Nonlinear Effects of Bank Size on Capital Adequacy: Evidence from Nigerian Deposit Money Banks

Simeon Oamen Obode and Benneth Kiyentei Gini
Department of Economics,
University of Port Harcourt, Rivers State, Nigeria
simeon.obode1@gmail.com and noblegini@gmail.com
https://doi.org/10.56201/jafm.vol.12.no9.2026.p41.58

Abstract
This study examines the nonlinear effects of bank size on the capital adequacy of Nigerian deposit money banks from 2008 to 2024. Panel Threshold Regression was used to determine whether a threshold relationship exists and to identify the critical level of bank size at which the effect on capital adequacy changes. In addition, the System Generalized Method of Moments (System GMM) estimator was adopted to account for the dynamic nature of capital adequacy and potential endogeneity among the independent variables. The threshold regression revealed a bank-size threshold of 18.80, separating the banks into two separate regimes. Below the threshold, bank size had a positive significant effect on capital adequacy, while above the threshold; the effect was positive but declined to a coefficient of 0.0088. This shows that although bank expansion contributes positively to capital adequacy, its marginal contribution declines as banks become larger. The System GMM results further showed that capital adequacy is highly persistent over time, with lagged capital adequacy ratio having a positive significant effect. The study concludes that bank size has a nonlinear effect on capital adequacy, with the positive effect of bank size declining as banks become larger. The study therefore recommends that Nigerian deposit money banks should pursue growth while maintaining adequate capital positions and effective risk management.

Keywords: *Bank Size; Capital Adequacy; Panel Threshold Regression; System GMM; Deposit Money Banks; Nigeria.*

1.1: Introduction

A well-capitalized banking system is significant to a country's financial stability and economic growth. Capital adequacy shows the ability and resilience of a bank to absorb unforeseen losses that may occur from credit, operational and market risks. Monetary authorities view capital as a necessary buffer to absorb possible losses before such losses are charged against deposits. Capital adequacy is the ability of banks to maintain some level of capital relative to risk-weighted assets under the Basel regulatory framework (Kang et al., 2024; Iskender et al., 2026). Deposit money banks (DMBs) need to maintain sufficient capital to absorb shocks and continue to meet their obligations (Hirtle and Plosser 2025). Capital is important for the protection of bank depositors and for the maintenance of public confidence in the operations of the bank. The capital of a bank includes the common equity, retained earnings, other disclosed reserves used to absorb financial losses and for other banking operations.

The capital adequacy ratio (CAR) is often used to measure the financial strength and solvency of banks. The ratio shows whether the shareholders' funds are adequate in relation to the risk exposure of banks. According to Berger and Bouwman (2013), higher capitalization enhances banks' ability to absorb financial shocks, while insufficient capital often causes banks to face insolvency risk and financial instability. The Basel committee on banking supervision (BCBS) usually recommends minimum capital requirements for banks in order to ensure stability within the financial system. In Nigeria, the minimum capital adequacy ratio as required by CBN for DMBs with regional and national authorization is 10%, while those with international authorization are to maintain 15% (CBN, 2024).

Factors that affect capital adequacy include profitability, asset quality, non-performing loan ratio, management efficiency, liquidity and bank size. In spite of the factors affecting bank capital, the amount of capital maintained by DMBs must be adequate and comply with the statutory requirements of the Central Bank of Nigeria (CBN). The relationship between capital adequacy and other business factors often affects the general performance of banks (Berger, 1995; Athanasoglou et al., 2008). However, bank size remains one of the major factors affecting capital adequacy level among banks. Bank size is the total assets owned by a bank which shows its market value and strength of its operations (Sufian and Habibullah 2009).

As stated by Nguyen and Nguyen (2020), the size of a firm including DMBs has been the critical determinant of capital structure decisions because large banks usually have strong capital positions to absorb financial risks. Due to the strong capital position of large DMBs, they easily have better access to financial markets and maintain high efficiency in their operations. As their size increases, they often earn more profits that can easily boost their capital position. Unlike small banks with restricted access to funding sources, larger banks usually enjoy easier access to external finance and minimal operational costs due to economies of scale (Mensi & Zouari 2010; Tan 2016). However, the relationship between bank size and capitalization may sometimes be negative. Excessive growth in bank size may lead to inefficiency in operations and poor credit risk decisions that often lead to a high level of non-performing loans (NPLs). As banks increase in size, they often face issues of corporate governance and a high level of NPLs that may have negative effects on their capital position and profitability.

