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Original Research Article

Nexus between Financial Innovation and Financial Stability in Nigeria

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Abstract: Motivated by the cashless policy drives of the Central Bank of Nigeria to digitalize the Nigerian payment system and the quest for ensuring financial stability, this paper examined the nexus between financial innovations and financial stability in Nigeria. The paper employed disaggregated and aggregated indices in measuring financial innovation and financial stability and analyzed the data using the Dynamic Ordinary Least Square (DOLS). The paper conducts robustness checks using the Autoregressive Distributed Lag (ARDL) model and by employing alternative proxies. The result indicates the presence of a long-run equilibrium relationship between disaggregated measures of financial stability and financial innovation. The outcome was consistent using alternative methods. However, the study also finds the absence of a long-run equilibrium relationship between the aggregated proxy of financial innovation and financial stability, nonetheless, other bank-base and macroeconomic indicators appear to influence financial stability. The impact of the various measures of financial innovation on financial stability appears to be mixed in both the main and robustness analysis, implying that technology-based financial products promote financial stability but are associated with a cost. Therefore, the Central Bank of Nigeria is encouraged to incentivize the use of financially innovative channels toward enhancing the stability of the Nigerian financial system, while employing appropriate prudential tools to safeguard any unsavoury consequences of innovation.

Keywords: Financial Innovation; Financial Stability; Cashless Policy; and DOLS.

JEL Codes: G23, G32, C32.

1.0 INTRODUCTION

Motivated by the cashless policy drives of the Central Bank of Nigeria aimed at reducing the prevalent use of cash payments, promoting the use of electronic payment channels for exchange, and the goal of maintaining a resilient and stable financial ecosystem, this paper aimed to investigate the nexus between financial innovation and financial stability. From the apex Bank perspective, the need for innovative finance in the payment system is driven by the ambition for inclusive growth, lowering the cost of providing banking services, and enhancing the ability of the Bank to better manage the economy in ensuring the effectiveness of Monetary Policy (Shonubi, 2012; CBN, 2020).

The cashless policy direction has challenged the financial services providers to aggressively improve their financial innovativeness, leading to the thriving of financial technology (Fintech), which took a leading role in shaping the payment system landscape with innovative products such as Debit and Credit Cards, Bank Transfers, Bank Direct Debits, Automated Teller Machines (ATMs), Point of Sale (POS), Web payment via the internet and even Mobile Applications. These developments have intensified the level of competition among banks, and other Fintech companies, including changes in technology. Financial innovation possesses the ability to enhance the profitability of the service providers, and the resilience of the system, among others, it is, however, associated with a cost (disruptive technology and cybersecurity risk, among others). The financial system is the recipient of both the benefits and the costs associated with financial innovation, therefore, there is a need to constantly examine and re-evaluate the nexus between financial innovation and financial stability. Financial stability is of great importance as it has remained the cardinal pillar or lubricant that keeps the wheel of any economy in constant motion, as a stable financial system ensures optimum and efficient resource mobilization and utilization.

The unprecedented outbreak of COVID-19 has induced a paradigm shift in service delivery, leading to massive use of technology. The financial system was not

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excluded from this as statistics indicate that in the fourth quarter of 2015, the total value of electronic payment via ATM, POS, Web, Mobile transfer, and Nigeria Inter-Bank Settlement System Electronic Fund Transfer (NEFT) increased by 58.77 percent from its levels at the first quarter of 2010. However, at the end of the fourth quarter of 2022, the increase was unprecedented, occasioned by the higher usage of financially innovative products due to the COVID-19 pandemic that encouraged e-channel payment on account of lockdown and social distancing. Consequently, the aggregated value of electronic payment channels increases from 58.77 percent in the fourth quarter of 2015 to 9,347.63 percent in the fourth quarter of 2022 [1].

Therefore, financial transformation from traditional to digital financing has attracted the attention of scholars and researchers to explore the connection between financial innovation and financial system stability. In advanced economies, a plethora of evidence indicates that financial innovation exerts a mixed impact on financial stability, with studies (Ionescu, 2012; Gorshkov, 2022; Kasri, *et al*., 2022) suggesting a positive impact. This outcome is of interest to policymakers as it enables additional effort to strengthen the robustness of the payment system with policies that encourage innovative financing. On the contrary, other studies reported a negative impact (Kühnhausen, 2014).

In Africa and particularly in Nigeria, studies that investigate this relationship are limited. Among the existing visible studies (Chukwunulu, 2019; Ibekwe, 2021; Musa & Abubakar, 2022; Nwosu *et al*., 2022). Chukwunulu (2019) focused on the impact of technological innovations measured by electronic payments system on economic growth, while other studies focus on its effect on firms' profitability and returns (Ibekwe, 2021) and some focus on theoretical relationship (Ionescu, 2012). The only visible study that connects financial innovation and financial stability is Kasri, *et al*., (2022) and Ashiru *et al*., (2023). The focus of Kasri *et al*., (2022) was the Indonesian economy while the focus of the latter was Nigeria. While this study shared similarities with the study of Kasri *et al.*, (2022), they, however, differ in jurisdictional focus having different economic fundamentals. Similarly, this paper shared some similarities with the study of Ashiru *et al*., (2023), but the paper has, however, improved on the study of Ashiru (2023) by employing DOLS as the main analytical method, which is capable of correcting for the endogeneity of the regressors and thus making the estimates more efficient, removes the bias in the coefficients that are caused by serial correlation and allows for better specification of the model's dynamics. The paper also introduces an aggregated measure of financial innovation and financial stability, which was ignored in the study of Ashiru *et al*., (2023). This aggregated measure is argued to provide the macro-wide perspective of financial innovation and financial stability.

Consequently, this study used both disaggregated measures of financial innovation using the distinct electronic payment channels and disaggregated measures of financial stability using the industry-wide returns on assets and returns on equity. In addition to the disaggregated measures, the paper used aggregated/composite ratios in measuring financial innovation as pioneered in the study of Zhang *et al*., (2019) and later adopted by Kasri *et al*., (2022) and others. This metric was considered more comprehensive than using the individual value of distinct electronic payment channels because the ratio showcases the degree of financial innovation in relation to the size of the economy being computed as a ratio of the total value electronic payment system to the gross domestic product. To the best of our knowledge, this paper is among the leading papers that use this ratio in the case of Nigeria. Secondly, the paper differs in data frequency, as we employ quarterly frequency data to study the relationship.

In essence, the paper contributes to the literature in the following ways. First, an extension of variable measurement using payment penetration ratio. Secondly, the paper accounted for the impact of financial innovation on financial stability using alternative techniques (DOLS and a robustness check with ARDL). This technique is different from the method used by (Nwosu *et al*., 2022, Ibekwe, 2021; Kasri, *et al*., 2022; Ashiru *et al*., 2023). Moreover, the paper conducts robustness checks using alternative variables and compares the outcome with the baseline/main result. Following this background, the specific objective of the paper is to examine the impact of financial innovation on financial stability in Nigeria using DOLS and robustness checks using ARDL and composite variable (z-score for financial stability and payment penetration ratio for financial innovation). The financial innovation is proxied by some specific electronic payment channels and payment penetration ratio (PPR), which is part of the contribution of the paper. Furthermore, financial stability is proxied by the banking system returns on assets and equity, and additionally used the Z-score index for the Nigerian banking industry, as the banking system dominates the Nigerian financial system, covering over 70 percent. Additional control variables are included given their relevance to the study such as bank size, inflation, growth of money supply, and interest rate.

Following this introduction, the literature review is in section 2, data, and method in section 3, while the result and discussion are featured in section 4, and the study concludes in section 5.

