The Impact of Technological Innovations on Bank Performance in Emerging Economies

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 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.

Keyword: Technological Innovation and Bank Performance

1. INTRODUCTION

Technological innovation in the banking sector has recently gained importance, especially in less developed countries in some regional economies such as emerging economies (Suleymanov, et al., 2019). At some point, the banking sector has longed to grow beyond conventional banking by embracing technology and financial innovation, making the banking industry the most prominent institution (Guo and Liang, 2016). Based on technological advancement, banks can effectively and conveniently provide their services by introducing various financial products and services (Lin, 2007; Tasaki and Yamakawa, 2011) and customers can bank through various channels through internet banking, ATMs channels, point of sale, mobile banking, mobile money, fund transfers and electronic banking through innovative payment systems and improved banking activities (Yao et al., 2018; Guo and Liang, 2016).

Achieving higher financial performance in investments remains the central objective of every operating bank and technological innovation has gained the dominant popularity of banks by making banks extend their services to the most vulnerable unbanked people without having to build a banking hall (Salehi and Alipour, 2014). Some of the important technological innovations for banking performance include enabling convenient secure banking, personal banking and a greater variety and quality of services provided by banks to customers (Kelvin, 2012). However, various scholars have documented that it is generally recognized that a well-functioning payment infrastructure is essential to increase the efficiency of the banking sector, financial markets and the financial system, which increases customer/investor confidence, facilitates economic cooperation and trade (see Bank doe International Settlement, 2006; Humphrey et al., 2006).

The extensive literature has produced some unmistakable observations that banks have performed better when they have adopted technological innovation (see Kuzmenko and Ovchrenko, 2018; Huang et al. 2018; Mustafa et al. 2018; Yoa et al. 2018; Dong et al. 2020; Zu et al. 2019) among others. According to McWaters and Galaski (2017), although technological innovation has successfully led to innovation efforts and increased customer expectations from banks through financial innovation, customers who are willing to switch from manual banking to innovative banking are motivated by the benefits it offers them. Recently, more and more studies have investigated the relationships between technological innovation and bank performance in their different paradigms, both in a country-specific and cross-country stance. For example, banking relationships between FinTechs and BigTechs (Stulz 2019; FSB 2019a; OECD 2020) or technological innovation and firm development (BIS, 2018), yet there are

several types of literature on technological innovation and bank performance in emerging economies economy. However, this study will contribute to the existing body of literature by focusing on studying the impact of technological innovation on bank performance in emerging economies.

In addition, we will use some key indicators of technological innovation such as Mobile Banking (MB), Internet Banking (INTB), ATM (ATM) and Electronic Banking (E-Banking) was used to measure technological innovation. In addition, bank performance was measured using bank return on assets (ROA) and bank return on equity (ROE), and we controlled for the exchange rate (EXR) and inflation rate (INFR). Furthermore, we generated an index of technological innovation to create 2 additional models as a robustness check to deepen the investigation of the impact of technological innovation on bank performance in emerging economies. To estimate the specified models, we used a panel autoregressive distributed lag (ARDL) model and a panel differential and system generalized method of moment (GMM) as a robustness check. And we will base our investigation on CAMELS dimensions - Capital Adequacy, Asset Quality, Governance, Profit Liquidity and Sensitivity based on the study of Mustafa et al. (2018). Therefore, 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 (Nami Elime, 2020). 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 (Nami Elime, 2020).

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 (Rose, 2022), yet financial services are almost universally available in high-income countries in most emerging countries'will become unattainable (World Bank, 2022).

Emerging markets contain more than 1.6 billion people and 200 million small businesses that lack access to formal financial services (Alexander et al. 2017)). 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 (Rose, et al. 2022). Figure 1 below shows technology adoption in emerging economies.

