Nexus Between Digital Finance Ecosystem, Cyber Security and Banking Sector Performance in Emerging Economies: The Role of National Security and Economic Uncertainty

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Abstract

This study examined the nexus between the digital finance ecosystem, cyber security and banking sector performance in emerging economies from 1995 to 2022 and accounted for the influence of national security and economic uncertainty, which was estimated with the autoregressive distributed lag model (ARDL) as the baseline model and dynamic ordinary least squares (DOLS) as the robustness. We measured the digital finance ecosystem with indicators such as automatic teller machines, point of sale, internet banking, mobile money, and mobile payment, while banking sector performance was measured with bank return on assets and bank return on equity. Findings from the ARDL baseline model show that digital finance ecosystem indicators – automated teller machines, point of sale, internet banking, mobile money and mobile purchase have significant effects on both bank return on assets and bank return on equity in emerging. Furthermore, we controlled for the influence of cyber security, financial literacy, financial deepening, institutional quality, and macroeconomic volatility and found that they have mixed significant impacts on banking sector performance in emerging economies. Relatedly, from the result of the DOLS analysis – the robustness checks, we also found that digital finance ecosystem indicators – automated teller machines, point of sale, internet banking, mobile money, and mobile purchase have positive and significant effects on both bank return on assets and bank return on equity in emerging economies. Furthermore, from the

results of the control variables, (cyber security, financial literacy, financial deepening, institutional quality, and macroeconomic volatility) we found that they have both negative and positive effects on banking sector performance in the emerging economies. Based on the result findings, we recommend policies improvement of digital finance, financial inclusion, financial technology, internet banking, mobile money, and digital financial payment systems in Nigeria and Kenya to forestall increased banking sector performance.

Keywords: Digital Finance Ecosystem, Banking Sector Performance, Financial Literacy

1. Introduction

The banking sector's performance is an important indicator of economic growth and development because it is crucial for economic stability, growth, and the efficient functioning of financial systems, benefiting individuals and the broader economy (Andres, 2009). Banks efficiently allocate capital by lending to businesses and individuals, supporting investment and consumption that drive economic growth, aid in the management and mitigation of financial risks, provide better access to credit for consumers, and offer various investment products, such as savings accounts, bonds, and mutual funds, which helps individuals grow their wealth, drive financial innovation, offering new products and services that can benefit investors and consumers alike, ensures smooth and secure transactions, including electronic payments and transfers, enhance financial inclusion, by providing underserved communities with access to banking and financial products, foster trust and confidence among consumers and investors through adherence to rigorous regulatory standards, contribute to economic multipliers by financing businesses that, in turn, create additional economic activity and job opportunities in the community (Bhattacharya, 1993). Left for itself, the banking sector's performance cannot be fully achieved without the efficient functioning of the digital finance ecosystem – a complex network of people, businesses, and systems that use technology to interact with one another, especially following the recent wave of the internet since the 2000s. The digital finance ecosystem is crucial to the performance of banks, influencing various aspects of their operations and competitive positioning (Roger 1983). To achieve great success in the banking sector, a well-developed digital finance ecosystem is vital for enhancing bank performance by improving customer experience, operational efficiency, and innovation. It also enables better data analytics, expanded market reach, and effective security and compliance management, ultimately contributing to the bank's overall success and competitiveness (Gerrand 2003).

A well-integrated digital finance ecosystem aids banks in devising and delivering financial products seamlessly easily, efficiently, and effortlessly (Mogan 2010). The digital finance ecosystem is fathomed because, in today's dynamic and complex environment, banks cannot operate in isolation. They must collaborate with other financial industry actors and stakeholders, such as fintech companies, regulators, customers, and other institutions, to provide comprehensive and innovative financial services that allow banks to expand their services beyond traditional banking products and offer a wider range of solutions to meet customer needs (Mogan 2010). Through efficient connectivity of the digital finance ecosystem, banks open their APIs to third-party developers, allowing them to access and integrate banking

services into their applications, to enable the integration of various financial services and promote interoperability in the ecosystem, thereby, putting customers at the centre of the business by providing personalized and tailored financial solutions and offering a wider range of services such as budgeting tools, investment platforms, or insurance products (Gosh 2022). Also, they work closely with regulators to ensure compliance with financial regulations and standards, creating a secure and transparent ecosystem to protect customer data and maintain the integrity of financial transactions (Feld et al. 2021).

In light of the above discussions, it could be deduced that the digital finance ecosystem can enhance the banking sector's performance through diverse means. However, the digital finance ecosystem is a vast concept that encompasses the network of financial institutions, technology providers, infrastructure, fintech companies, payment systems, digital channels, data analytics, regulatory framework, security measures of members of the digital finance ecosystem, and partnership and collaborations that enable digital financial services to thrive (International Telecommunication Union – UTI, 2016). However, in this study, we paid a kin interest in how the digital finance ecosystem influences financial institutions, fintech companies, payment systems, and digital channels. Our main reason for studying the influence of the digital finance ecosystem in this regard is because of its ability to improve bank performance through increased financial inclusion, improved access to financial services, and enhanced customer experience, bringing efficiency and reduced financial transaction costs for both banks and customers and fostering banks to provide innovative financial products and services and when this is efficiently achieved, increased banking sector performance will be achieved. Furthermore, this study is based on Nigeria and Kenya out of other emerging economies due to their high rate of technological acceptance which can improve banking sector performance of the region. Therefore, we investigated the nexus between the digital finance ecosystem and banking sector performance in emerging economies with emphasis on Nigeria and Kenya. To this end, this research paper was guided by the following research questions. a). What are the effects of automated teller machines on banking sector performance in emerging economies? b). How does the point of sale influence banking sector performance in emerging economies? c). In what ways does internet banking affect banking sector performance in emerging economies? d). What are the effects of Internet banking on banking sector performance in emerging economies? e). How does mobile money influence banking sector performance in emerging economies? f). How does mobile payment affect banking sector performance in emerging economies?

To provide answers to the above research questions, this study employed the autoregressive distributed lag model (ARDL) which is consistent in estimating both long-run and short-run impacts of the digital financial ecosystem on banking sector performance, measured digital finance ecosystem with indicators such as automated teller machine, point of sale, internet banking, mobile money and mobile purchase; bank return on assets and bank return on equity were all investigated about banking sector performance in emerging economies with emphasis on Nigeria and Kenya. Although existing studies (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020,

Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) have made insightful contributions on this topic, yet banking sector performance in emerging economies especially in Nigeria and Kenya remained quite lower when compared with banks in other countries. It is therefore very crucial to re-evaluate the effects of the digital finance ecosystem on banking sector development in emerging economies with emphasis on Nigeria and Kenya in the light of the synergy between automated teller machines, point of sale, internet banking, mobile money, and mobile purchase, bank return on assets and bank return on equity to gain a deeper understanding of their relationship. However, at the time we wrote this paper, no study had investigated the nexus between the digital finance ecosystem and banking sector development in emerging economies with emphasis on Nigeria and Kenya in the light of the synergy between automated teller machines, point of sale, internet banking, mobile money and mobile purchase, bank return on assets and bank return on equity.

This study therefore lends to the body of existing knowledge as follows. Firstly, we examined the influence of automated teller machines (ATMs) on banking sector performance given that Automated Teller Machines (ATMs) are a critical component of modern banking infrastructure, significantly impacting bank performance and customer service. ATMs have greatly influenced the banking sector by enhancing convenience, reducing operational costs, expanding market reach, and improving customer experience. They also contribute to revenue generation, fraud prevention, and data analytics. ATMs provide customers with around-the-clock access to their accounts, allowing for cash withdrawals, deposits, and balance inquiries at any time, which enhances customer satisfaction. By automating routine transactions, banks can reduce the need for in-branch staff, lowering operational costs related to staffing and customer service. Secondly, we examined the nexus between the points of sale (POS) on banking sector performance in emerging economies since Point of Sale (POS) systems have had a profound impact on the banking sector's performance in several key areas. POS systems support financial inclusion by providing payment solutions to a wider range of businesses, including small and micro-enterprises, thereby increasing access to electronic payment methods. POS systems have significantly influenced the banking sector by enhancing transaction efficiency, increasing revenue opportunities, and improving customer experience. It also contributes to operational efficiency, fraud prevention, and data insights while supporting market expansion and merchant acquisition.

Thirdly, we examined the synergy between Internet banking and banking sector performance in emerging economies given that Internet banking has a wide range of profound influences on the performance of the banking sector. It allows customers to access their accounts and conduct transactions at anytime from anywhere and perform financial transactions such as checking balances, transferring funds, paying bills, and applying for loans—without visiting a branch, enhancing their overall experience. Internet banking lowers operational costs operation costs for banks and customers, improves financial inclusion by reaching customers in remote or underserved areas without needing to establish physical branches, and broadens their market reach. In addition, internet banking has significantly impacted the banking sector by enhancing customer experience, reducing operational costs, and increasing market reach. It also drives

innovation, improves operational efficiency, and provides valuable data insights. Fourthly, we examined the effects of mobile money on banking sector development in emerging economies since mobile money has a profound influence on the banking sector by enhancing financial inclusion, improving customer experience, and increasing operational efficiency. It also creates new revenue opportunities, drives innovation, and expands market reach. The benefits of mobile money make it a critical component of modern financial services. Mobile money simplifies and reduces the cost of remittances and money transfers, which can be particularly beneficial in developing regions. It facilitates economic participation by enabling individuals to engage in transactions, access credit, and manage finances, contributing to overall economic development, enabling new players, such as fintech companies and telecom operators, to enter the financial services market, offering personalized services and recommendations based on user behaviour and preferences, and aid banks to assess the performance of their services and identify opportunities for growth and optimization.