[1] https://www.cbn.gov.ng/Paymentsystem/ePaymentStatistics.asp

2.0 LITERATURE REVIEW

2.1. Theoretical Literature Review

In the extant theoretical literature, the Schumpeterian Innovation Theory (SIT), Innovation Diffusion Theory (IDT), and the theory of constraint-induced financial innovation, where the most predominant theoretical underpinning employed to validate the nexus between financial innovation and financial stability, which tends to explain why institutions that provide access to financial services adopt technological advancements. Therefore, for this study, the Schumpeterian and constraint-induced financial innovation theories were considered apt in explaining the nexus between financial innovation and financial stability in Nigeria. Thus, these theories served as the theoretical underpinning of the study.

2.1.1. Schumpeterian Innovation Theory

The theory suggests the role of innovation in promoting creative destruction that translates to progress and growth (Gorshkov, 2022). In the original version of the theory, Schumpeter (1912) proposes that technological advancements create opportunities for new profits, driven by increased investment by the firms (banks or financial institutions in this context) in innovative products such as POS, ATM, Mobile applications, and Web payment channels, among others. The paper, therefore, hypothesizes that innovations would change the dynamics of financial activities, creating an opportunity for firms to increase performance (returns on asset and equity), which would ultimately translate to greater financial stability. Essentially, the realized benefit of financial innovation is likely to create additional economic value with higher liquidity within the financial ecosystem. However, friction in the workings of the innovative-driven financial system implies stability risk. From the above, it can be inferred that financial stability is the function of financial innovation, mathematically expressed below:

$$Financial\ stability = f(financial\ innovation) \ldots\ldots.eqn.\,2.1$$

The above relationship could be further broken to proxy financial innovation with several electronic channel payments or the composite ratio. Similarly, financial stability can be proxied by returns on assets and equity or the Z-score. In essence, the Schumpeterian innovation theory posits that innovation is a determining factor of growth and stability. Consequently, this paper adopts this theory to examine the nexus between financial innovation and financial stability.

2.1.2. Constraint-Induced Financial Innovation Theory

In the theory of constraint-induced financial innovation, Silber (1983) argues that the banking industry, marked by extensive regulations, imposes constraints that limit the scope of innovation. Consequently, regulation has dual consequences. First, they diminish the banks' and other Fintech players' capacity to explore novel innovative ideas and secondly, they may also hinder the efficiency of banking institutions. Therefore, banks and Fintech companies will exert considerable effort to mitigate these effects, leading to considerable innovation in products to overcome the restraints. The COVID-19 pandemic serves as an experimental ground to explore how constraints can drive innovation, born out of necessity. A study conducted by Naeem and Ozuem (2021) highlights that the lockdowns prompted by COVID-19 led to increased social media usage, facilitating the swift adoption of Internet banking by both banks and other financial services firms, where over 80 percent of transactions go online via mobile transfer, web, ATM and POS, among others. Similarly, the Naira redesign policy of 2022 has demonstrated how constraints drive the adoption of innovative financing channels. As such, the financial system benefits from an enhanced utilization of electronic channels and therefore, the theory sheds light on the reasons why banks engage in financial innovation. This theory was also considered relevant in explaining the need for financial innovation and is therefore adopted in addition to the Schumpeterian innovation theory as the theoretical underpinning of this study.

2.2. Empirical Literature Review

The extant literature is inundated with pieces of evidence that financial innovation enhances stability (Kasri *et al.*, 2022; Yin *et al*., 2022). Others show the contrary that higher innovation had a negative relationship with a firm's stability (Kühnhausen, 2014). Specifically, empirical evidence indicates a non-linearity in the financial innovation and stability nexus as Law *et al*., (2018) discovered an inverted U-shaped non-linear relationship between finance and innovation in a study that examined the non-linear relationship between financial development and innovation under the Generalized Method of Moments (GMM) framework in a panel analysis 75 developed and developing countries for the period 1996 to 2010. The outcome implies that finance spurs innovation to a certain threshold, beyond which continuous development of finance appears to be inimical to innovation. The study further suggests the finance-innovation curve varies with different settings of institutional quality; thus, robust institutional quality is a prerequisite for financial development that will be beneficial to innovation. The major takeaway from this finding is that there appears to be a feedback reaction between financial stability and financial innovation. This may require conducting a causality test to verify this assertion. Furthermore, the findings pointed out the non-linear relationship, which implies that the nexus between financial innovation and financial stability could be a non-linear relationship and it has a threshold where further financial development could harm financial innovation. Thus, this outcome gives a pointer that the impact of financial innovation on financial stability in Nigeria could be asymmetric.

This study and the work of Law *et al*., (2018) share some similarities in that both studies aim to examine the finance and innovation nexus. However, this study extends the work of Law *et al*., (2018) in two respects. First, in measuring financial innovation, this study took a divergent approach of using bank-level specific data (value of electronic payment channels) against the total patent application and the total patent grants per labor employed in the study of Law *et al*., (2018). Second, this study employed rather a different methodology for measuring the relationships using the DOLS and robustness analysis with ARDL.

In a related study on financial innovation, Gorshkov (2022) examines the level of cashless payment in the Russian economy. In the finance literature, cashless payment or any form of electronic payment transaction is broadly treated as financial innovation. In this regard, Gorshkov (2022) calculated the ratio of cashless payment in Russia and discovered that the shape of cashless payment or put differently innovative payment is a J-curve exponential growth. This implies the higher adoption of innovative payment channels in Russia, majorly driven by the increase in financial transactions using debit cards; nonetheless, the use of credit cards and e-money payments also contributes to the J-shaped exponential growth in cashless payment.

Driving by the mixed outcome on the nexus between digital payment and financial stability, especially in an emerging market economy with conventional and Islamic (Non-interest) banking systems, Kasri *et al*., (2022) examine the impact of digitalization on financial stability, in Indonesia using Vector Error Correction Model (VECM) and Vector Autoregressive (VAR). Innovatively, the study uses the payment penetration ratio (PPR) computed as the total value of digital payment divided by the level of economic activity (Gross Domestic Product), whereas financial stability is measured in the study by the value of Z-Score. The finding suggests digital payment transactions have an equilibrium and long-run relationship with banking stability in Indonesia. Furthermore, the study pointed to the existence of one-directional causality from digital payment to banking stability. The study of Kasri *et al*., (2022), Gorshkov (2022), and Law *et al*., (2018) shows the significance of cashless policies that promote financial and resilient banking and financial system.

This study benefits from the work of Kasri *et al*., (2022), which indicates the shortcomings of using the Z-score in measuring financial stability in its inability to capture real and market indicators such as spread on credit, stock prices and indexes, interest rate, inflation, effective exchange rate, and credit expansion. Consequently, as an extension of the work of Kasri *et al*., (2022), this study used disaggregated proxies and tested the robustness of the Z-score using the Nigerian dataset. The disaggregated proxies capture some important accounting and market dimensions that are theoretically established to determine financial stability. Moreover, instead of the sole use of PPR by Kasri *et al*., (2022), this study also employs various electronic payment channels to proxy financial innovation.

In Nigeria, Nwosu *et al*., (2022) use the Panel Autoregressive Distributed Lag (PARDL) framework to study the impact of Fintech on financial stability in Nigeria. The study uses Google trends for the Fintech index and the study indicates that both bank-specific and macroeconomic factors determine the graduation of risks in the financial system, providing further evidence of a negative relationship between bank size and the stability of selected neo-banks. While the study is relevant to the concerns of the rapid growth of Fintech in Nigeria and the attendant vulnerabilities and challenges to financial, however, using Google trend appears to be inadequate in pointing to the real development in Fintech and financial innovation. Therefore, this study overcomes this shortcoming by using actual bank-level financial innovation data.