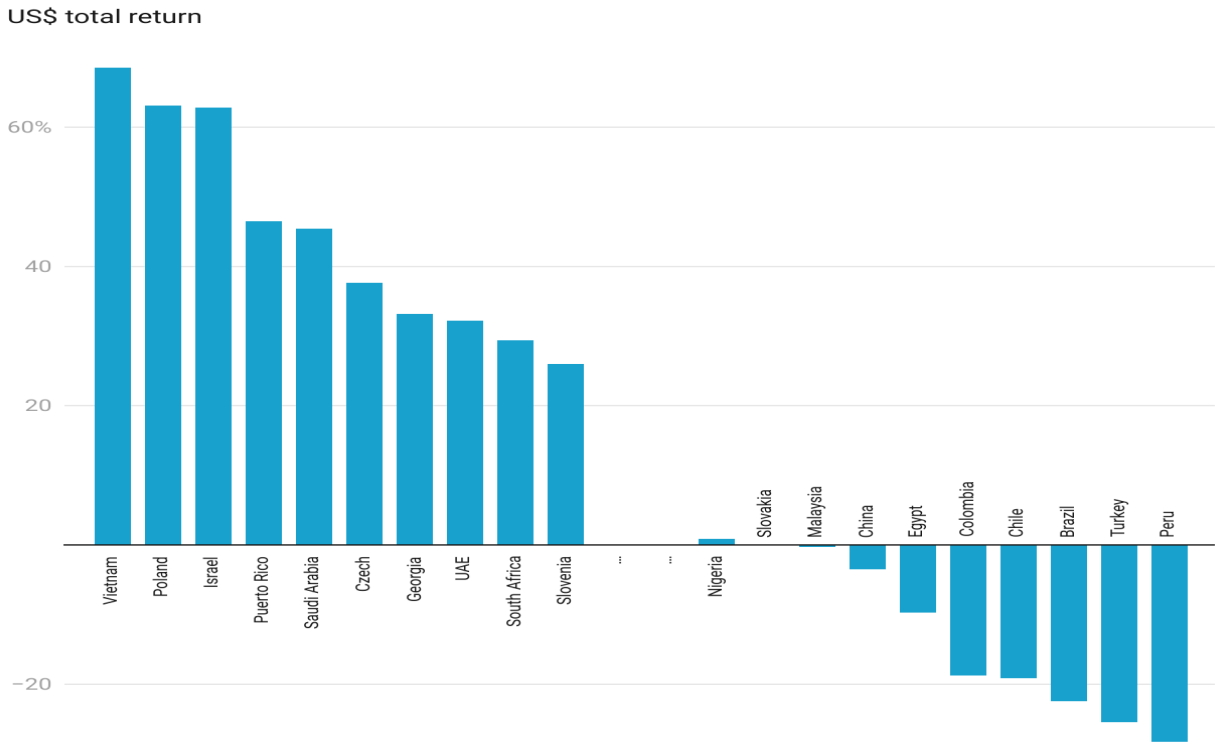
Figure 1: Technology adoption in emerging economies

Source: World Economic Forum

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 (Nami Elime, 2020). 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 (Nami Elime, 2020).

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 (Rengasamy 2012). 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 (Regnasamy, 2012). Figure 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 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 Figure 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 will focus 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 (Chetan Sehgal, 2018). 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 (WIPO, 2017).

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 (1997) 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 (2005) 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 (CBK, 2014). 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 (1983). 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 in Cunningham (2003) in Moga (2010) tested the theory of electronic banking adoption. The nominalized factors are complexity, trialability and observability (Moga, 2010). 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 (Rogers, 1983). 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 (Rogers, 1983). 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 (1983) 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 (Rogers, 1983). 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 (Rogers, 1983).

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 (Davis, 1989). 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 (Davis, 1989). The second is perceived ease of use, defined as “the extent to which a person believes that using a particular system would be effortless (Davis, 1989).

Empirical Literature

From an empirical point of view, several kinds of literature have investigated the impact of technological innovation on bank performance in a different paradigm. For example, Kuzmenko and Ovcharenko (2018) attempted to investigate the innovation capacity of banking sectors in Ukraine. In this context, regression analysis is used for this purpose. It has been found that the quality of banks' technology is improving to better innovate. Similarly, Huang et al. (2018) conducted a study to evaluate innovation in the Taiwanese banking sector. In this framework, a simultaneous stochastic frontier model is considered. They concluded that financial innovation is a significant way to increase competitive strength, while YawObeng and Mkhize (2019) conducted interviews with customers in Ghana to understand the key points in the process of developing innovative products. They emphasized the importance of technological efficiency in this process.