Fifth, we examined the influence of mobile payment on banking sector performance in emerging economies since mobile payment systems have had a transformative impact on the banking sector's performance, shaping various aspects of banking operations and customer interactions. Mobile payment systems can significantly influence the banking sector by enhancing customer experience, increasing revenue generation opportunities, and operational efficiency by driving innovation, providing valuable data insights, and expanding market reach which make them a vital component of modern banking and financial services. Mobile payments support financial inclusion by providing access to banking services for individuals who may not have traditional banking options, especially in developing regions. Sixth, we estimate the relationship that exists between the impacts of the digital financial ecosystem on banking sector performance, measured digital finance ecosystem with indicators such as automated teller machine, point of sale, internet banking, mobile money, and mobile purchase; bank return on assets and bank return on equity with the panel autoregressive distributed lag model (ARDL) which is consistent in estimating both long-run and short-run impacts simultaneously. Seventh, we conducted these estimations in both cross-country and country-specific analyses which prior studies (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) neglected to improve the understanding between the digital finance ecosystem and banking sector performance in both Nigeria and Kenya. The remainder of the study was organized as follows. Section 2 reviews the literature; Section 3 deals with materials and methods; Section 4 deals with empirical results and analysis; and Section 5 offers conclusion, policy implications, and recommendations.

2. Review of Related Literature

2.1 Theoretical Review

Innovation is central to the growth of the business, it is the stimulus that drives the performance of the industry through the acceptance of the medium through which banking processes are being carried out with the use of technology. This theory explains that individual intention to

adopt a technology as a modality to perform 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 e-banking adoption. The nominalized factors are complexity, trialability, and observability (Moga, 2010). Banks have developed a way to make the business of banking easier and more comfortable for their customers, unlike the brick-and-mortar way of banking with long queues and a lot of paperwork without the adoption of technology which makes it more stressful and the process of interbank transactions cumbersome. With the use of sophisticated technology, interbank transactions are easy, it is far safer and more convenient to carry out transactions through the use of internet-connected ATMs, computers, point of sales machines, Mobile Banking, etc. The government has also adopted this medium for its tax payment processes through an online banking platform such as the collection of PAYE, Stamp duties processing, water bills electricity bills, and other means of government revenues which are easy and speedy to collect and process.

Banks are financial intermediaries between parties in a contractual business either to finance projects or as an accepter of funds belonging to its client or customer for safekeeping purposes. The theories of intermediation have been built on the models of resource allocation based on perfect and complete markets by suggesting that financial frictions such as transaction costs and asymmetric information are important in understanding intermediation (Allen and Santomero, 1998). Also, according to Bhattacharya and Thakor (1993), the financial intermediation theory highlights the role of financial intermediaries in the economy; most of the studies performed highlight their role in achieving durable economic growth, and the impact of regulations on financial intermediation, accentuating the role of the central bank in the regulation, supervision and control of financial intermediaries. The most important contribution of the theory of financial intermediation is a steady flow of funds from savers to end users. Financial institutions fulfill the following main functions: i). The Brokerage Function: financial intermediaries match transactions and provide transaction and other services. As a result, they reduce transaction costs and remove information costs. ii). The asset transformation functions: Financial institutions issue claims that are far more attractive to savers (in terms of lower monitoring costs, lower liquidity costs and lower price risk) than the claims issued directly by corporations.

According to Bhattacharya (1993), Financial Intermediaries reduce the costs of transacting with services ranging from brokerage to attribute transformation, and with information asymmetries, both depository and non-depository Financial Intermediaries gain from an increase in size because of lower incentive costs per agent. To be able to carry out its role as an intermediary, the bank needs to ensure it puts in place the various tools necessary for ease of doing business as well as improving on the confidence level of the customers; this is why the need to invest in technology comes to play. This technology brings the bank and the customers together most especially the internet, which serves as a medium of information exchange among the bank, the customers and third parties. According to Andres (2009), the

financial intermediation theory highlights the role of financial intermediaries in the economy; most of the studies performed highlight their role in achieving durable economic growth, and the impact of regulations on financial intermediation, accentuating the role of the central bank in the regulation, supervision and control of financial intermediaries. According to in Financial intermediaries are financial institutions specialized in the activity of buying and selling (at the same time) assets and financial contracts (Benston and Smith, 1976 in Andres, 2009).

2.2 Review of Empirical Literature

Empirically, Demirez et al. (2021) discussed digitalization and technological innovations in the banking sector and tried to determine their possible effects. Demirhan (2021) targeted to decide the current level of digitalization in the banking sector in Turkey and the effects of the development of digital channels on branch channels. They concluded that digitalization caused both a decrease in the number of customer visits, transaction numbers, and branches and cost advantages and flexible structuring. Tseng et al. (2021) focused on developing an intelligent service system model in the banking sector. They created a model based on cyber systems, cloud service and sharing, and transparency improvements among the more than forty criteria. Jünger, and Mietzner (2020) aimed to determine why families living in Germany are likely to adopt services based on new digital technologies developed by banks. The study's findings presented that families good at financial literacy, transparency, and economic level tend to prefer Fintech. Garg et al. (2021) aimed at identifying the perceived commercial advantages of blockchain technology in the banking sector. Feld et al. (2021) concentrated on the influence of digital banking on bank fees charged to Brazilian consumers and determined that it positively affects fees. Del Gaudio et al. (2021) analyze the relationship between digital finance technology (ICT diffusion) and banking sector features in terms of stability using data from the country level in the EU 28 banking industry from 1995 to 2015. The findings imply that ICT advancements enhance the banking industry's performance concerning the shift to digital payment services.

Another study by Banna and Alam (2021) using 153 Islamic banks from 32 countries during the period 2011 to 2017 demonstrates that financial inclusion after the global financial crunch played a significant role in promoting banking efficiency. Nguyen and Du (2022) document a positive relationship between financial inclusions with bank Z-scores for ASEAN countries. A positive association between FI and banking stability has been also found by Ghosh (2022) for a sample of 1,495 banks across 116 countries. Wang and Luo (2022) examined the impact of financial inclusion on bank stability in 36 emerging economies and found a positive nexus, influenced by macro environment factors, such as business cycle, financial circumstances, governmental strength, and policy environment. Employing a sample of 3,071 Asian banks, Vo et al. (2021) found a positive relationship between traditional FI and banking stability and showed that FI can support banks to increase revenue, curtail costs, and extend their market share. On the contrary, Sayev (2024) documents a negative impact of financial innovation on bank stability, taking into account the moderating role of shadow banking. In sum, the main idea embraced by these studies is the fact that higher levels of FI, adversely influence BS by increasing credit volumes and the share of non-performing loans, due to capturing previously

unbanked, over-indebtedness or vulnerable segments. Using a large sample of 4,168 European banks over the 2010–2017 period, Danisman and Tarazi (2020) highlight that financial inclusion has a stabilizing effect on the European banking system. Sodokin et al. (2022) highlight that the effects of digital transformation on FI are more pronounced in the banking stability background. A positive relationship between digital financial inclusion and bank stability is also documented by Chinoda and Kapingura (2023) in the case of Sub-Saharan Africa.

3. Material and Methods
3.1 Data and Sources

This study investigates the nexus between the digital finance ecosystem and banking sector performance in emerging economies – a case of Nigeria and Kenya from 1995 to 2022 owing to data availability and what informed our choices of the selected emerging economies (Nigeria and Kenya) was their high record of technological adoption in the banking sector. Furthermore, we paid a kin interest in how the digital finance ecosystem actors like financial institutions, fintech companies, payment systems, and digital channels influence banking sector performance in Nigeria and Kenya. Our main reason for studying the influence of the digital finance ecosystem in this regard is due to its ability to improve bank performance through increased financial inclusion, improved access to financial services, and enhanced customer experience, bringing efficiency, and reduced financial transaction costs for both banks and customers and fostering banks to provide innovative financial products in the society. After conducting an extensive review of the literature, we considered the following variables. The digital finance ecosystem was measured with indicators such as the number of ATMs per 100,000 adults (ATM), point of sales (POS), internet banking (INB), mobile money (MM), and mobile purchase (MP); while the banking sector performance was measured with indicators such as bank return on assets (ROA) and bank return on equity (ROE) and we controlled for the influence of cyber security (CYS), financial literacy (FIL), financial deepening – a measure of broad money (M2) divided by gross domestic product (GDP) i.e. (M2/GDP), institutional quality – measured with the index of institutional quality measures (rule of law, regulatory quality, government effectiveness, political stability and absence of violence, voice and accountability and corruption control) and macroeconomic volatility (MEV). Hence, to enlighten the reader about the data, we defined each of the model variables as below.

Table 1: Variable Definitions and Sources

Acronym	Definition	Sources
Dependent Variables		
ROA	Bank Return on Assets	https://databank.worldbank.org/metadataglossary/global-financial-development/series/GFDD.SI.01
ROE	Bank Return on Equity	https://databank.worldbank.org/metadataglossary/global-financial-development/series/GFDD.EI.06

ATM	Automated Teller Machines	https://data.worldbank.org/indicator/FB.ATM.TOTL.P5?skipRedirection=true&view=map
POS	Point of Sale	https://databank.worldbank.org/metadataglossary/g20-financial-inclusion-indicators/series/GPSS_4
INB	Internet Banking	https://prosperitydata360.worldbank.org/en/indicator/IMF+FAS+FCMIBT_NUM
MM	Mobile Money	https://www.worldbank.org/en/publication/globalfindex
MP	Mobile Payment	https://www.worldbank.org/en/publication/globalfindex
Control Variables		
CYS	Cyber Security	https://www.itu.int/en/ITU-D/Cybersecurity/Pages/global-cybersecurity-index.aspx
FIL	Financial Literacy	https://www.worldbank.org/en/publication/globalfindex
M2/GDP	Financial Deepening – a ratio of broad money (M2) over GDP	https://data.worldbank.org/indicator/FM.LBL.BMNY.GD.ZS?locations=1W over https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
ISQ	Institutional Quality – Generated by taking the standard deviation of governance institutional quality measures – rule of law, regulatory quality, government effectiveness, political stability and absence of violence, voice and accountabilit	https://www.worldbank.org/en/publication/worldwide-governance-indicators

	y and control of corruption	
MEV	Macroeconomic volatility – a measure of the standard deviation of gross domestic product growth rate	https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