In a recent study, Jungo *et al*., (2023) examined the role of financial innovation and other finance-related variables such as financial inclusion in mitigating adverse effects of corruption on banks' credit risk, profitability, and financial stability using the Feasible Generalized Least Squares (FGLS). The outcome shows that financial innovation mitigates the effect of corruption on bank stability and credit risk. The finding implies the greater need for financial innovation aimed at achieving banking sector stability.

There was an increased interest in assessing the nexus between financial innovation and financial stability following the global financial crisis of 2008. In this regard, Ashiru *et al*., (2023) investigate the impact of financial innovation measured by electronic payments channels on banks' financial performance using the Granger causality test and ARDL model. They found that POS banking services exert the most significant influence on the performance of deposit money banks due to the substantial volume and value of transactions in the banking sector. This study shares similarities with this paper, but however, this study extends the study period to the fourth quarter of 2022 and adopts a different methodology. Additionally, this study utilized additional measures of stability and innovation.

Utilizing a distinct set of variables, Musa and Abubakar (2022) employed agency banking as a distinct metric of financial innovation and found that financial innovation has a positive and significant effect on the performance of deposit money banks (DMBs) in Nigeria in terms of efficiency. In the same spirit, other studies examine the impact of financial innovations on the economy and discovered that transactions through ATMs, Mobile Banking, Internet Banking, and point-of-sale terminals have significant positive effects on economic growth in Nigeria (Chukwunulu, 2019). This study is similar to this paper in two aspects. The first was the concentration on financial innovation and the second using an innovative payments system to measure financial innovation. However, this paper has introduced three additional innovations in the former study. First, the concentration of this paper is on financial innovations and financial system stability. Secondly, this paper utilized both distinct electronic payment channels and introduced aggregated measures of financial innovation using the value of the payments system as the ratio of GDP, which measures payment penetration. Thirdly, the studies of Chuckwunulu (2019) use the Generalised Methods of Moment (GMM), this paper uses DOLS and lastly, the former study was limited in scope covering 2008-2017. This sample size of 10 observations was insignificant for a robust and reliable econometric estimate as the parameters may produce a biased estimate, leading to misleading conclusions and recommendations. To address this issue, this paper utilized a quarterly series covering 2010Q1-2022Q4, this sample size produces sufficient observations, which is sufficient enough to produce a robust result as it is greater than 30 observations.

Other empirics such as Ibekwe (2021) found that financial innovation has enhanced the profitability and return on assets of the commercial banks in Nigeria. While higher profitability and a bank's return on an asset can be sub-metric of banking system stability, however, it is an insufficient measure of banks and by extension financial system stability. To contribute to this line, this paper augments the returns on assets with returns on equity and with the Z-score index of financial stability. Additionally, Qamruzzaman and Jianguo (2018) show that financial innovation fosters long-term economic growth for a group of four South Asian countries (Bangladesh, India, Pakistan, and Sri Lanka) as it encourages the expansion of financial services, enhances financial efficiency, promotes the accumulation of capital, and facilitates effective financial intermediation.

Further evidence has shown that financial innovation has made the banking processes easier, promotes economic activities, reduces transaction costs for the financial system through the provision of better financial services, and fast-tracks the process of capital accumulation by encouraging the saving propensity, which ultimately spurs economic growth (Khan, Fareed, Salameh, & Hussain, 2021). Recent findings indicate that banks in nations with greater financial innovation tend to experience more robust growth in their assets, loan portfolios, and profitability (Lee, Wang, & Ho, 2020). Additionally, factors such as banking regulations, financial reforms, and indicators of a country's governance have the potential to dampen the connection between financial innovation and bank expansion (Lee, Wang, & Ho, 2020).

Conclusively, the review highlights a renewed interest in financial innovation and financial stability nexus. However, the outcome of the existing studies was mixed with Kasri *et al*., (2022) showing a positive impact, Kühnhausen (2014) showing a negative impact, and others showing non-linearity (Law *et al*., 2018, Gorshkov, 2022). Other studies focus on innovation and growth nexus (Chukwunulu, 2019), while others are cross-country-oriented studies (Jungo *et al*., 2023; Gorshkov, 2022). It was also evident from the review that none of the studies utilizes DOLS in their estimation as well as the combination of the distinct and composite measures. The studies on Nigeria were also limited to 2021 (Ashiru *et al*., 2023), others utilize few observations, covering only 10 years (Chuckwunulu, 2019). To address the highlighted shortcomings and gaps in the empirics and contribute to the strand of literature, this study used the most recent available data, employed several alternative variables, aimed at teasing out a robust and reliable result, and used different techniques with an accompanied robustness analysis.

3.0. METHODOLOGY

3.1. Data Description and Measurement

The study makes use of quarterly data for the variables spanning 2010Q1 to 2022Q4 and sourced from the online database of the Central Bank of Nigeria, (see http://statistics.cbn.gov.ng/cbn-onlinestats/DataBrowser.aspx) and the online database of the National Bureau of Statistics (https://nigerianstat.gov.ng/elibrary).

To measure financial stability, the paper uses returns on asset and returns (ROA) and returns on equity (ROE) as these variables were found to be widely used in the reviewed literature. These variables are the disaggregated measures of financial performance and stability. In addition to the ROA and ROE, the paper computes a z-score index that captures the ability of the system to withstand shocks or cover-up return variability. This index was widely used in the extant literature, especially when the banking system dominates a financial system (Nwosu *et al*., 2021; & Atoi, 2018). Alternative approaches to measuring financial stability comprise of principal-component approach to aggregate several soundness indicators and then obtain a measure from the PCA, weighted-sum approach, and dynamic factor modeling approach. However, each of these approaches has advantages and disadvantages and has been used mostly based on the availability of data and the purpose of the study. Therefore, the justification for using the z-score index as an additional proxy for robustness, which provides an aggregated measure of stability was informed by its suitability and data availability for the index computation. The index was computed as the average ROA of all deposit money banks in the financial sector plus the ratio of equity to assets (ratio of ROE) of the banks divided by the standard deviation of ROA. This is computed as follows:

Financial Stability (FSS) index = $\frac{ROA + \frac{Equity}{Assets}}{Standard\ deviation\ of\ ROA}$ eqn. 3.1

Where, ROA is the return on assets, calculated by dividing net profit by total assets. The stability index measures the probability of default or bankruptcy risk of the banks. It shows how many standard deviations the bank is from depleting its capital base. A higher value of the index indicates increased solvency of banks while a lower value indicates otherwise.

The paper also uses the value of some notable electronic payment channels comprised of ATM, POS, Web, NEFT, and Mobile payment to measure financial innovation. The choice of the variables was driven by empirical evidence, which considered this variable appropriate for measuring financial innovation (Ashiru *et al*., 2023). In addition to these disaggregated variables, the paper uses a composite/aggregated variable measured by the payment penetration ratio. The ratio was computed as the ratio of the total value of digital payment to GDP instead of using the absolute value of electronic-based retail payment transactions to measure financial innovations. This was one of the contributions of the paper, as this measure was originally used by Zhang *et al*., (2019) and later adapted by Kasri *et al*., (2022). The payment penetration ratio is a comprehensive measure of digital payments composed of POS transactions, ATM transactions, Cheque payments, Web transactions, mobile payments, and NEFT transactions.

Other variables used in the paper were rooted in theory and the extant literature includes the growth of money supply (GMS) and money market rate (MMR), specifically using the open buyback rate. The choice of incorporating a monetary aggregate in the model was driven by the fact that Nigeria is operating a monetary targeting framework, therefore, the growth of money supply is expected to have an effect on financial stability, as higher money growth would translate to inflation that may have lower the resilience of the system. However, OBB was used as the rate measures the price where banks lend among themselves as such a higher rate implies a shortage of liquidity, which may negatively affect liquidity in the financial system and by extension the stability of the system. Another control variable introduced is the bank size measure as the natural logarithms of bank assets, this is an important indication of ample liquidity in the system and otherwise. Finally, inflation was also used as a macroeconomic variable that has a connection with the financial system. The variables are captured as the log differences to enable interpreting the result in elasticities and resolve the heterogeneous data scaling issues.

