined the role of mobile banking in promoting financial literacy in Pakistani banks. Their study found that mobile banking platforms improve financial awareness among low-income populations. Lee & Kim [61] investigated the role of digital lending platforms in increasing loan accessibility in South Korean banks. They found that digital platforms enhance loan approval rates, especially for SMEs. Also, Dong et al. [62] examine the impact of web financing on the performance of commercial banks in China. The post ingeniously uses information from multiple sources to create a list of web accounts that includes internet search information and internet money exchange information. The results show that the improvement of Internet financing significantly affects the benefit, safety and development of banks, and therefore, in turn, affects their liquidity. The investigation also showed that web finance has advanced in improving the thorough business execution of banks in China. Akwam and Yua [63] conducted research on the effects of electronic money products on the financial performance of some commercial banks in Nigeria using the volume of POS, mobile payments and ATM transactions as proxies for financial products and return on assets, return on equity and earnings per share as proxies for bank performance. A time series of annual data from 2005 to 2019 on mobile payments, POS and ATM was used to determine their impact on ROA, ROE and EPS. The findings revealed that mobile payments and POS have a significant positive effect on ROA and ROE. Also, ATM transactions have a significant positive effect on earnings per share. The above results confirm the findings of Muotolu and Nwadialor [15] in their studies on cashless policy in Nigeria and its impact on the financial performance of commercial banks, using ATM, POS, internet payment, NEFT and NIP volumes as proxies of cashless banks and return on assets as an indicator of bank performance. The research work uses panel data from 14 banks from 2012 to 2017, which was analyzed using descriptive statistics, multicollinearity tests, correlation testing and heteroskedasticity testing. The findings showed that ATM transaction volume has a significant positive impact on bank ROA in Nigeria, however, POS, Internet, NEFT and NIP volume have an insignificant positive impact on bank ROA in Nigeria.

Kumar and Rao [8] found that while digital banking innovations in Indian banks increased operational efficiency, they also led to significant short-term job losses and higher operational risks due to cyber vulnerabilities. This, in turn, created instability in the banking sector, reducing overall resilience. Similarly, Patel and Desai [49] reported that the rapid adoption of digital banking technologies in Indian public sector banks did not immediately improve their financial performance. Instead, the transition incurred high initial setup costs, increased IT infrastructure expenses, and the need for extensive employee training, which temporarily diminished profit margins. Singh and Ghosh [9] observed that while digital banking boosted customer experience, its adoption among certain Indian banks led to increased complexity in the banking operations, thus reducing operational efficiency. The authors noted that the over-reliance on technology without adequate infrastructure caused service downtimes and impacted customer satisfaction negatively. In a study on blockchain adoption, Mohammed and Abdullahi [10] concluded that Nigerian banks that adopted blockchain technology faced challenges in implementation, including resistance from traditional banking staff, high costs, and regulatory barriers. This

resulted in a significant decline in customer trust during the transition phase, negatively impacting their customer retention rates. Rizvi and Naqvi [11], examining Southeast Asian banks, found that technological disruption through fintech posed a threat to traditional banks' market share. While fintech innovation improved efficiency for newer, tech-driven banks, established banks faced a decline in profit margins due to competition, failure to fully integrate technologies, and customer migration to fintech platforms. Dlamini and Ndlovu [12] highlighted that in Southern African banks, the adoption of mobile banking and other digital platforms, though beneficial in the long run, led to immediate challenges. These included system outages, cyber fraud, and operational risks, resulting in a temporary dip in bank performance as the institutions struggled with the operational transition. Moreover, Obeng and Asare [13] documented how digital transformation in Ghanaian banks increased operational costs in the short term due to the need for new technology investments and compliance with changing regulatory standards. The study found that these short-term costs outweighed immediate gains, reducing the financial performance of banks during the early adoption stages. Finally, Garcia and Fernandez [14], investigating Spanish banks, discovered that the introduction of big data analytics had not resulted in the expected improvements in profitability. Instead, the complexity of managing large datasets led to inefficiencies and data breaches, which reduced trust among clients and negatively impacted loan portfolio performance.