Source: Conceived by the Researcher

3.2 Model Specifications
3.2.1 Baseline ARDL (p, q … q)

We examined the nexus between the digital finance ecosystem and banking sector performance in emerging economies with emphasis on Nigeria and Kenya from 1995 to 2022 in this section following Manasseh et al. (2023) using the panel autoregressive distributed lag (ARDL) estimation technique as the baseline model. ARDL is uniquely made with some special characteristics like its flexibility in allowing a set of variables to be integrated in a different order (Pesaran et al. 2001) and capacity to produce an error correction model (ECM) using linear transformation (Banerjee et al. 1993). ARDL estimators have several advantages over other cointegration methods like maximum likelihood-based Johansen (1991), the residual-based Engle and Granger (1987), the Johansen (1995), and the Johansen and Juselius (1990) tests among others, and have been widely employed by academics to conduct econometric investigations, hence, ARDL was used in this study have seen the limitations of abovementioned estimation techniques. Firstly, the autoregressive distributed lag model is preferable because it takes estimates into account no matter how small or finite the sample size is (Ghatak and Siddiki 2001). Second, ARDL works better when the order of the variables is exclusively integrated in the order I(0) and others in the order I(1). Third, according to Pesaran et al. (2001), modeling ARDL with an appropriate lag is right for both serial correlation and endogeneity issues. Fourth, according to Pesaran et al. (2001), the ARDL model can accurately estimate both long-run and short-run cointegrating relations. Thus, below is the outline of the empirical ARDL model for the study.

$$\Delta InBSPM_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta InBSPM_t + \sum_{i=1}^{n} \alpha_2 \Delta InATM_t + \sum_{i=1}^{n} \alpha_3 \Delta InPOS_t$$

$$+ \sum_{i=1}^{n} \alpha_4 \Delta InINB_t + \sum_{i=1}^{n} \alpha_5 \Delta InMM_t + \sum_{i=1}^{n} \alpha_6 \Delta InMP_t + \sum_{i=1}^{n} \alpha_7 \Delta InCYS_t$$

$$+ \sum_{i=1}^{n} \alpha_8 \Delta InFIL_t + \sum_{i=1}^{n} \alpha_9 \Delta InM2/GDP_t$$

$$+ \sum_{i=1}^{n} \alpha_{10} \Delta InISQ_t + \sum_{i=1}^{n} \alpha_{11} \Delta InMEV_t + \emptyset_1 InBSPM_{it} + \emptyset_2 InATM_t$$

$$+ \emptyset_3 InPOS_t + \emptyset_4 InINB_t + \emptyset_5 MM_t + \emptyset_6 MP_t + \emptyset_7 CYS_t + \emptyset_8 FIL_t$$

$$+ \emptyset_9 M2/GDP_t + \emptyset_{10} ISQ_t + \emptyset_{11} MEV_t + \varepsilon_{it} - - - (1)$$

Where: BSPM represents banking sector performance measures which include bank return on assets (ROA) and bank return on equity (ROE) which are also the dependent variables, similarly, the ATM is the automated teller machines, POS is the point of sale, INB is the internet banking, MM is the mobile money, MP is the mobile purchase, CYS is the cyber security, FIL is the literacy, M2/GDP is the financial deepening – a ration of broad money over gross domestic product, ISQ is the institutional quality and MEV is macroeconomic volatility. In addition, α_0 is the constant, $\emptyset_1 \, to \, \emptyset_{11}$ represents the coefficients of the long-run impacts, $\alpha_1 \, to \, \alpha_{11}$, is the coefficients of the short-run dynamics, Δ, is the first difference operator, and In is the natural logarithm, while ε_t is the white noise error term.

The assumption from equation 1 above is that, if the F-statistic lies above the upper-bound critical value for a given significance level, the conclusion is that there is a non-spurious long-run level relationship with the dependent variable. If the F-statistic lies below the lower bound critical value, the conclusion is that there is no long-run level relationship with the dependent variable. If it lies between the lower and the upper limits, the result is inconclusive. The general form of the null and alternative hypotheses for the F-statistic test is as follows:

$H_0: \emptyset_1 = \emptyset_2 = \emptyset_3 = \emptyset_4 = \emptyset_5 = \emptyset_6 = \emptyset_7 = \emptyset_8 = \emptyset_9 = 0$

$H_1: \emptyset_1 \neq \emptyset_2 \neq \emptyset_3 \neq \emptyset_4 \neq \emptyset_5 \neq \emptyset_6 \neq \emptyset_7 \neq \emptyset_8 \neq \emptyset_9 = 0 \; - - - - - (2)$

If the cointegration between variables is identified, then one can undertake further analysis of the long-run and short-run (error correction) relationship between the variables. The error correction representation of the series can be specified as follows:

$$\Delta InBSPM_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta InBSPM_t + \sum_{i=1}^{n} \alpha_2 \Delta InATM_t + \sum_{i=1}^{n} \alpha_3 \Delta InPOS_t$$

$$+ \sum_{i=1}^{n} \alpha_4 \Delta InINB_t + \sum_{i=1}^{n} \alpha_5 \Delta InMM_t + \sum_{i=1}^{n} \alpha_6 \Delta InMP_t + \sum_{i=1}^{n} \alpha_7 \Delta InCYS_t$$

$$+ \sum_{i=1}^{n} \alpha_8 \Delta InFIL_t + \sum_{i=1}^{n} \alpha_9 \Delta InM2/GDP_t + \sum_{i=1}^{n} \alpha_{10} \Delta InISQ_t$$

$$+ \sum_{i=1}^{n} \alpha_{11} \Delta InMEV_t + \varphi ECT_t + \varepsilon_t --- (3)$$

Where φ represents the speed of adjustment parameter, while the ECT is the error correction term (the residuals obtained from equation 1). The coefficient of the lagged error correction term φ is expected to be negative and statistically significant to further confirm the existence of a cointegrating relationship between the variables.

3.2.2 Robustness Check Model – FMOLS

Haven observed that the ARDL model is deficient in some areas such as not being able to handle some econometric estimation problems, we re-estimated the models by employing the panel dynamic fully modified ordinary least squares (FMOLS) and panel dynamic ordinary least squares (DOLS) models as robustness check for the study findings in the ARDL model. This is to ensure that we obtain a robust result that would be consistent in policymaking. The DOLS and FMOLS are also very efficient in estimating long-run coefficients if the coefficients are cointegrated. DOLS and FMOLS were both capable of correcting sequence correlation and endogeneity. The FMOLS, being a non-parametric approach, takes into account cross-sectional heterogeneity. It eliminates the connection between the explanatory variable and the random interference components, correcting autocorrelation and heteroscedasticity issues. The parametric DOLS methodology beats the FMOLS method (Kao and Chiang 2001). However, Pedroni (2001), on the other hand, proved that DOLS had less size distortion than the FMOLS estimation technique. DOLS, on the other hand, is a parametric technique. To reduce the link between explained variables and error terms, this technique adds the lag term of the explanatory variable to the cointegration equation. The FMOLS and DOLS are specified as follows:

$$\beta FMOLS = \left[N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} (P_{i,t} - P_t)^2 \right) \right] X \left[\left(\sum_{t=1}^{T} (P_t - P_t) \right) \right] S_{i,t} - T\Delta_{\varepsilon u} ----- (4)$$

$$\beta DOLS = \left[N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} (W_t + P_t)^{-1} \right) \left(\sum_{t=1}^{T} (P_t - P_t) \right) \right] S_{i,t} - T\Delta_{\varepsilon u} ------(5)$$

Where p̲ represents explanatory variables, S denotes a dependent variable, and Z shows the regressor's vector (W=P – P̄) respectively. Thus, emphasis has been laid on the problem of heterogeneity with differences in means among the individuals and differences in individual responses to short-run disturbances from cointegrating equilibrium as the main reasons for concern in estimating dynamic cointegrated panels (Pedroni, 2001) and the FMOLS (equ. 4) is consistent in addressing the problems. Worthy to note, the DOLS outperforms the OLS, ARDL and FMOLS estimators in finite samples in terms of unbiased estimation based on Monte Carlo

simulations. It equally takes care of endogeneity in a model thereby providing a robust correction for endogeneity in the explanatory variables.

4. Empirical Results and Discussions
4.1 Data Description

The empirical results obtained in the course of studying the nexus between the digital finance ecosystem and banking sector performance in emerging economies – the case of Nigeria and Kenya were presented, discussed extensively, and analyzed in this section. To buttress our understanding of the nature and characteristics of the variables, we subjected each of the variables to some basic econometric tests such as descriptive statistics and Spearman's correlation test and the results are presented below in Table 2. Descriptive statistics is used to measure the basic summary of the statistical characteristics of the model variables in econometric studies. It gives the researcher an insightful glimpse of how the variables behave. Findings from the results shows that the total variations in the series revolve around -6.526 and 12.10 which represent the least and highest values in the series. However, we also discovered that the mean values, median values, standard deviation values, Skewness and Kurtosis for all the model variables are not far from each other implying that error terms of the variables are normally distributed, as the probability values of the Jarque-Bera statistic for all the variables confirmed this since none of them were above 0.05.