3.2. Method of Data Analysis and Model Specification

To determine the appropriate model, institutional knowledge suggests that financial innovations and financial stability in Nigeria might possess endogeneity problems, occasioned by the regulation issued by the CBN for both measures, where all innovative/digital payment transactions must pass through the banking system. Therefore, this study uses DOLS as its empirical model, proposed by Saikkonen (1991) and Stock and Watson (1993). The choice of DOLS was driven by its ability to resolve endogeneity problems and applicability when dealing with cointegrated variables, i.e., non-stationary time series that move together over time (Brooks, 2008). The Unit root test has established a mixture of level and difference stationary series, and therefore, the bound test has testified to the existence of cointegration.

Other attractions of the DOLS lie in its ability to provide more robust and accurate estimates in comparison to simple Ordinary Least Squares (OLS) regression when dealing with long-run relationships between variables (Phillips & Ouliaris, 1990). Additionally, the DOLS corrects for the endogeneity of the regressors and thus makes the estimates more efficient, removes the bias in the coefficients that are caused by serial correlation, and allows for better specification of the model's dynamics.

Following the intuition of the Schumpeterian innovation theory, the specification of the general DOLS model based on Stock and Watson (1993) model is given as:

$$Y_t = \alpha + \beta X_t + \sum_{j=q}^{j=r} \delta \Delta X_{t-j} + \varepsilon_t \ldots\ldots\ldots eqn. 3.2$$

In equation 3.2, Y_t is the dependent variable, X_t is the vector of the predictors, $and\ X_{t-j}$ is the lag of the predictors, where q and r are the lags and leads of the differenced regressors, and thus, adding the lags and leads of the differenced regressors will soak up all the long-run correlation between the error terms. To formulate the above model using the lead and one lag, the equation is transformed as given below:

$$Y_t = \alpha + \beta_1 X_t + \beta_2 \Delta X_t + \beta_3 \Delta X_{t+1} + \beta_4 \Delta X_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots eqn. 3.3$$

The focus of interpretation is the β_1, while the differenced leads and lags $(\beta_2, \beta_3, \beta_4)$ are usually not interpreted, as Stock and Watson (1993) considered the differenced leads and lags as nuisance parameters, and their role is meant to address feedback effects and autocorrelation.

Consequently, the modified DOLS model for this study which specifies the nexus between financial innovation and financial stability is given as:

$$\mathrm{ROA_t} = \alpha + \beta_1 X_t + \beta_2 \Delta X_{t+1} + \beta_3 \Delta X_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots eqn. 3.4$$

In equation 3.4, $\mathrm{ROA_t}$ is the dependent variable in the model and stands for returns on asset, X_t is the vector of all the explanatory variables for the disaggregated measure of financial innovation comprises of ATM, POS, MBP, Web, and NEFT, while ΔX_{t+1} and ΔX_{t-1} are the differenced leads and lags of the explanatory variables. The maximum lag use was 1, chosen following AIC lag selection, and ε_t is the error term.

The second disaggregated model is given as:

$$\mathrm{ROE_t} = \alpha + \beta_1 X_t + \beta_2 \Delta X_{t+1} + \beta_3 \Delta X_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots eqn. 3.5$$

All parameters as previously defined, while $\mathrm{ROE_t}$ is the return on equity.

The paper also provides an additional analysis using aggregated proxies. This is given as:

$$\mathrm{FSS_t} = \alpha + \beta_1 X_t + \beta_2 \Delta X_{t+1} + \beta_3 \Delta X_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots \text{Eqn. 3.6}$$

Where $\mathrm{FSS_t}$ is the Z-score that measures financial stability, X_t is the vector of predictors consisting of payment penetration ratio (PPR) as previously defined, bank size (BKS), growth of money supply (GMS), money market rate (MMR), and inflation (INF). Other parameters were as previously defined.

Before estimating the DOLS, the paper considered two complementary unit root tests using Augmented Dickey Fuller (ADF) and Phillips and Perron (PP) to test for the stationarity of the series. The attraction of these tests was well documented in Dickey and Fuller (1981) and Phillips and Perron (1988). The study also conducts a robustness analysis using ARDL [2] models for the above DOLS models.

4.0. RESULT AND DISCUSSION

4.1. Preliminary Results

The formal analysis began with a pre-test estimation by exploring the data-generating process of the series via descriptive statistics and unit root tests.

4.1.1. Descriptive Statistics

The paper explores the descriptive statistics of the variables employed in the study. In panel 1a of Table 1, the variables described were the bank-based variables as earlier defined in the methodology, while the variables in panel 1b of Table 1 are the robustness variables as previously defined. The descriptive statistics indicate that the variables were not largely deviated from their respective mean values, indicating a low level of variability in the variables. The mean values explain the average of the respective series over the study period and the Jarque-bera is a combined measure of the skewness and kurtosis, measuring the normality of the variables. It appears from the descriptive statistics that except for bank size, inflation, and the growth of money supply, all the remaining variables appear not to be normally distributed. Despite this, the stationary test, which is the formal test for validating the stationarity status of economic indices revealed that all the variables are stationary, thereby, qualifying them for formal analysis and inference.

Table 1: Descriptive Statistics with Raw Data

Panel 1a: Main and Control Variables

	ROA	ROE	ATM	POS	MBP	WEB	NEFT	INF	BKS
Mean	2.06	21.09	10.01	16.84	20.54	21.76	23.80	12.85	30.68
Median	2.25	21.00	6.07	14.79	21.17	9.39	3.63	12.11	30.71
Std. Dev.	0.79	12.05	17.01	35.11	57.65	83.49	39.91	3.62	0.41
Skewness	-1.61	-0.22	2.06	-1.51	-0.30	4.83	1.73	0.46	-0.44
Kurtosis	9.60	11.65	9.19	19.25	11.41	31.22	4.36	2.32	2.60
Jarque-Bera	114.56	159.28	117.53	580.38	151.23	1890.72	29.93	2.78	2.08
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25*	0.35*
Observations	52	52	52	52	52	52	52	52	52

Panel 1a: Main and Control Variables

	ROA	ROE	ATM	POS	MBP	WEB	INF	BKS
Mean	2.06	21.09	10.01	16.84	20.54	21.76	12.85	30.68
Median	2.25	21.00	6.07	14.79	21.17	9.39	12.11	30.71
Std. Dev.	0.79	12.05	17.01	35.11	57.65	83.49	3.62	0.41
Skewness	-1.61	-0.22	2.06	-1.51	-0.30	4.83	0.46	-0.44
Kurtosis	9.60	11.65	9.19	19.25	11.41	31.22	2.32	2.60
Jarque-Bera	114.56	159.28	117.53	580.38	151.23	1890.72	2.78	2.08
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.25*	0.35*
Observations	52	52	52	52	52	52	52	52

[2] The paper does not specify the ARDL model here as the model was only used for robustness and the Unit root result produces a mixed order of integration, which justifies the use of ARDL.

Panel 1b: Additional Variables

	FSS	PPR	GMS	MMR
Mean	1.00	3.16	3.01	11.83
Median	1.08	0.30	2.92	11.53
Std. Dev.	0.37	6.16	3.30	6.04
Skewness	-1.63	1.94	0.01	1.44
Kurtosis	9.52	5.05	2.71	7.97
Jarque-Bera	113.28	40.95	0.17	70.32
Probability	0.00	0.00	0.91*	0.00
Observations	52	52	52	52

Note: * indicates acceptance of the null hypothesis of normality in the series

4.1.2. Unit Root Test

The outcome of the unit root test under two complementary approaches (ADF & PP) with constant in the estimation, constant and trend, and without constant and trend produced a mixed stationarity result, where some of the variables are stationary at levels and others at first difference. The mixed order of the series necessitated the estimation of cointegration using a bound test to establish evidence of cointegration among the non-stationarity series to enable the use of Dynamic Ordinary Least Squares (DOLS), which is often used when dealing with cointegrated variables.