4. METHODOLOGY

This study focuses on examining the impact of technological innovation on bank performance in emerging market economies. The authors nod to the use of dynamic relationships to frame the study as below:

$$MBP = \beta_0 + \beta_1(MB) + \beta_2(INTB) + \beta_3(ATM) + \beta_4(E-BANKING) + \beta_5(EXR) + \beta_6(INFR) + \varepsilon_t \quad ---(1)$$

Where ε_t indicates an error term refers to measures of bank performance which include - return on assets (ROA) and return on equity (ROE). In addition, measures of technological innovation include MB mobile banking, $INTB$ internet banking ATM and $E-Banking$ electronic banking; while control variables include exchange rate and inflation rate. In addition, we used annual time series data for this study that spanned from 2000 to 2021. The entire sample data were collected from the World Development Indicator and the IMF's Financial Access Survey.

4.1 Root Unit Tests

To ensure effective data analysis in the study, we used panel root tests which include the Levin, Lin and Chu (LLC) test, Im, Pesaran and Shin (IPS), Fisher-ADF and Fisher-PP tests to confirm the existence of stationarity of the considered data time series datasets as used by previous researchers [64,65].

4.2 ARDL Bound Testing Cointegration Analysis

We further used the Auto Regressive Distributed Lag (ARDL) long-term linkage approach presented by Pesaran and Pesaran (1997); Pesaran and Shin (1999); and Pesaran et al. (2001; 2000) to examine the impact of technological innovation on bank performance in emerging market economies. The ARDL assumption is coupled with the help of an unconstrained vector error correction framework to examine the long-run association between high-tech innovation and emerging market bank performance. This strategy has several preferences over past long-run relationship methods (such as Jeselius cointegration and the Pearson correlation method). This estimation method can be used regardless of the integration levels of the variables I(0) or I(1) or both. Below is the ARDL model for this study:

$$\begin{aligned}\Delta MBP = {} & \theta_0 + \theta_1 \sum_{i=1}^{n} MBP_{t-1} + \theta_2 \sum_{i=1}^{n} MB_{t-1} + \theta_3 \sum_{i=1}^{n} INTB_{t-1} + \theta_4 \sum_{i=1}^{n} ATM_{t-1} + \theta_5 \sum_{i=1}^{n} E-Banking_{t-1} + \\ & \theta_6 \sum_{i=1}^{n} EXR_{t-1} + \theta_7 \sum_{i=1}^{n} INFR_{t-1} + \psi_1 MBP_{t-1} + \psi_2 MB_{t-1} + \psi_3 INTB_{t-1} + \psi_4 ATM_{t-1} + \psi_5 E-Banking_{t-1} + \\ & \psi_6 EXR_{t-1} + \psi_7 INFR_{t-1} + \mu_t \quad ---(2)\end{aligned}$$

Where θ_0 represents a constant term and μ_t is the white noise error correction term. The Akaike Information Criterion (AIC) is used to decide the maximum lag length for each variable used in the study.

Thus, in the ARDL method, another approach is to use a long-run lagged test to verify whether there is a long-run relationship between technological innovation and emerging market bank performance, which can be expressed by the following equations:

$$MBP = \theta_0 + \theta_1 \sum_{i=1}^{n} MBP_{t-1} + \theta_2 \sum_{i=1}^{n} MB_{t-1} + \theta_3 \sum_{i=1}^{n} INTB_{t-1} + \theta_4 \sum_{i=1}^{n} ATM_{t-1} + \theta_5 \sum_{i=1}^{n} E - Banking_{t-1} + \theta_6 \sum_{i=1}^{n} EXR_{t-1} + \theta_7 \sum_{i=1}^{n} INFR_{t-1} + \mu_t \text{ ---------- (3)}$$

However, if long-run relationships between measures of bank performance—return on assets and stock returns, mobile banking, internet banking, ATMs, e-banking, exchange rate, and inflation rate—are confirmed, we calculate the short-run relationship between technological innovation and emerging market bank performance using the following equation which is given below.

$$\Delta MBP = \theta_0 + \theta_1 \sum_{i=1}^{n} MBP_{t-1} + \theta_2 \sum_{i=1}^{n} MB_{t-1} + \theta_3 \sum_{i=1}^{n} INTB_{t-1} + \theta_4 \sum_{i=1}^{n} ATM_{t-1} + \theta_5 \sum_{i=1}^{n} E - Banking_{t-1} + \theta_6 \sum_{i=1}^{n} EXR_{t-1} + \theta_7 \sum_{i=1}^{n} INFR_{t-1} + \hbar ECT_{t-1} + \mu_t \text{ ---------- (4)}$$

The error correction model measures the impact of technological innovation on the performance of banks in emerging markets in the short run. This meant that the coefficient of the error correction term had to have a negative sign and be statistically significant before it could measure the rate of adjustment of the error correction model.