Table 2: Summary of Results for Descriptive Statistics and Correlation Test

Var	ROA	ROE	ATM	POS	INB	MM	MP	CYS	FIL	M2/GDP	ISQ	MEV
Mean	2.684	3.806	0.813	24.24	0.892	1.452	21.10	1.691	0.515	36.40	24.24	3.021
Median	2.308	4.589	0.737	17.63	0.903	1.092	3.298	1.504	0.347	3.403	17.63	3.303
Maximum	9.894	8.402	4.842	1.210	1.821	8.801	7.432	7.966	1.768	2.554	12.10	5.529
Minimum	-1.549	-0.471	-0.596	0.075	0.003	-6.526	-6.235	0.000	0.013	-0.113	0.075	-4.383
Std. Dev.	2.466	2.785	1.138	30.58	0.508	2.304	103.5	1.466	0.463	64.07	30.58	1.770
Skewness	0.809	-0.215	1.362	1.969	-0.171	0.362	6.473	1.878	1.254	1.742	1.969	-2.060
Kurtosis	3.548	1.726	5.585	6.025	2.258	6.146	45.48	8.119	3.784	4.959	6.025	7.224
JB	6.568	4.067	31.74	55.51	1.502	23.45	4438.	90.75	15.55	35.96	55.51	1741.
Probability	0.037	0.000	0.000	0.000	0.471	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Obs.	54	54	54	54	54	54	54	54	54	54	54	51
ROA	1											
ROE	0.831	1										

ATM	-0.967	-0.994	1									
POS	0.401	0.709	-0.420	1								
INB	0.929	0.296	-0.478	-0.069	1							
MM	0.425	0.754	0.065	0.058	0.230	1						
MP	0.920	0.243	-0.208	-0.377	-0.692	0.004	1					
CYS	0.551	0.579	-0.524	0.313	0.436	0.472	-0.062	1				
FIL	0.897	0.256	-0.199	0.211	0.265	0.474	-0.616	0.451	1			
M2/GDP	-0.611	-0.681	0.493	-0.426	-0.256	-0.664	-0.589	0.426	-0.339	1		
ISQ	0.401	0.170	-0.142	0.758	-0.692	0.583	-0.377	0.313	0.525	-0.426	1	
MEV	-0.645	-0.027	-0.023	0.848	0.578	0.860	-0.451	0.709	0.399	0.039	0.618	1

Source: Computed

Also, deepening our investigation by employing Spearman's correlation test to ascertain if there is an existence of correlations between digital finance ecosystems and banking sector performance in emerging economies – Nigeria and Kenya, we found that while automated teller machines (ATMs) have strong negative correlations with the banking sector performance in emerging economies, other digital finance ecosystem indicators – point of sale (POS), internet banking (INB), mobile money (MM) and mobile payment (MP) have positive correlations with the banking sector performance in the emerging economies. We also discovered that cyber security (CYS) has strong positive correlations with the banking sector performance, and so also to financial literacy (FIL). This means that as people gain financial knowledge, there is every possibility that it would lead to increased banking sector performance as well as increase in cyber-attacks. Which would require intense cyber security system to safeguard the financial assets of people and businesses operating their businesses with banks. Surprisingly, we found that financial deepening (M2/GDP) and macroeconomic volatility (MEV) have strong negative correlations with the banking sector performance in emerging economies, while institutional quality (ISQ) showed a moderate positive correlations with banking sector performance in emerging economies.

4.2 Testing for Stationarity

Furthermore, since our estimations involves time series data that would lead the researcher to obtain spurious regression if not properly handled, we therefore employed four-panel unit root tests which include Levine, Lin and Chu (2002), Im, Pesaran and Shin (2003) and Fisher-based tests Fisher-ADF and Fisher-PP tests proposed by Madala and Wu (1999) to test the stationarity level and order of integrations of the variables following Manasseh et al. (2019) as presented

in Table 3. The null hypothesis guiding these unit root test states that "unit root", while the alternative hypothesis states that "no unit root" and the decision rule remains to reject the null hypotheses if the probability value is less than 0.05 otherwise do not reject. However, we found that the probability values for all the selected model variables are less than 0.05, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis. Therefore we conclude that there is no evidence of unit root in the series. In addition to these findings, we also discovered that the variables are integrated of order I(0) – (level) or I(1) – (first differenced) which is in line with assumptions of the ARDL model and thus, none of the model variables was integrated at I(2) – (second dfferenced) and above since at this level, the estimated results will go boosted or be spurious, misleading the decisions of the researcher. The result implication is that the variables are very good for the estimation of the ARDL model since the variables are integrated at level and first difference.

Table 3: Results for the Stationarity Test

Variables	LLC	IPS	Fisher-ADF	Fisher-PP	Integration Order	
					Level	First Diff.
ROA	-4.482***	-3.550***	19.01***	19.64***		–
	(0.000)	(0.000)	(0.000)	(0.000)	I(0)	
ROE	-9.069***	-8.706***	48.31***	49.67***	–	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
ATM	-3.985***	-3.119***	16.62***	17.04***		–
	(0.000)	(0.000)	(0.002)	(0.009)	I(0)	
POS	-6.767***	-5.466***	30.53***	30.53***	–	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
INB	-2.717***	-3.151***	17.15***	17.27***		–
	(0.003)	(0.008)	(0.001)	(0.001)	I(0)	
MM	-5.673***	-5.778***	32.73***	32.89***		–
	(0.000)	(0.000)	(0.000)	(0.000)	I(0)	
MP	-4.088***	-3.101***	16.86***	16.37***		–
	(0.000)	(0.001)	(0.002)	(0.002)	I(0)	
CYS	-9.076***	-8.378***	47.44***	54.61***	–	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
FIL	-4.574***	-5.569***	31.17***	30.97***	–	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
M2/GDP	-9.217***	-9.127***	51.76***	66.49***	–	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
ISQ	-6.767***	-5.466***	30.53***	30.53***	–	
	(0.000)	(0.000)	(0.000)	(0.000)		I(1)
MEV	-12.24	-11.91	330.3	327.4		–
	(0.000)	(0.000)	(0.000)	(0.000)	I(0)	

Source: Computed. Note: (.)=probability value; ***; ** and * = 1%, 5% and 10% levels of significance

4.3 Testing for Cointegration

We deepened our investigations by exploring if there is an existence of cointegration between the digital finance ecosystem and banking sector performance in emerging economies – Nigeria and Kenya since we have ascertained that the variables are stationary at level I(0) and the first difference (I(1) integration order. Two Panel cointegration tests – Pedroni (2003) and Kao (1999) cointegration tests were employed for this purpose – Pedroni's (2004) cointegration test and Kao's (1999) cointegration test. Pedroni's (2004) test was the main test for cointegration, while Kao (1999) was used to test for the robustness check. Pedroni (2004) proposed seven cointegration tests which were categorized under "Within Dimension" and "Between Dimension". Under the first category, he proposed the Panel v-statistic test, Panel rho-statistic test, Panel ADF-Statistic, and Panel PP-Statistic, while the second category has Group rho-statistic, Group PP-statistic, and Group ADF-statistic. The null hypothesis for the test is "no cointegration" and the alternative hypothesis is "cointegration". Findings suggest that the null hypothesis be rejected since the probability values for at least 5 out of 7 in each of the specified models Pedroni's (2003) cointegration results are less than 0.05. Thus, we conclude that there is an existence of cointegration between the digital finance ecosystem and banking sector performance in Nigeria and Kenya. Also as a way of robustness check, we employed Kao's (1999) cointegration test to validate the results findings from the Pedroni cointegration results. Thus, our findings confirmed the existence of cointegration between the digital finance ecosystem and banking sector performance in Nigeria and Kenya.

Table 4: Results from the Cointegration Test

	Between Dimension				Within Dimension			Robustness Check
	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	-1.209 (0.887)	-8.316*** (0.000)	-9.762*** (0..000)	-6.262*** (0.000)	0.014*** (0.000)	-15.56*** (0.000)	-7.523*** (0.000)	-2.713*** (0.003)
Model 2	9.431011*** (0.0000)	-0.942 (0.173)	-3.290*** (0.001)	-3.128*** (0.000)	-0.211 (0.416)	-2.829*** (0.002)	-2.665*** (0.003)	-6.350*** (0.000)
Model 3	-1.519 (0.771)	-3.464 (0.002)	-12.85 (0.000)	-12.76 (0.000)	-4.355 (0.000)	-16.55 (0.000)	-15.85 (0.000)	4.867 (0.000)
Model 4	-1.393 (0.627)	-3.448 (0.008)	-12.45 (0.000)	-11.06 (0.000)	-1.262 (0.378)	-18.35 (0.000)	-15.92 (0.000)	3.857 (0.003)
Model 5	-6.712*** (0.000)	-4.507*** (0.000)	-36.60*** (0.000)	-8.094*** (0.000)	1.891 (0.970)	-32.88*** (0.000)	-6.853*** (0.000)	-7.194*** (0.000)

Source: Computed. Note: ***, ** and * represents the 1%, 5% and 10% levels of significance; (.) represents probability value

4.4 Testing for Long-Run Relationship

To deepen this study's investigations, we switched our explorations towards searching for long-run relationships between the digital finance ecosystem and banking sector performance in emerging economies – a case of Nigeria and Kenya using the ARDL bound testing approach. This test involves running a comparative analysis between the computed F-statistic and the upper critical values of both Pesaran et al. (2001) and Narayan (2004). Thus, the guiding principle for the test is that "if the F-statistic is greater than the critical values, then there is the existence of the long-run relationship, if the critical values are greater than the F-statistics, then there is no existence of a long-run relationship and finally, if the F-statistic is equal to the critical values, then the result will be inconclusive". However, we present the ARDL long-run bounds test results in Table 5 below. This test has a null hypothesis "no long-run relationship" and an alternative hypothesis "long-run relationship". Evidence from the ARDL bound test results shows that the null hypothesis is rejected since the values of the F-statistic in the specified models in both Nigeria and Kenya are greater than 1% upper critical values of both Pesaran et al. (2001) and Narayan (2004). Therefore we conclude that there is the existence of a long-run relationship between the digital finance ecosystem and banking sector performance in Nigeria and Kenya.

**Table 5: Results for ARDL Bounds Test**

		F-Statistics	K	Pesaran et al. (2001)						Narayan (2004)					
				1%		5%		10%		1%		5%		10%	
				I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Nigeria	Model 1	91.08	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 2	20.78	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 3	7.125	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 4	9.985	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 5	11.30	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
Kenya	Model 1	6.967	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 2	12.53	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 3	23.04	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 4	81.24	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90
	Model 5	14.09	9	3.74	5.06	2.86	4.01	2.45	3.52	4.59	6.37	3.28	4.63	2.70	3.90

Source: Computed by the Researcher

4.5 Stability Test – CUSUM and CUSUMSQ Graphs

Furthermore, we test for stability of the data during the period covered by the research by employing the ARDL recursive CUSUM and CUSUMSQ graphs as proposed by Brown et al. in 1975. The tests aimed at measuring the stability of model variables in the estimated period. The decision rule for the test is that if the bound curve line is remained within the 5% critical bounds of the graph, it means that the variables were stables, and if not, the variables were unstable during the period of the study. Hence the findings from the graphs show that the variables of the specified models in Nigeria and Kenya were stable over the period covered by the research since the critical lines of both CUSUM and CUSUMSQ graphs lie within the 5% critical bounds of the graphs.