Table 2: Stationary Test of the Variables

Panel A: Augmented Dickey Fuller (ADF)									
	ROA	ROE	ATM	POS	MBP	WEB	NEFT	INF	BKS
With Constant Only									
level	-4.29*	-5.12*	-6.32*	-9.08*	-10.77*	-7.00*	-3.24**	-1.34	-3.49**
1st difference	-4.85*	-9.71*	-13.46*	-12.96*	-5.95*	-8.67*	-8.79*	-4.78*	-4.79*
I(d)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)
With Constant and Trend									
level	-3.74**	-5.13*	-6.33*	-8.99*	-10.66*	-7.16*	-6.75*	-2.37	-5.89*
1st difference	-4.79*	-9.60*	-13.39*	-12.82*	-5.87*	-8.58*	-8.74*	-4.95*	-4.75*
I(d)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)
Without Constant and Trend									
level	-1.27	-2.06**	-2.97*	-7.12*	-9.13*	-6.64*	-2.87*	0.20	5.11
1st difference	-4.90*	-9.81*	-13.60*	-13.09*	-6.03*	-8.77*	-8.89*	-4.79*	-3.88*
I(d)	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)
Panel B: Phillips and Perron (PP)									
With Constant Only									
level	-4.00*	-4.86*	-6.38*	-10.90*	-12.17*	-7.00*	-6.64*	-1.01	-2.67***
1st difference	-24.60*	-26.86*	-22.30*	-61.22*	-80.76*	-33.48*	-20.21*	-4.78*	-4.79*
I(d)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)
With Constant and Trend									
level	-4.00**	-4.87*	-6.40*	-10.75*	-12.02*	-7.17*	-6.92*	-1.87	-5.26*
1st difference	-24.93*	-26.51*	-32.89*	-60.33*	-79.84*	-33.83*	-20.25*	-4.88*	-4.75*
I(d)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)
Without Constant and Trend									
level	-1.34	-2.06**	-5.14*	-7.19*	-8.96*	-6.64*	-6.14*	0.25	3.41
1st difference	-24.40*	-27.27*	-22.41*	-55.98*	-77.55*	-34.67*	-20.46*	-4.79*	-3.88*
I(d)	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

In addition to the main variables of analysis, an additional set of variables was considered in the paper for robustness checks and their stationarity status shows a mixed order of stationarity (combination of level and difference order of integration). This outcome implies the appropriateness of ARDL for robustness checks, which accommodate a mixture of level and difference variables.

Table 3: Unit Root of additional variables used for robustness analysis

Panel A: Augmented Dickey Fuller (ADF)				
	FSS	**PPR**	**GMS**	**MMR**
With Constant Only				
Level	-4.23*	0.81	-6.77*	-3.48**
1st difference	-4.87*	-1.87	-8.33*	-7.50*
I(d)	I(0)	I(2)	I(0)	I(1)
With Constant and Trend				
Level	-3.72**	-0.61	-6.88*	-3.42***
1st difference	-4.81*	-6.27*	-8.23*	-7.45*
I(d)	I(1)	I(1)	I(1)	I(1)
Without Constant and Trend				
Level	-1.23	1.43	-1.10	-1.21
1st difference	-4.92*	-1.62***	-8.42*	-7.56*
I(d)	I(1)	I(1)	I(1)	I(1)
Panel B: Phillips and Perron (PP)				
With Constant Only				
Level	-3.95*	0.90	-6.77*	-3.40*
1st difference	-24.10*	-6.16*	-26.02*	-9.63*
I(d)	I(0)	I(1)	I(0)	I(0)
With Constant and Trend				
Level	-3.95**	-0.49	-6.94*	-3.34
1st difference	-24.56*	-6.51*	-25.07*	-10.59*
I(d)	I(0)	I(1)	I(1)	I(1)
Without Constant and Trend				
Level	-1.25	1.52	-4.01*	-0.85
1st difference	-23.86*	-5.95*	-25.96*	-9.21*
I(d)	I(1)	I(1)	I(0)	I(1)

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

4.2. Main Analysis

Following the pre-estimation analysis, where the variables under consideration pass the basic preliminary tests, in this section, the results of the main analysis were presented and discussed.

4.2.1. Cointegration Analysis of Financial Innovations and Financial Stability

The outcome of the dynamic ordinary least square indicates the existence of a long-run cointegrating relationship between the financial industry's return on assets and innovative financial instruments. Specifically, a negative and significant long-run relationship was observed between return on asset and the value of ATM and NEFT transactions. This implies that an improvement in the holdings of ATM and NEFT values lowers banks' return on assets. This outcome is counterintuitive, however, from the operational point of view, the higher value of transactions in these innovative channels is associated with a higher cost of operation, which may likely negatively impact the returns on assets. The outcome was similar to the case of POS though it was statistically insignificant. However, transactions via mobile money transfer and web payment produce a positive impact on banks' return on assets. The outcome of this paper indicates the possibility of the asymmetric impact of financial innovation on financial stability. Some of the results validate the previous findings of Law *et al.*, (2018) and were consistent with the theoretical underpinning of the study, which suggests that innovation is a double-edged sword capable of enhancing and equally disrupting economic variables. However, when control variables (macroeconomic indicator and bank-level indicator) are considered in the model, the negative and statistically significant impact of one of the financial innovation variables (ATM) remains consistent. Nonetheless, the control variables produced a null effect on the returns on assets but moderated the significant effect of other innovative variables on the model. The model evaluation indicates that the result produces a good fitness of fit and residual diagnostics show that the result is stable and free from serial correlation and heteroskedasticity (Appendix A, B & H).

Table 4: Dynamic Ordinary Least Square Results of Returns on Asset and Financial Innovations

Dependent Variable: Industry's Return on Asset (ROA)				
Variable	**Without Control Variables**		**With Control Variables**	
	Coefficient	Std. Error	Coefficient	Std. Error
C	2.62	0.13	39.15	22.45
ATM	-0.04**	0.01	-0.07**	0.03
POS	-0.01	0.01	0.01	0.02
MBP	0.03*	0.01	0.01	0.01
NEFT	-0.02*	0.01	0.00	0.01
WEB	0.01	0.00	0.01	0.00
INF			0.03	0.06
BKS			-1.23	0.75

Model Evaluation			
Adj. R-Squared	0.9982	R-squared	0.7554
F-stat	723.0650	F-statistic	2.0963
Prob(F-stat)	0.0000	Prob(F-stat)	0.0486
Durbin-Watson stat	2.2777	Durbin-Watson stat 1.8153	

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

The result of the alternative measure of financial stability corroborates the persistent impact of ATMs among innovative financial instruments on financial stability. The result suggests that the value of ATM transactions enhances banks' returns on equity, evidenced by the long-run cointegrating relationship. However, when additional macroeconomic and bank-level indicators are introduced into the model as control variables, they were able to intermediate the impact of the innovation variables on returns on equity. Consequently, in the extended model that captures the influence of bank size and inflation, the outcome indicates that bank size was the leading variable that affects financial stability (measured by returns on equity). The model evaluation and the residual diagnostics indicate that the results were fit, stable, homoscedastic, and serially correlated-free (appendix C, D & I).