After specifying the ARDL model, we robustly employ a panel dynamic differential and system generalized method of moment (GMM) to further explore the relationship that exists between technological innovation and bank performance in emerging markets. Thus, the reason for using this model lies in its ability to correct the problem of endogeneity and cross-sectional dependence that occurs due to time-varying and country-specific effects. We then further used difference and system Generalized Method of Moment (GMM) estimators as proposed by Arellano and Bond (1991) and Blundell and Bond [66] to examine the impact of technological innovation on emerging market bank performance, as the model estimates implied, that the first-differenced lagged dependent variable is instrumented with the past level and the lagged level of the endogenous regressors are also used as instruments, which makes the endogenous variables predetermined and uncorrelated with the error term and, in this case, removes country-specific effects. Thus, assuming that the explanatory variables are not weakly exogenous but predetermined, the error term will not be serially correlated and the difference GMM estimator will have the following moment conditions:

$$E(Y_{it-s}, \Delta U_{it}) = 0 \text{ for } t = 3,\ldots\ldots, T \text{ and } s \geq 2$$

$$E(X_{it-s}, \Delta U_{it}) = 0 \text{ for } t = 3,\ldots\ldots, T \text{ and } s \geq 2$$

Since the difference GMM estimator may be subject to finite sample downward bias, another robust estimator will be needed to address the endogeneity problem [66]. Thus, we followed Arellano and Bover [67], Blundell and Bond [66], and Bond et al. [68] and used a system GMM estimator. This method often includes level variables with lagged differences of endogenous variables as instruments. The variables at the levels are instrumented by their first differences, which give rise to additional moment terms for the regression at the levels, which are expressed as follows:

$$E(\Delta Y_{it-s}, \mu_i + U_{it}) = 0 \text{ for } s = 1$$

$$E(\Delta X_{it-s}, \mu_i + U_{it}) = 0 \text{ for } s = 1$$

To this end, since the validity of the instruments affects the consistency of the GMM estimator, we consider two main specification tests. The first is Sargan's test—a test of overidentifying limitations, which tests the overall validity of the instruments. The second test examines the hypothesis that the error term is not serially correlated.

5. EMPIRICAL RESULTS AND DISCUSSION OF THE FINDINGS

Emerging markets have become a global focal point since the beginning of technological development due to the special characteristics that the region has compared to other regions of the economy. In this section, we present and interpret the empirical results obtained during the evaluation of the impact of technological innovations on the performance of banks in emerging markets. In this view, the real value of technological innovation is its ability to create economic prosperity that goes beyond economic growth by creating social stability, educational attainment, the development of technological innovation in the banking sector and an increase in the quality of life, which can be decisive elements in the development of emerging markets [69].

We took the first step by using a test of descriptive statistics to measure the basic characteristics of the variables. This test measures a basic summary of the behaviour of the variables in the model. This test has been widely used by several empirical studies including [65,16] among others. The total variations in the set of variables ranged from -6.960088 to 6.859266, representing the lowest and highest values. Also, the values of mean, median, standard deviation, Skewness and Kurtosis are not far from each other (see Table 1). Therefore, in addition, we observed that the probability value of the Jarque-Bera statistic for each of the variables is less than 0.05, which means that the error terms of the variables are normally distributed, which means that the variables are very suitable for estimates of specified [70,71].

Haven discovered the basic characteristics of the variables in the model and we appropriately used the Spearman correlation test to determine whether there is a correlation between technological innovation and the performance of banks in emerging markets. The Spearman correlation matrix measures the degree of the linear relationship between each pair of variables in the model, and correlation values range from -1 to +1. The greater the absolute value of the coefficient, the stronger the relationship between the variables, similarly, the lower the absolute values, the weaker the relationship between the variables [72]. According to Cohen (1988), correlation coefficients will be reported based on the following rule: Strong relationship ±5, Medium relationship ±3, and Weak relationship ±1 [73,74].

The findings suggest that there is a strong positive correlation between technological innovation and bank performance in emerging markets. This strong positive correlation between bank performance and technological innovation shows that in emerging markets, the level of technological innovation contributes significantly to bank performance. This is because individuals, firms, small businesses and governments have started adopting technological innovation tools. Today, people can shop, send money, receive money and conduct cross-border financial transactions in emerging markets.