Fig. 1: Graphs of CUSUM and CUSUMSQ for Nigeria and Kenya

Source: Computed by the Researcher
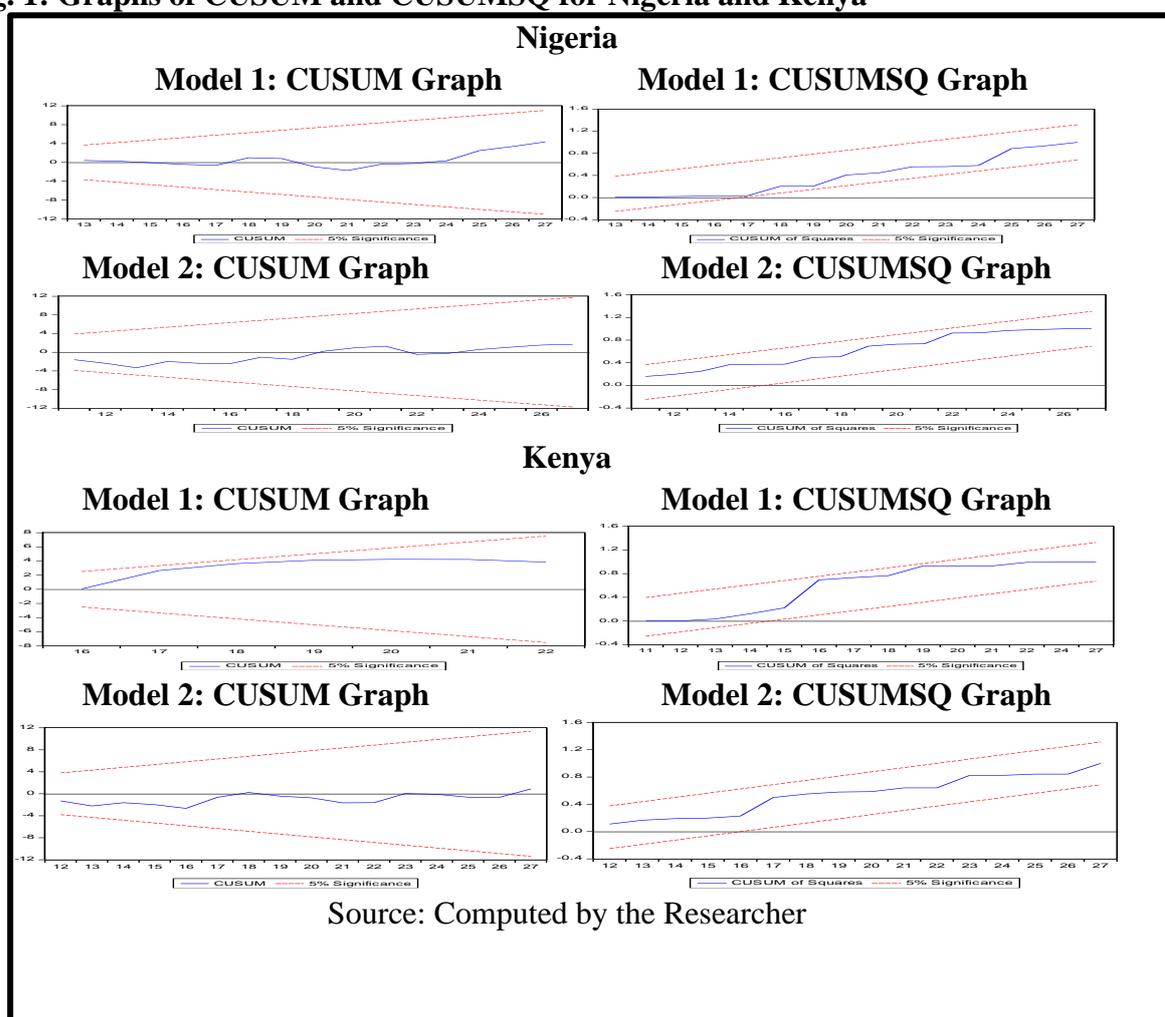
4.6 Analysis of the Baseline ARDL (p, q) model

To investigate the nexus between the digital finance ecosystem and banking sector performance in emerging economies, we employed the autoregressive distributed lag model (ARDL) for the analysis and the reason for choosing Nigeria and Kenya as countries studied is due to their level of technological acceptance among others emerging economies. However, given that the

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digital finance ecosystem is vast, the authors are very interested in how the products of the fintech companies, payment systems, and digital channels, as well as their products such as automated teller machines (ATMs), point of sale (POS), internet banking (INB), mobile money (MM) and mobile payment (MP), influences the banking sector performance to avoid ambiguity. Also, given that the aforesaid indicators are not the only variables that influence banking sector performance in emerging economies, we controlled for the role of cyber security (CYS), financial literacy (FIL), financial deepening – a ratio of broad money (M2) over gross domestic product (GDP) i.e. (M2/GDP), institutional quality – a measure of institutional quality index which encompass (government effectiveness, political stability and absence of violence, voice and accountability and control of corruption) and macroeconomic volatility (MEV). The essence of controlling for these factors is because they are the key influencers of the performance of the banking sector especially in emerging economies. However, below in preceding sections, we analyzed the results of the nexus between digital finance ecosystem and banking sector performance in both Nigeria and Kenya.

4.6.1 Nexus between Digital Ecosystem and Bank Return on Asset in Nigeria

At first, we subjected the models to pre-econometric tests such as normality test, serial correlation test, Ramsey model specification test, and White heteroscedasticity test as presented in Table 5 below. From the result findings, we discovered that errors in the models are normally distributed, serially uncorrelated, and homoscedastic and the models are specified correctly. Findings from the results show that across the models, the past values of bank return on assets (ROA (-1)) have a significant positive impact on the current values of bank return on assets in Nigeria except in model 1 which has negative effects on current bank return on asset values in Nigeria. The result findings show that automated teller machines (ATMs) have a positive and significant impact of 0.388 on the banking sector performance in Nigeria. Relatedly, we found that the point of sale (POS) has a significant positive impact of 0.008 on banking sector performance in Nigeria. Contrary to this, we discovered that internet banking (INB) and mobile money (MM) have significant negative impacts of -0.017 and -0.066 on banking sector performance respectively in Nigeria, while mobile payment portrayed a positive and significant impact of 0.013 on bank return on assets in Nigeria. When we controlled for the influence of cyber security (CYS) we discovered that it has significant positive impacts on bank return in assets (ROA) in Nigeria for all the specified models. In addition, we discovered financial literacy (FIL) showed a negative and significant impact on bank return on assets in model 1, and negative impact in model 3, and positive and significant impacts in models 2 and 4, but a positive and insignificant impact in model 5. Also, we found that financial deepening has a significant negative impact on bank return on assets in Nigeria across the models; while the institutional quality has positive and significant impacts in models 1, 3, and 5, but showed negative and significant impacts in models 2 and 4 respectively. The authors also found that macroeconomic volatility have negative and significant impacts on bank return on assets in Nigeria. In the short-run, the coefficients of the error correction model (ECM) was discovered to possess negative signs and are statistically significant and therefore measured the speed of adjustments from the long-run in various degrees in the short-run in Nigeria across the specified

models. These findings align with previous empirical findings made by scholars like (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Table 5: ARDL Results for Digital Finance Ecosystem and Bank Return on Asset

Variable	1	2	3	4	5
ROA (-1)	-0.233***	0.244***	12.52***	0.208***	78.93***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ATM	0.388***				
	(0.000)				
POS		0.008***			
		(0.000)			
INB			-0.017***		
			(0.006)		
MM				-0.066***	
				(0.000)	
MP					0.013***
					(0.002)
CYS	0.242***	36.71***	0.233***	0.076***	0.143***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FIL	-0.022***	23.93***	-0.082	0.122***	0.003
	(0.000)	(0.000)	(0.547)	(0.000)	(0.2234)
M2/GDP	-0.054***	-3.680***	-0.056***	-2.904***	-0.036***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.006)
ISQ	0.206***	-0.584***	6.158***	-0.012***	49.96***
	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)
MEV	-0.002	-0.024***	-1.592***	-0.054***	6.987***
	(0.771)	(0.002)	(0.000)	(0.000)	(0.000)
No of Obs.	27	27	27	24	25
Normality	1691	123.2	1659	1691	486.0
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Serial Corr.	0.486	3.621	3.263	0.486	3.626
	(0.614)	(0.877)	(0.858)	(0.614)	(0.877)
Ramsey	0.108	-0.042	-0.416	0.018	-0.425
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Heteroscedasticity	3.017	40.55	1.112	3.017	40.55
	(0.372)	(0.753)	(0.592)	(0.372)	(0.753)
ECM (-1)	-0.765	-0.613	-0.831	-0.677	-0.683
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Source: As Conceived by the Author. Note: ***, **, and * represent the 1%, 5%, and 10% significant levels, (.) represent the probability values, and the variables are expressed in natural logarithms.