To explore innovative technologies in the banking sector, YuSheng and Ibrahim (2019) focused on the benefits of innovation for the banking sector in Ghana. In their analytical process, a survey of 450 commercial bank customers is conducted. They found that service innovation has a positive effect on customer satisfaction in the banking sector. Furthermore, Taghizadeh et al. (2018) focused on the determinants of banks' innovation capacities. For this purpose, a structural equation model is constructed with 253 managers representing 26 banks in Bangladesh. They concluded that innovative products could contribute to increased customer satisfaction. In the same vein, Mustafa et al. (2018) attempted to identify key performance indicators of commercial banks in Kenya. They defined these variables based on the Capital Adequacy, Asset Quality, and Governance, Profitability Liquidity and Sensitivity (CAMELS) dimensions.

Dong et al. (2020) in a recent paper looked at the effect of web-based financing on the performance of commercial banks in China. The post makes inventive use of multi-source information to create a list of web accounts containing

internet search information and 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. In a related study, Yao et al. (2018) examine the impact of payment technologies on the financial performance of the banking sector in China using an impulse vector auto-regression model to analyze third-party payment (TPP) data from 2007 to 2014. The findings revealed that TPP increases monetary turnover and positively affects the growth earnings of the financial sector. Thus, the results empirically suggest that innovation in payment technology contributes to industrial synergy in the development of China's financial industry. In the Indian context, Vikram and Gayathri (2018) examine the impact of information technology on the financial performance of banks in India using panel data consisting of cross-sectional and time-series data of 21 banks over the period 2011-2015 and find that IT investment increases bank profitability. Conversely, Zu et al. (2019) in their studies entitled impact of payment systems technology on e-banking performance evidence in Africa using a descriptive research design and panel regression model found that ATMs positively affect bank profitability while POS and internet payments negatively affect profitability.

Anselm Ngwa (2020) in his study on electronic banking transactions and their effect on the financial performance of some selected commercial banks in Cameroon uses econometric techniques of descriptive analysis and uses regression analysis on quarterly data of 4 commercial banks from 2012-2018 to investigate the effect of mobile payments, of ATMs, prepaid cards (PPV) and DTF for the return on bank assets. The findings revealed that mobile money transfer, domestic transfer fund equivalent of RTGS transactions and electronic point terminals through all have a positive impact on return on assets, but prepaid cards such as ATMs. Debit cards have negative effects on the profitability of bank assets. Specifically, the overall findings indicated that electronic payment transactions have a significant effect on the financial performance of banks in Cameron. Similarly, Vekya (2017) who adopted a descriptive research design on data from 43 commercial banks to examine the impact of e-banking on the financial performance of banks in Kenya established a positive significant relationship between ATM transactions and bank profitability.

In an extensive study, Frank and Binaebi (2019) examined the impact of electronic payment system implementation on the financial performance of Nigerian commercial banks. The research uses annual data from 2009 to 2018 and uses the ordinary least squares regression technique. Four measures of payment system technology, namely ATM transactions, POS transactions, Internet payments and mobile payments, were used, while the aggregate asset base was used as a measure of commercial bank performance. The empirical results of the study showed that the implementation of payment system innovations had a mixed effect on the financial performance of banks in Nigeria. ATMs and internehurtments have a positive effect on the financial performance of banks, while POS terminals harm the performance of banks. Similarly, Orji et al. (2018) in their study on e-banking innovation and some selected banks in Nigeria, using the SURE model to analyze data from six selected banks in Nigeria from 2007-2016, revealed that ATMs, POS, mobile payments and bank size have a positive and significant effect on the bank's financial performance. In the same vein, Nwakoby et al. (2020) investigated the effects of electronic payments on the performance of 9 selected banks out of 15 listed on the Nigerian Stock Exchange. The research paper implemented an OLS regression analysis technique using ATM transactions, POS transactions and mobile payments as measures of e-banking with return on equity as a measure of bank profitability. The findings revealed that ATM transactions are hurting DMB. While both POS and mobile payments have a positive impact on the return on equity of DMBs in Nigeria.

In a more recent study, Akwam and Yua (2021) conducted research on the effects of e-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 revenues on assets, return on equity and earnings per share as indicators of bank performance. A time series of annual data from 2005-2019 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. However, in the Nigerian context, Muotolu and Nwadialor (2019) in their studies on cashless policy in Nigeria and its impact on the financial performance of commercial banks used ATM, POS, internet payment, NEFT and NIP volumes as proxies for cashless policy and return on assets as an indicator of bank

performance. In the research work, they adopted panel data from 14 banks in the period from 2012 to 2017, which was analyzed using descriptive statistics, multicollinearity test, correlation testing and heteroscedasticity 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.