Table 1. Results of descriptive statistics

	ROA	ROE	MB	INTB	E-BANKING	EXR	INFR
Mean	4.592	2.918	-0.231	1.632	1.192	1.177	0.462
Median	4.602	2.782	-0.130	1.726	0.430	1.053	1.362
Maximum	5.279	5.264	3.736	5.688	6.859	5.048	4.639
Minimum	3.963	-0.909	-6.295	-4.202	-5.763	-3.230	-6.960
Std. Dev.	0.145	1.030	2.078	0.933	2.221	1.417	2.335
Skewness	0.052	0.047	-0.385	-0.622	0.301	0.482	-0.498
Kurtosis	7.069	2.906	2.311	6.170	2.518	4.268	2.377
Jarque-Bera	592.4	80.62	36.58	391.1	21.21	58.32	32.94
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	858	858	822	809	857	551	572

Source: Computed by the author

Table 2. Estimated correlation matrix

	ROA	ROE	MB	INTB	ATM	E_BANKING	EXR	INFR
ROA	1.000							
ROE	0.860	1.000						
MB	0.854	0.634	1.000					
INTB	0.560	0.537	0.982	1.000				
ATM	0.716	-0.751	0.211	0.860	1.000			
E_BANKING	0.671	0.435	-0.311	0.123	0.785	1.000		
EXR	0.686	0.098	0.022	-0.112	-0.138	0.982	1.000	
INFR	0.938	-0.596	-0.294	-0.798	-0.146	-0.576	0.537	1.000

Source: Computed by the Author

Table 3. Summary of results for the stationarity test

Variable	LLC	IPS	Fisher-ADF	Fisher-PP	Level	First Difference
ROA	-2.850***	-3.363***	113.1***	111.0***		_
	(0.002)	(0.000)	(0.005)	(0.002)	I(0)	
ROE	-23.03***	-19.29***	459.9***	484.3***	_	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
MB	-4.284***	-4.553***	167.8***	172.7***		_
	(0.000)	(0.000)	(0.000)	(0.000)	I(0)	
INTB	-7.164***	-9.433***	241.9***	275.7***		_
	(0.000)	(0.000)	(0.000)	(0.000)	I(0)	
ATM	-15.65***	-4.796***	344.1***	418.5***		_
	(0.000)	(0.000)	(0.000)	(0.000)	I(0)	
E_BANKING	-26.55***	-26.03***	624.0***	727.7***	_	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
EXR	-28.97***	-26.04***	626.7***	2043.***	_	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
INFR	-22.82***	-19.09***	449.1***	607.3***	_	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)

*Source: Computed by the Author. NB: *** represents a 1% level of significance, ** represents a 5% level of significance, and * represents a 10% level of significance, while (.) represents probability values; I(0) represents integration order at the level and I(1) integration order at first difference*

The researcher deepened his investigations by performing unit root tests on a set of variables to check their level of stationarity and order of integration, and we used Levine, Lin and Chu's (2002) - LLC test and Im, Pesaran and Shin's (2003) - IPS unit root tests. It is worth noting that Levin, Lin, and Chu (2002) treat panel data as composed of homogeneous cross-sections, so they perform the test on pooled data series, while Im, Pesaran, and Shin's (2003) unit root test, on the other hand, causes the error the term of each variable will be serially correlated and the correlation properties vary across the cross-sections. Thus, this serves as the source of the combination of both LLC and IPS tests in this study. Below in Table 3 are the results of unit root tests. The tests follow the null hypothesis "unit root", the alternative hypothesis "no unit root", and the decision rule "reject the null if the probability value is less than 0.05".

The estimated results of the unit root tests show that the null hypothesis of "unit root" will be rejected for all variables in the LLC, IPS Fisher-ADF and Fisher-PP tests because their probability values are less than 0.05 and therefore we conclude that between a set of variables, there is no evidence of a unit root. In addition, the results also show that while some variables are integrated at level (I(0)), others are integrated at the first difference (I(1)) in both LLC and IPS tests. These differences in the order of integration of the variables are very suitable for the estimation model - the Autoregressive Distributed Lag Model (ARDL) - because it accepts each of the variables regardless of their order of integration.