4.6.2 Nexus between Digital Ecosystem and Bank Return on Equity in Nigeria

We employed another measure of banking sector development – bank return on equity (ROE) and explored how the digital finance ecosystem influences it in Nigeria. The authors firstly ensured that the specified models passed through the basic econometric tests like the normality test, serial correlation test, Ramsey reset specification test, and White heteroscedasticity test, and findings show that the errors of the models are normally distributed, serially uncorrelated, and homoscedastic and the models are specified correctly. It was also discovered that the past values of bank return on equity (ROE) have contributed to the current values of bank return on equity (ROE) in Nigeria in the negative ends in models 1, 3, and 5; but positively contributed to the current bank return on equity values in model 2 and 4. The result findings evidenced that the indicators of the digital finance ecosystem automated teller machines (ATM), point of sale (POS), and mobile payment (MP) have a significant negative impact on bank return on equity in Nigeria, while the internet banking (INB) and mobile money (MM) have positive and significant impacts on bank return on equity (ROE) in Nigeria. From the result of the control variable (CYS), we discovered that cyber security has significant negative impacts on bank return on equity in models 1, 3, and 5, but showed a positive and significant impact on bank return on equity in models 2 and an insignificant impact in model 4. We further discovered that financial literacy (FIL) showed a positive insignificant impact in models 1 and 3, a positive and significant impact on bank return on equity in models 2 and 5, and a negative and significant impact on bank return on equity in model 5. The implication is that the level of financial literacy in Nigeria remains low and as such does not have meaningful effects on banking sector performance in Nigeria. Further exploration revealed that financial deepening – a measure of the ratio of broad money (M2) and gross domestic product (GDP) has a negative and significant impact on bank return on equity in models 1, 3, and 4, but showed a positive and significant impact on bank return on equity in models 2 and 5. We also controlled for the influence of institutional quality (ISQ) and found that it has a positive and significant impact on bank return on equity across the models except in model 2 with a negative and significant impact on bank return on equity in Nigeria. Our results findings also show that in the short-run, the coefficient of the error correction model (ECM) has a negative sign and is statistically significant for all the models and as such measured the speed of adjustment from the long-run in various degrees in the respective models in the short-run. These findings are in corroborate the earlier findings made by scholars such as (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Table 6: ARDL Results for Digital Finance Ecosystem and Bank Return on Equity

Variable	1	2	3	4	5
ROE (-1)	-0.038*** (0.019)	6.697*** (0.000)	-5.501*** (0.000)	0.092*** (0.000)	-1.346*** (0.000)
ATM	-0.049*** (0.018)				
POS		-0.033** (0.016)			

INB			2.688***		
			(0.004)		
MM				24.26***	
				(0.000)	
MP					-0.291***
					(0.006)
CYS	-0.005***	14.95***	-0.008***	0.008	-0.008***
	(0.000)	(0.000)	(0.002)	(0.221)	(0.000)
FIL	0.012	2.369***	0.004	-0.233***	0.005**
	(0.3981)	(0.000)	(0.162)	(0.000)	(0.015)
M2/GDP	-1.547***	-0.003***	9.183***	-0.009***	27.12***
	(0.000)	(0.006)	(0.000)	(0.006)	(0.000)
ISQ	0.895***	-0.091***	1.531***	0.003	4.462***
	(0.000)	(0.000)	(0.000)	(0.120)	(0.000)
MEV	-0.009***	-0.946	-0.002	-8.070***	0.384
	(0.003)	(0.604)	(0.580)	(0.000)	(0.000)
No of Obs.	27	25	26	24	22
Normality	7312.	5080.	4704	2188.	2775
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Serial Corr.	0.131	1.542	1.755	0.003	0.973
	(0.138)	(0.287)	(0.125)	(0.884)	(0.865)
Ramsey	0.265	0.819	0.812	-0.221	1.111
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Heteroscedasticity	1.929	1.001	1.020	5.539	0.954
	(0.073)	(0.459)	(0.434)	(0.873)	(0.531)
ECM (-1)	-0.387	-0.342	-0.590	-0.478	--0.342
	(0.0000)	(0.0000)	(0.0011)	(0.0015)	(0.0080)

Source: As Conceived by the Author. Note: ***, **, and * represent the 1%, 5%, and 10% significant levels, (.) represent the probability values, and the variables are expressed in natural logarithms.

4.6.3 Nexus between Digital Ecosystem and Bank Return on Asset in Kenya

In the Kenyan context, we explored the nexus between the digital finance ecosystem and bank return on assets (ROA) in this section. From the results, we discovered that the past values of bank return on assets (ROA) significantly contributed to the current values of bank return on assets in Kenya. Evidence from the result findings revealed that automated teller machines (ATM) have a significant positive impact of 0.012 on bank return on assets in Kenya. A similar finding was made from the point of sale (POS) which showed a positive and significant impact of 3.744 on bank return on assets in Kenya. We also found that mobile money (MM) and internet banking (INB) portrayed negative and significant impacts of -0.096 and -9.397 on the bank return on assets in Kenya, but the mobile payment (MP) showed a positive and significant impact of 1.083 on bank return on assets in Kenya. The result findings further revealed that cyber security (CYS) showed a negative and significant impact on bank return on assets across

the models in Kenya. Also, it was discovered that financial literacy (FIL) has negative and significant impacts on bank return on assets in Kenya across models 1, 3, and 5, but shows a significant positive impact on bank return on assets in Kenya in models 2 and 4 respectively. The result findings further revealed that while financial deepening showed significant positive impacts on bank return on assets in models 1 & 5, it has significant negative impacts on bank return on equity in models 2, 3, and 4. We found that institutional quality (ISQ) and macroeconomic volatility portrayed significant negative effects on bank return on assets across the models except for models 1&4 for macroeconomic volatility which showed a positive and significant impact on bank return on assets in Kenya. These findings are in line with previous empirical findings by scholars such as (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Table 7: ARDL Results for Digital Finance Ecosystem and Bank Return on Asset

Variable	1	2	3	4	5
ROA (-1)	-13.85 (0.004)	0.204 (0.000)	0.776 (0.000)	0.203 (0.000)	-44.58 (0.000)
ATM	0.012 (0.000)				
POS		3.744 (0.000)			
INB			-9.397 (0.000)		
MM				-0.096 (0.000)	
MP					1.083 (0.000)
CYS	-0.422 (0.000)	-9.402 (0.000)	-0.422 (0.000)	-4.125 (0.000)	-0.423 (0.000)
FIL	-0.056 (0.000)	5.7147 (0.0000)	-0.055 (0.0000)	4.986 (0.000)	-0.057 (0.000)
M2/GDP	1.753 (0.000)	-0.034 (0.000)	-1.418 (0.000)	-0.065 (0.001)	5.471 (0.000)
ISQ	-9.324 (0.000)	-0.010 (0.000)	5.984 (0.000)	-0.068 (0.000)	-3.029 (0.000)
MEV	0.251 (0.000)	-0.001 (0.535)	0.496 (0.000)	0.031 (0.000)	-0.252 (0.000)
No of Obs.	23	26	27	27	26
Normality	677.8 (0.000)	3639. (0.000)	3970. (0.000)	449.1 (0.000)	464.6 (0.000)
Serial Corr.	2.669 (0.093)	2.689 (0.372)	2.514 (0.088)	1.045 (0.365)	1.972 (0.524)
Ramsey	1.251 (0.000)	1.266 (0.000)	0.144 (0.000)	0.511 (0.000)	-1.547 (0.000)

Heteroscedas ticity	1.779 (0.616)	1.782 (0.000)	3.183 (0.986)	0.292 (0.382)	6.893 (0.526)
ECM (-1)	-0.416*** (0.008)	0.483*** (0.002)	0.087*** (0.001)	0.072*** (0.000)	-0.466** (0.014)

Source: As Conceived from the Author. Note: ***, ** and * represent the 1%, 5% and 10% significant levels, (.) represent the probability values and the variables are expressed in natural logarithms.

4.6.4 Nexus between Digital Ecosystem and Bank Return on Equity in Kenya

To deepen our analysis, we examined the nexus between the digital finance ecosystem and bank return on equity in Kenya to further explore how the digital finance ecosystem influences bank performance in Kenya. We firstly observed that the past values of bank return on equity (ROE) significantly contribute to the current values of bank return on equity (ROE) in Kenya except in model 4. From the results of the digital finance ecosystem, we found that automated teller machines (ATM) have a negative and significant impact of -0.583 on bank return on equity in Kenya. On the opposite end, we discovered that point of sale (POS) and internet banking (INB) have significant positive impacts of 0.247 and 0.099 on bank return on equity in Kenya, and we also find that the mobile money (MM) has negative and significance impact of -0.749 on the bank return on equity in Kenya. In addition, we found that the mobile purchase (MP) had a positive and significant impact of 0.385 on bank return on equity in Kenya. We further discovered from the control variables that cyber security (CYS) has significant positive impacts on bank return on equity across the models, while the financial literacy (FIL) has negative and significant impacts on bank return on equity in models 1, 2 and 5 respectively, but showed a positive and significant impact on bank return on equity in models 3 and 4. This is similar to financial deepening which has a positive and significant impact on bank return on equity in Kenya in model 1, but showed a significant negative effect on bank return on equity in models 2 – 5. Furthermore, the institutional quality was found to portray significant positive impacts on bank return on equity across the models except in model 2; while macroeconomic volatility (MEV) showed negative and significant impact on bank return on equity in Kenya across the models except in model 5 which has significant positive impact on bank return on equity in Kenya. The authors also found that values of error correction model (ECM) for all the models have negative signs and are statistically significant in Kenya, and this shows that the speed of the adjustment was measured in various degrees for each of the specified models. These findings are in line with the earlier findings by (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Table 8: ARDL Results for Digital Finance Ecosystem and Bank Return on Equity

Variable	1	2	3	4	5
ROE (-1)	0.091*** (0.000)	0.036*** (0.000)	0.902*** (0.000)	0.102 (0.064)	0.969*** (0.000)
ATM	-0.583*** (0.000)				

POS		0.247***		
		(0.008)		
INB			0.099***	
			(0.007)	
MM				-0.749***
				(0.001)
MP				
				0.385***
				(0.000)
CYS	0.840***	0.433***	0.829***	0.929***	0.927***
	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
FIL	-0.347***	-0.188***	0.975***	0.975***	-0.924***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)
M2/GDP	0.4610***	-0.006***	-0.676***	-0.186***	-0.816***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ISQ	2.785***	-0.984***	0.916***	0.986***	0.931***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
MEV	-0.235***	0.129***	-0.326***	-0.326***	0.124***
	(0.000)	(0.003)	(0.006)	(0.006)	(0.000)
No of Obs.	25	27	27	27	21
Normality	16.96	38.72	12.43	24.27	23.93
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Serial Corr.	0.707	1.061	0.763	0.026	2.652
	(0.499)	(0.355)	(0.482)	(0.973)	(0.101)
Ramsey	0.019	0.863	-0.635	-0.241	0.355
	(0.032)	(0.000)	(0.000)	(0.001)	(0.002)
Heteroscedasticity	0.351	0.185	0.980	0.767	0.412
	(0.960)	(0.994)	(0.489)	(0.647)	(0.910)
ECM (-1)	-0.655745	-0.547621	0.016656	0.024626	-0.176791
	(0.0010)	(0.0004)	(0.2237)	(0.0236)	(0.0076)

Source: As Conceived from the Author. Note: ***, ** and * represent the 1%, 5% and 10% significant levels, (.) represent the probability values and the variables are expressed in natural logarithms.