In emerging market economies, Saidi (2018) investigated the impact of electronic payment technology on bank performance and the study relied on secondary data. Data analysis was performed using time-dimensional, panel least squares models and sorted into an index. The study confirms that emphasis should be placed on the current resources of banks, not on the performance of previous banks. Similarly, Purnomo and Khalda (2019) assessed the impact of financial technologies on national financial institutions. Using descriptive methods and gathering information/data from the internet, their findings show that financial technology could hinder the development of banking. In a recent study, Aduaka and Awolusi (2020) assessed the impact of e-banking on the profitability of the Nigerian banking industry. Primary and secondary data were collected through questionnaires and audited financial reports of banks. Using multiple regression, cards play a significant role more than other channels, closely followed by ATMs. It also found that e-banking channels contributed to banks' profitability. In addition, Ibekwe (2021) conducted a study on the financial innovation and performance of DMBs in Nigeria. Using CBN data and Augmented Dickey-Fuller Test for unit roots and OLS regression, ATM, POS, mobile banking and internet banking have a positive effect on the performance of DMB.

Bömer and Maxin (2018) correctly noted that the relationship between technological innovation and bank performance deserves attention given the special features of the financial services industry characterized by increased regulatory requirements after the 2008 financial crisis, long-term relationships between banks and their clients based on trust and loyalty and also on the rapid technological development until the middle of the 21st century, resulting in new products, processes and business models. In a more recent study, Li, et al. (2021) used a descriptive and questionnaire model and found that the use of online banking channels is associated with higher customer retention rates; also found evidence that the company's market share in the research sample is also systematically higher in markets with high levels of online banking channel usage. Similarly, Suleymanov et al. (2019), looking at cross-country panel data, examined the effects of electronic payment innovations on bank performance using dynamic panel data as a method of analyzing data from 23 developed and developing countries over the period 2008–2018. The study found that all channels of the payment system in the study affect profitability, except for POS and Internet services, which negatively affected profitability.

From an emerging economy perspective, Yao et al. (2018) examine the impact of payment technologies on the financial performance of the banking sector in China using an impulse vector auto-regression model to analyze third-party payment (TPP) data from 2007 to 2014. The findings revealed that TPP increases monetary turnover and positively affects the growth earnings of the financial sector. Thus, the results empirically suggest that innovation in payment technology contributes to industrial synergy in the development of China's financial industry. Also, Dong et al. (2020) 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 (2021) 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 2005-2019 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 (2019) 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.

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:

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

Where ε_t indicates an error term refers to measures of bank performance which included - 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 (Ibekwe 2021; Manasseh et al. 2021).

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); 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:

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

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 (1998) 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:

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

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

Since the difference GMM estimator may be subject to finite sample downward bias, another robust estimator will be needed to address the endogeneity problem (Blundell and Bond 1998). Thus, we followed Arellano and Bover (1995), Blundell and Bond (1998), and Bond et al. (2001) 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 (Aubert, 2004).

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 (Manasseh et al 2021; Akwam and Yua 2021) 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.

Table 1: Results of descriptive statistics

	ROA	ROE	MB	INTB	E_BANKING	EXR	INFR
Mean	4.592206	2.918892	-0.231409	1.632013	1.192961	1.177995	0.462646
Median	4.602868	2.782127	-0.130674	1.726478	0.430788	1.053602	1.362430
Maximum	5.279137	5.264846	3.736517	5.688221	6.859266	5.048297	4.639523
Minimum	3.963324	-0.909860	-6.295953	-4.202903	-5.763951	-3.230542	-6.960088
Std. Dev.	0.145822	1.030454	2.078594	0.933614	2.221652	1.417882	2.335666
Skewness	0.052398	0.047335	-0.385261	-0.622751	0.301146	0.482350	-0.498647
Kurtosis	7.069605	2.906962	2.311108	6.170669	2.518925	4.268750	2.377268
Jarque-Bera	592.4728	80.62853	36.58842	391.1655	21.21755	58.32273	32.94703
Probability	0.000000	0.000000	0.000000	0.000000	0.000025	0.000000	0.000000
Observations	858	858	822	809	857	551	572

Source: Computed by the author.