Table 5: Dynamic Ordinary Least Square Results of Returns on Equity and Financial Innovations

Dependent Variable: Industry's ROE				
Variable	**Without Control Variables**		**With Control Variables**	
	Coefficient	Std. Error	Coefficient	Std. Error
C	17.17	3.00	12.47	3.56
ATM	0.39**	0.18	-0.20	0.32
POS	-0.12	0.19	0.06	0.24
MBP	0.17	0.14	0.09	0.15
NEFT	-0.14	0.16	0.07	0.16
WEB	0.00	0.05	0.02	0.05
INF			-0.34	0.26
BKS			71.13**	26.58

Model Evaluation

R-squared	0.5232	R-squared	0.7370
Durbin-Watson stat	1.4212	F-statistic	2.0766
F-statistic	1.6169	Prob(F-statistic)	0.0480
		Durbin-Watson stat	1.8378

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

4.3. Robustness Analysis Using Alternative Proxies and Methods

The paper considered an alternative measure of financial innovation and financial stability as earlier stated as well as an alternative method in examining the nexus between financial innovations and financial stability. The payment penetration ratio that measures the deepness of financial innovations produces a negative and significant long-run relationship with financial stability measures by the z-score index. However, bank size produces a positive and significant cointegrating relationship with financial stability, implying that an increase in the size of banks in terms of assets would lead to higher financial stability. This result was consistent with the theoretical underpinning and previous results of Kasri *et al*., (2022). Similarly, inflation as a measure of price stability/economic stability appears to negatively affect financial stability. This outcome implies that heightened inflationary pressure would lower financial stability, given the consequences of inflation in lowering the returns on investment, increases in the cost of funds, and tightening of financial conditions.

The alternative proxy of financial innovation, which is the composite of the various individual innovative financial measures expressed as the ratio of economic activity indicates that the Nigerian financial ecosystem is still growing in innovative space and as time progresses there is a tendency for the payment penetration ratio to produce a significant impact on financial stability. The model evaluation suggested that the model was well fitted, and the residual diagnostics indicate the absence of issues that would invalidate the result such as heteroskedasticity, serial correlation, and stability tests.

Table 6: Nexus between Financial Innovation and Financial Innovation with alternative proxies

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.65	0.18	9.21	0.00
PPR	-0.01	0.00	-1.54	0.18
BKS	0.97	0.30	3.19**	0.02
MMR	0.00	0.00	-1.37	0.22
MSP	0.03	0.05	0.61	0.56
INF	-0.04	0.01	-3.38**	0.01
Model Evaluation				
R-squared	0.990	F-statistic	805.269	
Durbin-Watson stat	1.519	Prob(F-statistic)	0.000	

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

4.3.1. Robustness Analysis with Alternative Method

Using an alternative dynamic model, the paper tests the long-run and short-run nexus between financial innovations and financial stability with both disaggregated and aggregated measures of financial stability and financial innovation. Deducing from the outcome presented in Table 7, the result shows evidence of a long-run relationship between the disaggregated measures of financial innovation and financial stability. This outcome supports the earlier result of dynamic ordinary least squares, and thus, enables the estimation of the long-run and short-run results to understand the dynamics between the variables.

Table 7: ARDL Bound test for return on asset and disaggregated financial innovations

Test Statistic	Value	Hypothesis: No Level relationship		
		Sig. Level	Lower bound	Upper bound
F-statistic	4.39*	10%	2.08	3.00
K	5	5%	2.39	3.38
		1%	3.06	4.15

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

The result in Table 8 suggests that in the short run, ATMs exert a positive impact on returns on assets. However, in the long run, ATMs appear to exert a negative and significant impact on returns on assets. The long-run result shared similitude with the earlier finding using dynamic ordinary least squares. Noticeably, in the short run, the nexus was positive but the direction changes to negative in the long run possibly due to lag effect in the short run. The narrative was similar in the case of web payment. In aggregation, the ARDL result seems to produce a higher significant result for most of the variables than the dynamic ordinary least square. The adjustment parameter indicates that disturbances and frictions will be corrected within a quarter with a 52.7 percent speed of adjustment. The model passes all the post-estimation residual diagnostics (Appendix E &J).

Table 8: Long-Run and Short-Run ARDL Result of ROA Model

Long-Run			**Short-Run**		
Variable	Coefficient	Std. Error	Variable	Coefficient	Std. Error
C	1.309	0.278	ΔATM (-1)	0.023*	0.005
ATM	-0.026*	0.009	ΔMBP	-0.003**	0.001
POS	0.006	0.004	ΔWEB (-1)	0.002*	0.001
MBP	-0.003**	0.005	ECT (-1)	-0.527*	0.088
NEFT	-0.0004	0.005			
WEB	0.002	0.001			

Model Evaluation

R-squared	0.564	Adj. R-squared	0.503	Durbin-Watson stat	1.516

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

The bound test outcome for the return on asset model also indicates the presence of levels relationship between return on asset and disaggregated measure of financial innovations evidenced from the higher level of the test statistic to the lower and upper bound values. Given this finding, the subsequent result in Table 10 presents the long-run and the short-run results.

Table 9: ARDL bound test for return on equity and disaggregated financial innovations.

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Sig. Level	Lower bound	Upper bound
F-statistic	4.85*	10%	2.08	3.00
k	5	5%	2.39	3.38
		1%	3.06	4.15

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

Consistent with the dynamic ordinary least square result and previous empiric (Ashiru *et al.*, 2023), the result shows the presence of long-run and short-run equilibrium relationship between disaggregated financial innovations and financial stability measures. One striking result was the significance of financial innovations indices on return on equity. This implies the importance of innovation in stimulating or mitigating financial stability. Notably, among the financial innovations' variables, ATM stands out as the most consistent variable with significant impact, implying the usage of ATM in the Nigerian financial ecosystem.

The result further pointed out that any friction in financial stability due to financial innovation will be adjusted within a quarter with an average speed of 89.5 percent speed. The postestimation diagnostics in the appendices revealed that the result is reliable and stable for policy.

Table 10: Long-Run and Short-Run ARDL Result of ROE Model

Long-Run			**Short Run**		
Variable	Coefficient	Std. Error	Variable	Coefficient	Std. Error
C	18.005	6.697	ΔATM	-0.233*	0.069
ATM	-0.390**	0.175	ΔPOS (-3)	0.048***	0.025
POS	0.051	0.225	ΔMBP	-0.034**	0.016
MBP	0.016	0.135	ΔNEFT (-3)	0.079**	0.036
NEFT	0.079	0.052	ΔWEB (-2)	-0.032*	0.009
WEB	-0.032**	0.013	ECT (-1)	-0.895*	0.135

Model Evaluation

R-squared	0.939	Adjusted R-squared	0.892
Durbin-Watson stat	1.598556		

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

The aggregated measure of financial stability and financial innovation indicated the presence of a cointegrating equilibrium relationship between financial innovations and financial stability. Hence, the need for the long run and the short run estimation, which is presented in Table 12.

Table 11: ARDL Bound test for aggregated financial stability and financial innovations

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Sig. Level	Lower bound	Upper bound
F-statistic	14.61*	10%	2.08	3.00
k	5	5%	2.39	3.38
		1%	3.06	4.15

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

The aggregated analysis was consistent with the earlier result of the dynamic ordinary least square. The composite measure of financial innovation produces a null impact on financial stability; however, the macroeconomic indicator and the bank-level idiosyncrasies produce a short-run and long-run equilibrium nexus with financial stability.