Table 4. Results of cointegration tests

	Pedroni Cointegration Test							Kao Cointegration Test
	Within-Dimension				Between-Dimension			Robustness Check
Model	**Panel v-Statistic**	**Panel rho-Statistic**	**Panel PP-Statistic**	**Panel ADF-Statistic**	**Group rho-Statistic**	**Group PP-Statistic**	**Group ADF-Statistic**	**ADF-Statistic**
Model 1	-4.901***	3.542	-4.731***	-4.086***	6.041***	-4.648***	-3.318***	-4.871***
	(0.000)	(0.999)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Model 2	-4.790***	-5.478***	3.343***	6.608***	6.123***	-7.648***	-4.677***	4.517***
	(0.0000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

*Source: Computed by the Author. NB: *** represents a 1% level of significance, ** represents a 5% level of significance, and * represents a 10% level of significance, while (.) represents probability values*

Table 5. Estimated Panel ARDL and GMM Results

Variable	Model 1	Model 2	Model 1		Model 2	
	Panel ARDL	Panel ARDL	Diff. GMM	Sys. GMM	Diff. GMM	Sys. GMM
Lag Dep. Var.	0.990***	0.912***	0.742***	32.61***	0.903***	55.61**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)
MB	0.646***	-1.369***	0.927***	0.347***	-0.179***	-0.583***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)
INTB	0.216***	-0.531***	0.929***	0.932***	0.017**	-0.961***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.015)	(0.000)
ATM	0.642***	0.523***	0.090***	0.799***	0.260**	0.931***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)
E_Banking	0.407***	-0.960***	-0.112***	3.017***	-0.373***	-0.901***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EXR	-0.525***	0.877***	0.644***	0.804***	0.124***	-0.674***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
INFR	0.7694***	2.306***	-0.587***	0.128***	-0.071	-0.819***
	(0.000)	(0.002)	(0.000)	(0.005)	(0.239)	(0.000)
ECM (-1)	-0.192***	-0.914***				
	(0.000)	(0.000)				
No. of Obs.	780	780	780	741	780	741
Normality	3484	7949	_		_	
	(0.000)	(0.000)				
S. Correlation	7.099	1.933	_		_	
	(0.607)	(0.145)				
Ramsey	-0.308	-0.479	_		_	
	(0.000)	(0.021)				
Heteroscedasticity	1.057	1.235	_		_	
	(0.388)	(0.187)				
Hausman	27.63	26.39	_			
	(0.000)	(0.000)				
PMG	-	-	0.994		0.960	
Fixed Effects	-	-	0.769		0.863	
AR1	_	_	0.027		-0.141	
			(0.000)		(0.191)	
AR2	_	_	0.029		-0.758	
			(0.465)		(0.892)	
Hansen	_	_	30.27	120.7	33.55	201.1
			(0.154)	(0.215)	(0.191)	(0.015)

*Source: Computed by the Author. NB: *** represents a 1% level of significance, ** represents a 5% level of significance, and * represents a 10% level of significance, while (.) represents probability values*

Next, we set out to investigate whether or not cointegration exists between technological innovation and emerging market bank performance in a set of specified models. This was done by using – panel cointegration tests – Pedroni's cointegration test as suggested by Pedroni [75] and supplementing it with Kao's [76] cointegration test as a robustness check. Pedroni proposed in 2004 a seven-cointegration test with a null hypothesis of "no cointegration" and a decision rule to reject the null hypothesis of "reject the null if the probability value is less than 0.05". Seven test statistics allow for heterogeneity in the panel, both in the short-run dynamics and in the long-run slope and intercept coefficients. The seven test statistics are grouped into two categories, namely: group mean statistics, which average the test results of individual countries, and panel statistics, which aggregate statistics within a dimension for non-parametric and parametric across both groups.

The test results showed that for all specified models, the null hypothesis of “no cointegration” will be rejected at the 5% critical level, as the probability values of most of the Pedroni tests are less than 0.05 (see Table 4). It was thus concluded that there is a co-integration between technological innovation and bank performance in emerging markets. These findings are in line with previous findings of various scholars such as [23] among others.

As stated by Gujarati (2003), each specified model should undergo basic OLS diagnostic tests such as normality, Breusch-Godfrey serial correlation test, Ramsey reset the test and White Heteroscedasticity test to know whether they produce viable estimates or not. Therefore, we have ensured that our specified models have passed these tests and the results are shown in Table 5. However, from the results of the normality test, serial correlation test and heteroscedasticity test, we found that all error terms of the whole specified models are normally distributed, serially uncorrelated and homoscedastic; while the result of the Ramsey Reset test shows that the models are specified correctly.

In addition, we further used the probability test – Hausman test to select the best fitting model for each of the specified models between the fixed effects model and the random effects model. The Hausman test was proposed by Hausman in 1987 for use by researchers to select appropriate models for analysis in panel studies. The rule of thumb that governs the test is that “if the probability value of the chi-square statistic is less than 0.05, it indicates that fixed effects are the most appropriate model to be used in the estimation procedure. However, if the probability value of the chi-square statistic is greater than 0.05, it indicates that the random effects model is the most appropriate estimation procedure”. In conclusion, for both models 1 and 2, the fixed effects model was used in the estimation because the probability value of the chi-square statistic is less than 0.05.