4.7 Robustness Check – DOLS

After examining the nexus between the digital finance ecosystem and bank performance with the autoregressive distributed lag model (ARDL) in Nigeria and Kenya, we carried out a re-examination of the nexus between the digital finance ecosystem and bank performance by employing the dynamic ordinary least squares (DOLS) estimation technique. Worth to note also that we based our focus on how the products of the fintech companies, payment systems and digital channels and their products – automated teller machines (ATMs), point of sale (POS), internet banking (INB), mobile money (MM) and mobile payment (MP) influenced banking sector performance in both Nigeria and Kenya to avoid ambiguity. We also controlled for the influence of cyber security, financial literacy, financial quality, institutional quality and

macroeconomic volatility. However, the rationale behind conducting these robustness checks is that ARDL is a parametric model, while the DOLS is a non-parametric model. Also, the ARDL is consistent in estimating the long-run and short-run impacts simultaneously, accept the variables into the models irrespective of their order of integration so long as they are integrated of I(0) or I(1); while the DOLS takes care of some estimation problems like endogeneity, cross-sectional dependency issues, country-specific effects, and simultaneity problems using the lags and leads mechanisms. However, below in the preceding sections, we analyzed the estimated results of the robustness checks in both Nigeria and Kenya respectively.

4.7.1 Nexus between Digital Finance Ecosystem and Bank Return on Assets in Nigeria

While exploring the nexus between digital finance ecosystem and bank return on assets in Nigeria using the DOLS estimation technique, we found that the past values of the ban return on assets (ROA) have significant positive contributory effects on the current values of bank return on asset in Nigeria except for model 5. We found that automated teller machines (ATM) has significant positive effects of 0.954 on the bank return on assets in Nigeria and similar findings were made from the results of point of sale (POS), internet banking (INB) and mobile purchase (MP) which have significant positive effects of 0.347, 0.677 and 0.054 on bank return on assets in Nigeria. On the contrary, we discovered that the mobile money (MM) has negative and significant effects of -0.788 on bank return on assets in Nigeria. According to the result findings, cyber security (CYS) shows a negative and significant effects of -2.045 on bank return on assets, positive and significant effects of 1.164, 0.986 and 0.557 on bank return on assets in Nigeria, and positive and insignificant effects of 0.486 on bank return on assets in Nigeria. Also, a similar finding was made from the financial literacy (FIL) which has significant negative effects in models 1, 3 and 4, but showed a significant positive effect on bank return on assets in Nigeria in models 2 and 5 respectively. Findings further shows that financial deepening – increase in the financial services has positive and significant effect on bank return on assets in Nigeria across the models, while the institutional quality (ISQ) and macroeconomic volatility (MEV) have mixed effects of negative and positive significant effects on bank return on assets in Nigeria. The result findings also shows that R-squared greatly explained the dependent variable – bank return on assets in Nigeria with over 50% effects. These findings are in consonance with prior findings made by scholars such as (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Table 9: DOLS Results for Digital Finance Ecosystem and Bank Return on Asset

Variable	1	2	3	4	5
ROA (-1)	0.541*** (0.000)	0.121 (0.064)	0.798*** (0.000)	0.798*** (0.000)	-0.769*** (0.000)
ATM	0.954*** (0.000)				
POS		0.347*** (0.000)			
INB			0.677***		

				(0.000)	
MM				-0.788***	
				(0.000)	
MP					0.054**
					(0.016)
CYS	-2.045***	1.164***	0.486	0.986***	0.557***
	(0.000)	(0.000)	(0.464)	(0.001)	(0.000)
FIL	-0.532***	0.012**	-1.057***	-0.057***	0.783***
	(0.000)	(0.012)	(0.001)	(0.000)	(0.000)
M2/GDP	0.983***	0.091***	0.130**	0.130**	0.957***
	(0.000)	(0.002)	(0.020)	(0.020)	(0.000)
ISQ	0.241***	-0.248***	0.145***	-0.019***	0.205***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)
MEV	-0.004	-0.019***	0.004***	6.677***	-0.001
	(0.634)	(0.002)	(0.000)	(0.000)	(0.421)
No of Obs.	27	22	24	27	27
R-squared	0.561	0.668	0.870	0.557	0.912

Source: As Conceived from the Author. Note: ***, ** and * represent the 1%, 5% and 10% significant levels, (.) represent the probability values and the variables are expressed in natural logarithms.

4.7.2 Nexus between Digital Finance Ecosystem and Bank Return on Equity in Nigeria

From the results of the DOLS with emphasis on how digital finance ecosystem influence bank return on equity in Nigeria, we found that the previous values of bank return on equity (ROE (-1)) contributed significantly to the current values of bank return on equity in Nigeria. It was also discovered that the automated teller machines (ATM) has significant positive effect of 7.458 on the bank return on equity in Nigeria. On the other hand, we found that point of sale (POS) has a negative and significant effects of -10.33 on bank return on equity in Nigeria. We also discovered a similar findings from the result of internet banking which showed a negative and significant effects of -4.879 on bank return on equity in Nigeria. However, we found that mobile money (MM) and mobile purchase (MP) have significant positive effects of 10.49 and 7.157 on bank return on equity in Nigeria. The results further revealed that cyber security (CYS) has positive and significant effects on bank return on equity in models 1 and 5, but showed a negative and significant effects on bank return on equity in Nigeria in models 2, 3 and 4 respectively. From the results of financial literacy, we discovered that in models 1, 3 and 5, FIL has negative effects on bank return on equity, but showed positive effects on bank return on equity in models 2 and 4. We discovered that financial deepening – increase in the financial services (M2/GDP) has significant positive effects on bank return on equity in Nigeria and this is similar to the findings made from the institutional quality (ISQ) which showed a positive and significant effect on bank return on equity in Nigeria. On the other hand, we discovered that macroeconomic volatility (MEV) has negative and significant effects across the models on bank return on equity in Nigeria. Furthermore, we found that the R-squared results – measures

of goodness of fit shows that to a great extent, digital finance ecosystem explained the bank return on equity in Nigeria. Hence, these findings are in corroboration with previous empirical findings made by (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Table 10: DOLS Results for Digital Finance Ecosystem and Bank Return on Equity

Variable	1	2	3	4	5
ROE (-1)	0.052***	10.95***	-70.24***	-0.011***	-9.721***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ATM	7.458***				
	(0.000)				
POS		-10.33***			
		(0.000)			
INB			-4.879***		
			(0.000)		
MM				10.49***	
				(0.000)	
MP					7.157***
					(0.000)
CYS	23.54***	-0.424***	-0.239***	-0.422***	7.023***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FIL	-14.97***	0.005**	-30.26***	0.003**	-4.253***
	(0.000)	(0.021)	(0.000)	(0.033)	(0.000)
M2/GDP	0.019***	0.007***	4.535***	0.008***	64.37***
	(0.002)	(0.000)	(0.000)	(0.006)	(0.000)
ISQ	0.045***	0.005***	33.95***	0.005	10.63***
	(0.000)	(0.019)	(0.000)	(0.123)	(0.000)
MEV	-2.033	-2.805	-0.518	-2.898	-1.218
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No of Obs.	24	26	25	27	25
R-squared	0.498	0.542	0.785	0.698	0.711

Source: As Conceived from the Author. Note: ***, ** and * represent the 1%, 5% and 10% significant levels, (.) represent the probability values and the variables are expressed in natural logarithms.

4.7.3 Nexus between Digital Finance Ecosystem and Bank Return on Assets in Kenya

We extended the study of the nexus between digital finance ecosystem and bank return on assets to Kenyan economy and the results of the estimated DOLS obtained were presented in Table 11 and analysed in this section. However, findings from the results shows that the past values of bank return on assets (ROA (-1)) has contributed to the current values of bank return on assets in Kenya across the models. We also found that the automated teller machines (ATMs) and point of sale (POS) have negative and significant effects of -7.108 and -0.023 on bank return on assets in Kenya. Furthermore, we found that internet banking (INB), mobile

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money (MM) and mobile payment (MP) have significant positive effects on bank return on assets in Kenya. We also found that while cyber security has significant negative effects on bank return in Kenya across the models, while financial literacy showed positive and significant effects on bank return on assets in Kenya across the models. This is in line with findings made from financial deepening – which measure the increase in financial services in Kenya that showed significant positive effects on bank return on assets in Kenya. Our findings also shows that institutional quality (ISQ) has significant negative effects on bank return on assets in Kenya, while the macroeconomic volatility (MEV) showed negative and significant effects on bank return on assets in models 1, 3 and 5, and significant positive effects on bank return on assets in models 2 and 4 respectively. We also discovered that the value of the R-squared entailed that the explanatory variables greatly determine bank return on assets in Kenya. These findings are in line with the previous findings made by scholars such as (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Table 11: DOLS Results for Digital Finance Ecosystem and Bank Return on Asset

Variable	1	2	3	4	5
ROA (-1)	-0.038	-0.074	0.014	0.043	-0.041
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ATM	-7.108				
	(0.000)				
POS		-0.023			
		(0.000)			
INB			1.625		
			(0.000)		
MM				0.084	
				(0.000)	
MP					3.128
					(0.006)
CYS	-0.069	-2.799	-2.027	4.002	-2.426
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FIL	0.001	3.866	0.002	-0.075	0.001
	(0.000)	(0.000)	(0.617)	(0.000)	(0.000)
M2/GDP	0.032	0.064	0.038	0.947	0.036
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)
ISQ	2.367	-0.813	-0.492	-0.082	-2.229
	(0.002)	(0.000)	(0.417)	(0.000)	(0.000)
MEV	-0.455	0.009	-0.857	0.075	-0.855
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No of Obs.	22	22	24	20	27
R-squared	0.885	0.652	0.752	0.631	0.810

Source: As Conceived from the Author. Note: ***, ** and * represent the 1%, 5% and 10% significant levels, (.) represent the probability values and the variables are expressed in natural logarithms.