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 relationships between the variables (Gujarati, 2003). According to Cohen (1988), correlation coefficients will be reported based on the following rule: Strong relationship ±5, Medium relationship ±3, and Weak relationship ±1.

Table 2: Estimated correlation matrix

	ROA	ROE	MB	INTB	ATM	E_BANKING	EXR	INFR
ROA	1							
ROE	0.860861	1						
MB	0.854610	0.634421	1					
INTB	0.560839	0.537614	0.982260	1				
ATM	0.716491	-0.751570	0.211725	0.860861	1			
E_BANKING	0.671885	0.435922	-0.311199	0.123959	0.785902	1		
EXR	0.686497	0.098248	0.022586	-0.112272	-0.138169	0.982484	1	
INFR	0.938187	-0.596874	-0.294787	-0.798204	-0.146342	-0.576799	0.537614	1

Source: Computed by the Author

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. These findings are confirmed by previous discoveries by scientists including (Muotolu and Nwadialor 2019) among others.

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".

Table 3: Summary of Results for the Stationarity Test

Variable	LLC	IPS	Fisher-ADF	Fisher-PP	Level	First Difference
ROA	-2.85040*** (0.0022)	-3.36395*** (0.0004)	113.195*** (0.0057)	111.099*** (0.0082)	I(0)	_
ROE	-23.0339*** (0.0000)	-19.2977*** (0.0000)	459.979*** (0.0000)	484.300*** (0.0000)	_	I(1)
MB	-4.28449*** (0.0000)	-4.55370*** (0.0000)	167.818*** (0.0000)	172.751*** (0.0000)	I(0)	_
INTB	-7.16427*** (0.0000)	-9.43300*** (0.0000)	241.953*** (0.0000)	275.761*** (0.0000)	I(0)	_
ATM	-15.6559*** (0.0000)	-4.79630*** (0.0000)	344.143*** (0.0000)	418.573*** (0.0000)	I(0)	_
E_BANKING	-26.5566*** (0.0000)	-26.0349*** (0.0000)	624.095*** (0.0000)	727.705*** (0.0000)	_	I(1)
EXR	-28.9716*** (0.0000)	-26.0425*** (0.0000)	626.796*** (0.0000)	2043.29*** (0.0000)	_	I(1)
INFR	-22.8275*** (0.0000)	-19.0959*** (0.0000)	449.139*** (0.0000)	607.326*** (0.0000)	_	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 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.

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 (2004) and supplementing it with Kao's (1999) 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 (Chetan, 2018) among others.

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	-4.900641*** (0.0000)	3.542782 (0.9998)	-4.731576*** (0.0000)	-4.086223*** (0.0000)	6.041684*** (0.0000)	-4.648112*** (0.0000)	-3.318696*** (0.0005)	-4.871126*** (0.0000)
Model 2	-4.790551*** (0.00000)	-5.478170*** (0.0000)	3.343583*** (0.0000)	6.608737*** (0.0000)	6.123609*** (0.0000)	-7.648735*** (0.0000)	-4.677519*** (0.0000)	4.517506*** (0.0000)

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.

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 below. 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 (Aduaka and Awolusi, 2020; Akwam and Yua 2021; Ngwa, 2020; Chetan, 2018; FSB. 2019a; and Huang et al. 2018). 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 earlyliealignes performed by (Aduaka and Awolusi, 2020;

Akwam and Yua 2021; Ngwa, 2020; Chetan, 2018; FSB. 2019a; and Huang et al. 2018; Dong et al., 2019; and Bina, 2019 ; Orji et al. 2018; Nwakoby et al. 2020; Taghizadeh, et al. 2018; Vekya, 2017; Saidi 2018; Mustafa et al. 2018; Ibekwe 2021) among others.