Table 12: Aggregated Long and Short ARDL result for financial stability and financial innovations

Long Run			**Short Run**		
Variable	Coefficient	Std. Error	Variable	Coefficient	Std. Error
C	2.094671	0.266124	ΔINF (-2)	-0.051**	0.022
PPR	0.005	0.010	ΔGMS	-0.033*	0.007
MMR	-0.007	0.012	ΔBKSR (-1)	1.314*	0.228
INF	-0.034	0.022	ECT (-1)	-0.716*	0.065
GMS	-0.120*	0.042			
BKSR	-2.720*	0.595			

Model Evaluation

R-squared	0.814	Adjusted R-squared	0.770
Durbin-Watson stat	2.294		

Notes: (*) Significant at the 1%; (**) Significant at the 5%; and (***) Significant at the 10%. *MacKinnon (1996) one-sided p-values.

Appendices

Appendix A: Residual Diagnostics for the DOLS model of ROA without control variables

Technique	**F-Stat & JB/ (Prob)**	**Null Hypothesis**	**Decision**
	DOLS (ROA1)		
Serial Correlation	1.977 (0.124)	No serial correlation	Accepted
Heteroscedasticity	0.443 (0.967)	Homoscedascity	Accepted
Normality Test	3.302 (0.232)	Normal distribution	Accepted

Appendix B: Residual Diagnostics for the DOLS model of ROA with control variables

Technique	**F-Stat & JB/ (Prob)**	**Null Hypothesis**	**Decision**
	DOLS (ROA2)		
Serial Correlation	0.129 (0.879)	No serial correlation	Accepted
Heteroscedasticity	0.376 (0.990)	Homoscedascity	Accepted
Normality Test	4.177 (0.123)	Normal distribution	Accepted

Appendix C: Residual Diagnostics for the DOLS model of ROE without control variables

Technique	**F-Stat & JB/ (Prob)**	**Null Hypothesis**	**Decision**
	DOLS (ROE1)		
Serial Correlation	0.261 (0.772)	No serial correlation	Accepted
Heteroscedasticity	1.957 (0.062)	Homoscedascity	Accepted
Normality Test	1.748 (0.417)	Normal distribution	Accepted

Appendix D: Residual Diagnostics for the DOLS model of ROE with control variables

Technique	**F-Stat & JB/ (Prob)**	**Null Hypothesis**	**Decision**
	DOLS (ROE2)		
Serial Correlation	2.978 (0.068)	No serial correlation	Accepted
Heteroscedasticity	1.266 (0.608)	Homoscedascity	Accepted
Normality Test	1.452 (0.483)	Normal distribution	Accepted

Appendix E: Residual Diagnostics for the ARDL model of ROA

Technique	**F-Stat & JB/ (Prob)**	**Null Hypothesis**	**Decision**
	ARDL (ROA)		
Serial Correlation	0.758 (0.475)	No serial correlation	Accepted
Heteroscedasticity	0.967 (0.495)	Homoscedascity	Accepted
Normality Test	1.180 (0.554)	Normal distribution	Accepted

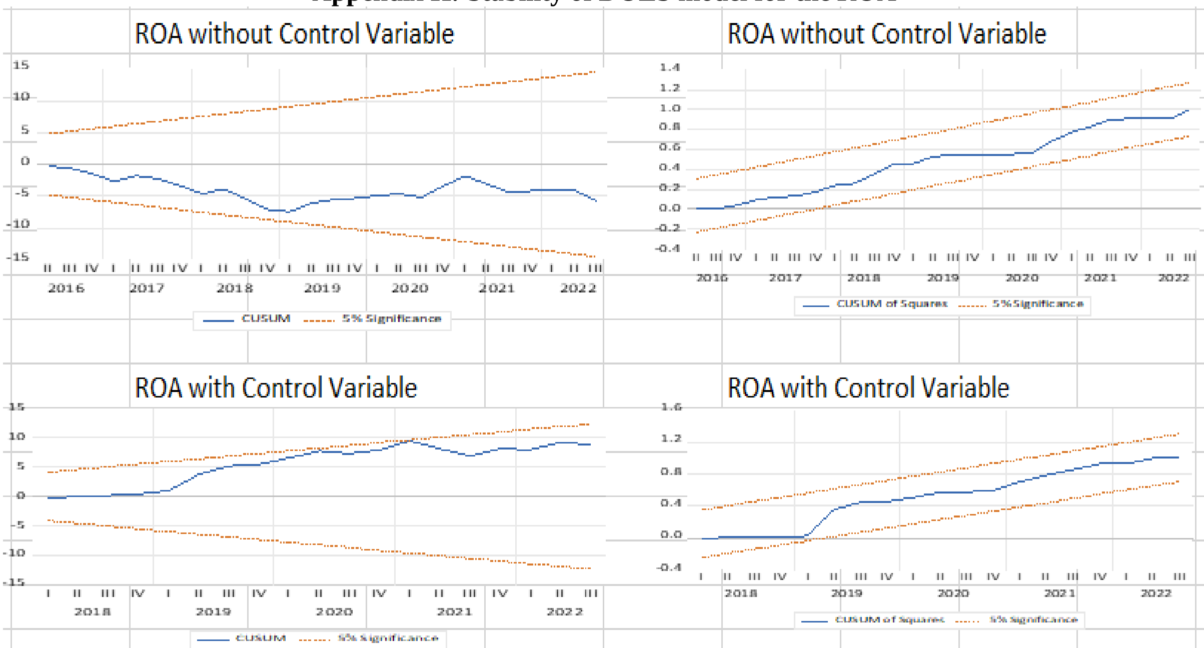
Appendix F: Residual Diagnostics for the ARDL model of ROE

Technique	F-Stat & JB/ (Prob)	Null Hypothesis	Decision
	ARDL (ROE)		
Serial Correlation	0.194 (0.824)	No serial correlation	Accepted
Heteroscedasticity	0.558 (0.860)	Homoscedascity	Accepted
Normality Test	4.091 (0.129)	Normal distribution	Accepted

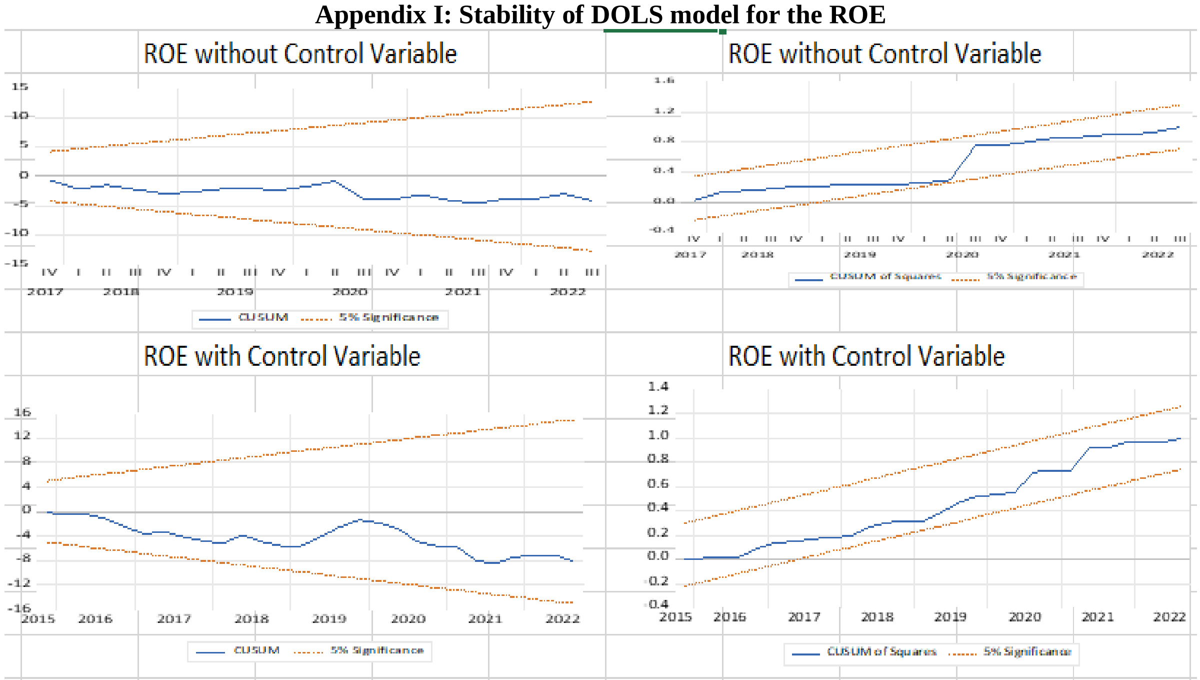
Appendix G: Residual Diagnostics for the ARDL model of FSS