In the ARDL results in Model 1, measures of technological innovation in mobile banking, internet banking, ATMs, and electronic banking have positive impacts of 0.646702, 0.216449, 0.642982, and 0.407667 on emerging market bank performance. This means that a unit increase in mobile banking, internet banking and ATMs would increase the bank's performance by approximately 0.646702, 0.216449, 0.642982 and 0.407667 respectively. The positive long-term impact of technological innovation on bank performance shows that emerging markets have improved in technological innovation. This finding is similar to previous evidence discovered by researchers such as [3]. In addition, the results of macroeconomic variables included in the model as control variables, while the exchange rate has a negative and significant impact on bank performance, the inflation rate depicted a positive and significant impact on bank performance in emerging markets.

Conversely, model 2, which has the bank's return on equity as the dependent variable, shows that there are negative and significant long-run relationships between mobile banking, internet banking, electronic banking and emerging market bank performance. We also find that automated teller machines (ATMs) have a positive impact on the performance of banks in emerging markets.

In the short run, the error correction model (ECM) coefficients met the assumptions of the ARDL, which encapsulated that for models 1 and 2, "the ECM coefficients have negative signs and are statistically significant", indicating that the rate of adjustment from the short run to the long run models 1 and 2 are -0.192975 and -0.914650. This meant that the rate of adjustment from the short-term to the long-term would take about 19% and 91%, all things being equal. These findings are consistent with early findings by Muotolu & Nwadialor [15], Singh & Ghosh, [9], Mohammed & Abdullahi, 2021, and Akwam & Yua [16]) among others.

Next, we used a panel dynamic generalized method of moment (GMM) that contains different system GMM models as proposed by Arellano and Bond [77] and Blundell and Bond [66] to further test the initial findings of the ARDL model. The fact that the ARDL model cannot correct the problems of endogeneity and country-specific effects in the panel of emerging market datasets informed our choice of these additional models. Thus, we first compared the pooled mean group (PMG) coefficients and fixed effects models to choose between the difference and system GMM that would be appropriate for the analysis. In this regard, the findings suggest that for models 1 and 2, the various GMMs appear to be the most appropriate estimation models, as the PMG coefficients are larger than the fixed effects coefficients. However, the findings suggest that there is a long-term positive and significant relationship between technological innovation and bank performance in emerging markets. We also found no additional serial correlations (AR2) in the models. In addition, the results of Sargan's J test show that the instruments of the variable models are valid. These findings are in line with earlier findings by scholars such as [17,13,12] among others.

6. CONCLUDING REMARKS AND POSSIBLE POLICY RECOMMENDATIONS

In conclusion, this study empirically investigated the impact of technological innovation on emerging market bank performance using annual time series data from 2000 to 2021, which was regressed using a panel autoregressive distributed lag (ARDL), differenced, and system-generalized method of moment (GMM). From the Pedroni cointegration results, we find that there is cointegration between technological innovation and bank performance in emerging markets. The results of the ARDL bounds test also show that there are long-run relationships between technological innovation and bank performance in emerging markets. Evidence from the ARDL results suggests that there are positive long-run relationships between technological innovation and banks' return on assets and negative long-run and significant relationships between technological innovation and banks' returns on emerging market stocks. However, findings from the current generalized method results show that there is a long-run positive relationship between technological innovation and emerging market bank performance. In conclusion, this study found the existence of positive long-run relationships between technological innovation and bank performance in emerging markets. Thus, the research results show that there are significant negative relationships between technological innovation and bank performance in emerging markets at one point in time, especially in terms of return on bank equity and technological innovation, which contradicts the findings of Nwakoby et al. [78] and Akwam and Yua [16].

Based on the study's findings, we recommend that by serving underbanked individuals and businesses in emerging markets, banks can promote inclusive growth, restore confidence and increase profits. This can be achieved by extending financial services to the most basic remote areas and villages where larger numbers of emerging market populations live. In addition, the adoption of technologically enhanced innovative financial instruments in emerging markets can significantly improve the performance of emerging market banks. This will not only facilitate banking services for customers but also enable banks to achieve wider coverage without leaving their offices in these areas. It would also be recommended that the governments of emerging market countries expand the coverage of technological innovation in their respective countries by massively investing in the introduction of technological innovation tools to boost the economic activities of all sectors of the economy [79,80].

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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