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.	0.990665*** [0.107180] {9.243002} (0.0000)	0.912472*** [0.131515] {6.938159} (0.0000)	0.742423*** [0.030315] {24.49005} (0.0000)	32.61870*** [4.432217] {7.359454} (0.0000)	0.903875*** [0.013079] {69.11149} (0.0000)	55.61221** [21.66568] {2.566835} (0.0105)
MB	0.646702*** [0.082586] {7.830649} (0.0000)	-1.369754*** [0.115239] {-11.88620} (0.0000)	0.927455*** [0.106476] {8.710460} (0.0000)	0.347961*** [0.087780] {3.964012} (0.0008)	-0.179939*** [0.019988] {-9.002161} (0.0000)	-0.583214*** [0.215389] {-2.707723} (0.0069)
INTB	0.216449*** [0.004401] {49.18628} (0.0000)	-0.531088*** [0.119287] {-4.452193} (0.0000)	0.929904*** [0.040985] {22.68888} (0.0000)	0.932660*** [0.123289] {7.564827} (0.0000)	0.017265** [0.007135] {2.419610} (0.0158)	-0.961299*** [0.075149] {-12.79190} (0.0000)
ATM	0.642982*** [0.078063] {8.236706} (0.0000)	0.523423*** [0.160005] {3.271291} (0.0008)	0.090518*** [0.000527] {171.7609} (0.0000)	0.799704*** [0.105289] {7.595323} (0.0000)	0.000260** [0.000102] {2.548452} (0.0110)	0.931425*** [0.116011] {8.028764} (0.0000)
E_Banking	0.407667*** [0.042124] {9.677784} (0.0000)	-0.960086*** [0.138653] {-6.924379} (0.0000)	-0.112705*** [0.007698] {-14.64081} (0.0000)	3.01E-08 [0.000524] {5.74E-05} (1.0000)	-0.004373*** [0.000859] {-5.091246} (0.0000)	-0.900113*** [0.018585] {-48.43223} (0.0000)
EXR	-0.525240*** [0.130377] {-4.028613} (0.0001)	0.877934*** [0.103893] {8.450367} (0.0000)	0.644284*** [0.047465] {13.57387} (0.0000)	0.804102*** [0.014936] {53.83650} (0.0000)	0.124041*** [0.016388] {7.569207} (0.0000)	-0.674969*** [0.015904] {-42.43963} (0.0000)
INFR	0.769476*** [0.021608] {35.61142} (0.0000)	2.306593*** [0.762016] {3.026960} (0.0025)	-0.587557*** [0.096944] {-6.060787} (0.0000)	0.128922*** [0.054719] {2.356073} (0.0056)	-0.071346 [0.060571] {-1.177875} (0.2392)	-0.819224*** [0.085226] {-9.612371} (0.0000)
ECM (-1)	-0.192975*** [0.042764] {-4.512584} (0.0000)	-0.914650*** [0.015056] {-60.74986} (0.0000)	–	–	–	–
No. of Obs.		780	780	741	780	741
Normality	34841.02 (0.0000)	79491.34 (0.0000)	–		–	
S. Correlation	7.099640 (0.6079)	1.933641 (0.1453)	–		–	
Ramsey	-0.001308 (0.0002)	-0.000479 (0.0219)	–		–	
Heteroscedasticity	1.057968 (0.3889)	1.235435 (0.1875)	–		–	
Hausman	27.634418 (0.0003)	26.395387 (0.0004)	–			
PMG	-	-	0.994653		0.960458	
Fixed Effects	-	-	0.769476		0.863469	
AR1	–	–	0.027455 (0.7966)		-0.141046 (0.1919)	
AR2	–	–	0.029904 (0.4658)		-0.004758 (0.8925)	
Hansen	–	–	30.27416 (0.154050)	120.7303 (0.215737)	33.55964 (0.191659)	201.1974 (0.015238)

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 the standard error, {.} represents the T-statistics, and (.) represents probability values.

Next, we used a panel dynamic generalized method of moment (GMM) that contains different system GMM models as proposed by Arellano and Bond (1991) and Blundell and Bond (1998) 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 (Akwam and Yua 2021; Ngwa, 2020; Chetan, 2018; FSB. 2019a; and Huang et al. 2018; Dong et al. 2020; Frank and Binaebi, 2019; Orji . 2018; Nwakoby et al. 2020; Taghizadeh, et al. 2018; Vekya, 2017; Saidi 2018; Mustafa et al. 2018; Ibekwe 2021).

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 Nwakoba et al. (2020) and Akwam and Yua (2021).

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.

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