Technique	F-Stat & JB/ (Prob)	Null Hypothesis	Decision
	DOLS (FSS)		
Serial Correlation	2.342 (0.113)	No serial correlation	Accepted
Heteroscedasticity	1.459 (0.179)	Homoscedascity	Accepted
Normality Test	1.142 (0.564)	Normal distribution	Accepted

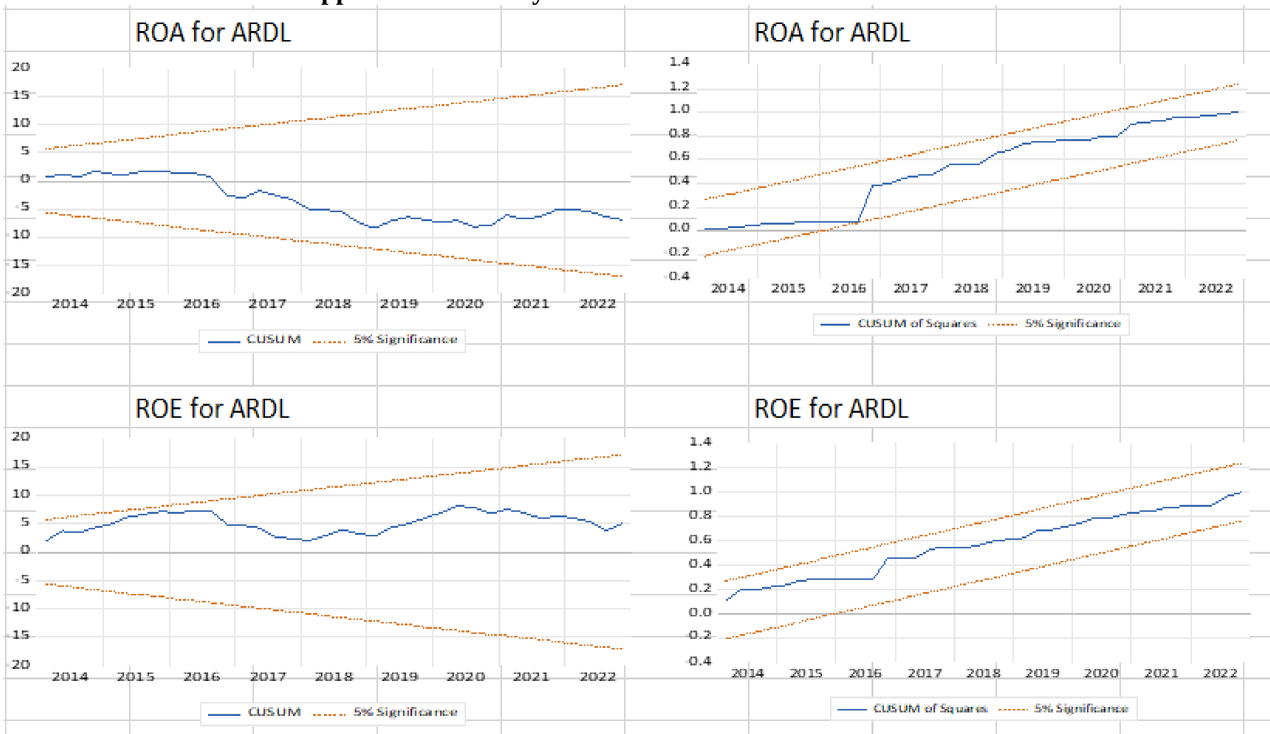
Appendix H: Stability of DOLS model for the ROA



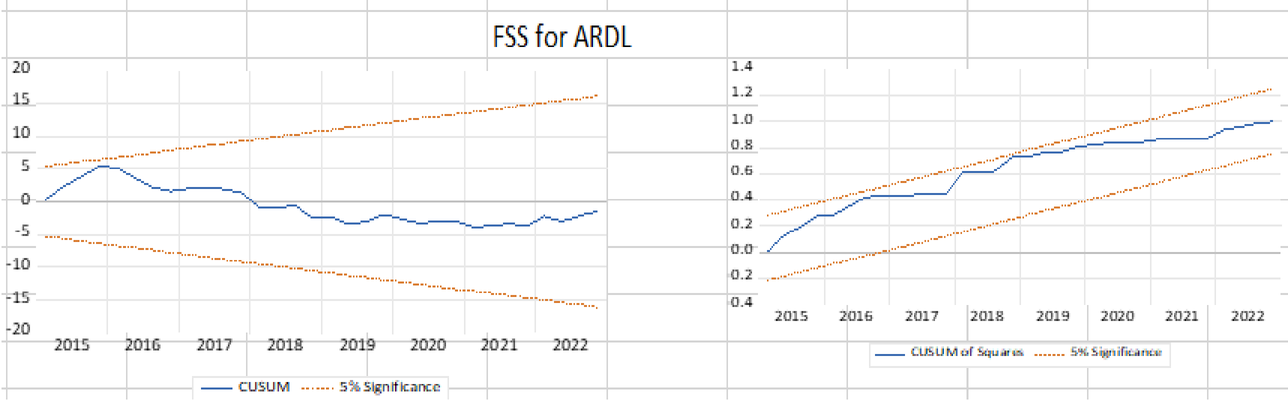
Appendix I: Stability of DOLS model for the ROE



Appendix J: Stability of ARDL model for the ROA & ROE



Appendix K: Stability of ARDL model for the FSS



5. CONCLUSION AND RECOMMENDATIONS

This study examines the dynamic nexus between financial innovation and financial stability using disaggregated and aggregated indices of financial innovation and financial stability. Employing the Dynamic Ordinary Least Squares model, the study evaluates the dynamic relationship between distinct electronic payment channels, considered as disaggregated measures of financial innovation and returns on asset, and returns on equity, considered as disaggregated measures of financial stability. The study further conducts a robustness analysis of the dynamic relationship using ARDL and composite measures of financial innovation and financial stability surrogated by payment penetration ratio and Z-score index of financial stability.

The result of the specific proxies of financial innovation shows a mixed impact of financial innovation on financial stability. The outcome shows that ATM and NEFT lower returns on assets, implying that higher value of ATM and NEFT transactions which in a way implies higher withdrawal from the banks and an increase in the liability on the financial institution perspective reduces the institution's return on asset. However, ATM was found to enhance returns on equity, which implies higher investment in financial innovation increases the shareholder's equities. The composite measure of financial innovation appears to exert a null impact on financial stability, while bank size fosters higher returns on equity and stability. On the contrary, growth in money supply and inflation tends to lower financial stability, implying that inflation erodes the value of investment.

The implications of the finding attest to the relevance of innovation in stimulating or mitigating stability. Therefore, the paper uppers the following recommendations:

i. The Central Bank of Nigeria is encouraged to incentivize the use of financially innovative channels toward enhancing the stability of the Nigerian financial system.
ii. Banks should intensify the deployment of appropriate electronic payment channels aimed at maximizing returns on investment.
iii. The Central Bank of Nigeria should sustain the regulatory framework of financially innovative channels aimed at safeguarding customers from its unsavory effect.
iv. The apex bank is encouraged to develop a standard metric for financial innovation and financial stability.

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