4.7.4 Nexus between Digital Finance Ecosystem and Bank Return on Equity in Kenya

In this section, we analysed the results obtained from the DOLS analysis while examining the nexus between digital finance ecosystem and bank returns on equity in Kenya. From the results, we found that the past values of the bank return on assets contributes to the current values of bank return on equity in Kenya. Furthermore, our findings shows that automated teller machines (ATM) has negative and insignificant effects of -0.068 on bank return on equity in Kenya, while the point of sale (POS) showed a negative and significant effect of -0.972 on bank return on equity in Kenya. Contrary to this, we found that the internet banking (INB) and mobile payment (MP) showed a positive and significant effects on bank return on equity in Kenya, while mobile money (MM) showed a significant negative effects of -0.028 on bank return on equity in Kenya. Across the models, the cyber security (CYS) showed negative and significant effects in models 1, 3 and 5 respectively, but portrayed positive and significant effect in models 2 and 4. We found that financial literacy (FIL), financial deepening (M2/GDP) and institutional quality (ISQ) have significant positive effects on bank return on equity in Kenya. On another note, we discovered a positive and significant effects of (MEV) on bank return on equity in model 1, whereas models 2, 3, 4 and 5 shows negative and significant effects on bank return on equity in Kenya.

Table 12: DOLS Results for Digital Finance Ecosystem and Bank Return on Equity

Variable	1	2	3	4	5
ROE (-1)	3.668 (0.000)	-0.038 (0.000)	1.548 (0.000)	-0.038 (0.000)	1.664 (0.000)
ATM	-0.068 (0.803)				
POS		-0.972 (0.000)			
INB			3.382 (0.000)		
MM				-0.028 (0.000)	
MP					3.343 (0.000)
CYS	-2.063 (0.000)	1.333 (0.005)	-1.017 (0.000)	2.435 (0.408)	-1.035 (0.000)
FIL	0.840 (0.000)	2.918 (0.000)	0.938 (0.000)	1.232 (0.007)	0.037 (0.000)
M2/GDP	0.095 (0.000)	0.967 (0.000)	0.092 (0.000)	0.057 (0.594)	0.018 (0.000)
ISQ	0.013 (0.006)	0.069 (0.722)	0.055 (0.000)	0.966 (0.000)	0.009 (0.528)

MEV	0.858	-1.022	-1.152	-1.026	-1.151
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No of Obs.	21	27	25	26	26
R-squared	0.611	0.542	0.803	0.774	0.985

Source: As Conceived from the Author. Note: ***, ** and * represent the 1%, 5% and 10% significant levels, (.) represent the probability values and the variables are expressed in natural logarithms.

4.8 Discussion of the Findings

We investigated the nexus between digital finance ecosystem and banking sector performance in emerging economies with emphasis on Nigeria and Kenya from 1995 to 2022 and availability of data informed our choices of the scope and study period. The authors estimated the nexus between digital finance ecosystem and banking sector performance in emerging economies with the autoregressive distributed lag (ARDL) model as the baseline model and the dynamic ordinary least squares (DOLS) as the model for robustness checks. Our emphasis was on exploring digital finance ecosystem focusing on how the product of the fintech companies, payment systems and digital channels as well as their products influence banking sector performance in the emerging economies. However, after a careful review of the literature, we selected the following variables The digital finance ecosystem was measured with indicators such as the number of ATMs per 100,000 adults (ATM), point of sales (POS), internet banking (INB), mobile money (MM) and mobile purchase (MP); while the banking sector performance was measured with indicators such as bank return on assets (ROA) and bank return on equity (ROE) and we controlled for the influence of cyber security (CYS), financial literacy (FIL), financial deepening – a measure of broad money (M2) divided by gross domestic product (GDP) i.e. (M2/GDP), institutional quality – measured with the index of institutional quality measures (rule of law, regulatory quality, government effectiveness, political stability and absence of violence, voice and accountability and corruption control) and macroeconomic volatility (MEV). From the analyzed results, the descriptive statistics revealed that the values of the mean, median, standard deviation, skewness and kurtosis did not drift so much from each other, and the probability values of the Jarque-Bera statistic for all the variables are less than 0.05 showing that the variables are normally distributed. We also found the existence of correlations between digital finance ecosystem in emerging economies from the results of Spearman's correlation test. Relatedly, we discovered no trace of unit root and the variables were integrated of I(0) and I(1) and not I(2). The results of Pedroni (2004) and Kao (1999) suggested that cointegration exists between digital finance ecosystem in emerging economies across models 1 to 5.

Furthermore, the analysis was stratified according to the countries – Nigeria and Kenya to get the in-depth analysis of the relationship between digital finance ecosystem and banking sector performance in the study. Findings from the ARDL baseline model shows that digital finance ecosystem indicators – automated teller machines, point of sale, internet banking, mobile money and mobile purchase have significant effects on both bank return on assets and bank return on equity in Nigeria and Kenya. Furthermore, we controlled for the influence of cyber

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security, financial literacy, financial deepening, institutional quality and macroeconomic volatility and found that they have mix significant impacts on banking sector performance in the emerging economies. Relatedly, from the result of the DOLS analysis – the robustness checks, we also found that digital finance ecosystem indicators – automated teller machines, point of sale, internet banking, mobile money and mobile purchase have positive and significant effects on both bank return on assets and bank return on equity in Nigeria and Kenya. Furthermore, from the results of the control variables, (cyber security, financial literacy, financial deepening, institutional quality and macroeconomic volatility) we found that they have both negative and positive effects on banking sector performance in the emerging economies. These findings are in line with some of the reviewed studies (Demirez et al. 2021, Demirahn 2021, Tseng et al. 2020, Junger & Meitzner 2020, Feld et al. 2021, Del Gaundin et al. 2021, Gosh 2020, Nguyen & Du 2022, Banna & Alam 2021, Vo et al. 2021, and Sayey 2024) among others.

Referring to the research questions that guide this study which was stated as follows. a). What are the effects of automated teller machines on banking sector performance in Nigeria and Kenya? b). How does the point of sale influence banking sector performance in Nigeria and Kenya? c). In what ways does Internet banking affect banking sector performance in Nigeria and Kenya? d). What are the effects of Internet banking on banking sector performance in Nigeria and Kenya? e). How does mobile money influence banking sector performance in Nigeria and Kenya? f). How does mobile payment affect banking sector performance in Nigeria and Kenya? Our research findings provided answers to the research questions in the following ways. Firstly, we found that the automated teller machines (ATM) has significant effects on the banking sector performance in the Nigeria and Kenya this implies that increase in ATMs would lead to increase in banking sector performance in Nigeria and Kenya. Secondly, from the results of the findings, it was discovered that the point of sale has significant effects on banking sector performance in Nigeria and Kenya. Thirdly, we also found that internet banking has significant effect on banking sector performance in Nigeria and Kenya. Fourth, based on the result findings, we discovered that mobile money has significant effects on banking sector performance in Nigeria and Kenya. Lastly, we discovered that mobile payment has significant effect on banking sector performance in Nigeria and Kenya. Conclusively, this study deduced that digital finance ecosystem has significant impact on banking sector performance in Nigeria and Kenya.

Our study is therefore differ from the above stated studies in the following ways. First, none of the prior studies examined the effects of digital finance ecosystem with emphasis on how the product of the fintech companies, payment systems and digital channels as well as their products indicators such as automated teller machines, point of sales, internet banking, mobile money and mobile purchase on banking sector performance in Nigeria and Kenya as at the time of writing. Second, we estimated these relationship with the aid of autoregressive distributed lag (ARDL) model as the baseline model which is consistent in estimating efficiently the long-run and short-run impacts simultaneously irrespective of the integration order of the variables. Third, we robustly checked the results of the ARDL model by employing the dynamic ordinary

least squares (DOLS) as the robustness check model which takes care of cross-sectional dependency and country-specific effects which the above-stated studies ignored.

5. Conclusion, Policy Implications and Policy Recommendations

The performance of the banking sector has a broad and profound impact on the economy. Strong and well-functioning banks support economic growth, stability, and efficiency, while weaknesses in the banking sector can lead to economic disruptions and financial crises. Banks stimulate economic expansion by providing loans to businesses and consumers, enabling investment in projects, expansion of businesses, and consumer spending, helps in the allocation of resources efficiently by channelling funds from savers to borrowers to support various sectors of the economy, thereby leading to optimal use of financial resources. Banks drive financial innovation by developing new products and services, which can enhance economic efficiency and accessibility and facilitate international trade and investment by providing foreign exchange services and financing. Other conditions and factors like cyber-crime and cyber security, financial literacy, financial deepening, institutional quality and macroeconomic volatility should be put into consideration while exploring banking sector performance. Findings from the ARDL baseline model show that digital finance ecosystem indicators – automated teller machines, point of sale, internet banking, mobile money and mobile purchase have significant effects on both bank return on assets and bank return on equity in Nigeria and Kenya and related findings were made from the DOLS result – the robustness check.

Based on the above conclusions, we recommend the following to improve banking sector performance in emerging economies. However, improving the banking sector through a digital finance ecosystem involves a range of policies aimed at enhancing efficiency, inclusivity, security, and innovation. In this regard, authorities should develop comprehensive regulations specifically tailored to digital banking and fintech, addressing issues like digital identity verification, consumer protection, and data privacy. They should also provide incentives, such as grants or tax breaks, for fintech startups to drive innovation in digital banking solutions, enhance partnerships between traditional banks and fintech firms to leverage new technologies and expand service offerings, promote policies that support the development of digital financial services in underserved and remote areas, ensuring that all citizens have access to banking services, and encourage the development and distribution of low-cost digital devices and internet access to enable broader participation in digital finance. Government and authorities should establish and enforce stringent cybersecurity standards for digital financial transactions and data protection to safeguard against fraud and cyberattacks, develop clear protocols and support systems for responding to and recovering from cybersecurity incidents, implement educational initiatives to improve digital literacy among consumers, helping them understand and safely use digital financial tools, develop and support industry standards for digital financial services to ensure interoperability between different systems and platforms, encourage open banking frameworks that allow third-party providers to access bank data (with customer consent) to foster innovation and competition, implement policies to simplify and reduce the cost of cross-border digital transactions, and enhancing global financial

connectivity. By adopting these policies, governments and regulatory bodies can help modernize the banking sector, drive innovation, improve customer experiences, and ensure that the benefits of digital finance are widely shared.

Suggestions for future research

Future research should incorporate methodologies capable of causal inference, such as natural experiments, IV approaches, or structural modelling, to conclusively establish the direction of causality and inform targeted policy interventions.

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