The CBN has implemented a series of structural reforms in the banking sector targeted at strengthening DMBs' capital positions and ensuring financial stability. As a result of the banking crisis of 2004, the CBN introduced a consolidation exercise where the minimum capital requirement for DMBs was increased from N2 billion to N25 billion. This policy reduced the number of DMBs in the country from 89 to 25 with stronger capital positions (CBN statistical bulletin, 2005). In recent years, the Nigerian banking sector has witnessed growth in terms of total assets and branch networks. However, macroeconomic shocks such as the economic recession of 2016, the COVID-19 pandemic and the exchange rate reforms of 2023 have negative effects on the banks' capital adequacy and profitability. The Nigerian banking sector has also experienced increasing risk due to depreciation of the exchange rate, increasing inflation, rising operating costs and declining asset quality. Some banks with large asset bases have recorded increases in non-performing loans which have negative effects on their capital adequacy ratio.

In order to address the effects of macroeconomic shocks on Nigerian banks, the CBN introduced new recapitalization policies in 2024 designed to strengthen the financial capacity of DMBs in the country. The minimum paid-up capital for banks with international authorization such as: Access Bank, First Bank of Nigeria, GTbank Plc, United Bank for Africa and Zenith Bank was

increased to N500 billion, while that for banks with national authorization including Fidelity Bank, Sterling Bank, Union Bank of Nigeria and FCMB was increased to N200 billion. Regional banks such as Providus Bank Plc, Parallex Bank Ltd, Signature Bank Ltd and Optimus Bank Ltd were asked to maintain a minimum capital base of N50 billion (CBN statistical bulletin, 2025). The aim of these reforms is to ensure the stability of the Nigerian financial system and to enhance the ability of DMBs to absorb losses. Even with these regulatory measures and recapitalization efforts, empirical findings on the relationship between bank size and capital adequacy remain inconclusive, while some studies show a positive relationship (see Obeid 2023; Abdurrahman & Susy 2021; Fransiska & Siswanti 2024), others state that excessive expansion may have negative effects on banks' capital positions (see Akinuli et al. 2024; Md Shah Naoaj 2023; Aza 2024).

Other studies on capital adequacy assume that the relationship between bank size and capital adequacy is linear (Adesola 2025; Naoaj 2023). Such studies believe that increases or decreases in bank size may have the same effects on capital adequacy without considering the possibility that the relationship may change beyond a certain threshold level. The effect of bank size on capital adequacy may not be the same across all levels of bank operations. For instance, small increases in bank size may initially increase capital adequacy through economies of scale and improved access to funding, but increases beyond a certain threshold may have negative effects on their capital adequacy. This shows that the relationship between bank size and capital adequacy may sometimes be nonlinear, and overlooking such nonlinearities may lead to inappropriate policy recommendations on recapitalization and banking sector reforms.

The specific objectives of the study are to: (i) examine whether bank size has nonlinear effects on capital adequacy. (ii) identify the critical threshold level beyond which increases in bank size begin to have significant negative effects on banks' capital positions. The study adopts a nonlinear regression to examine possible changes in the relationship between bank size and capital adequacy across different levels of selected DMBs in Nigeria. The findings of the study are expected to provide useful policy suggestions for banking sector regulation, recapitalization policies and financial system stability in Nigeria.

2.1: Conceptual Framework

2.2: Capital Adequacy Ratio

Mehrotra et al. (2023) described the capital adequacy ratio as the minimum regulatory capital requirement that deposit money banks (DMBs) must maintain to absorb unforeseen losses and reduce the risk of financial distress. The capital adequacy ratio measures the proportion amount of capital a bank holds in relation to its risk-weighted assets such as loans and advances. Adequacy capital is essential for banks' stability because it influences banks' ability to absorb unanticipated losses. Capital adequacy ratio measures the solvency of a bank, that is, it shows whether a bank has sufficient capital to absorb unexpected losses that may occur from lending, marketing and operational activities. The capital fund of a bank is considered adequate if it is enough to cover the bank's operational expenses, satisfy customers' financial needs and protect depositors against total or partial loss of deposits in the event of liquidation or financial distress (Kishore 2022). Bank capital acts as a financial cushion against unexpected losses. It reduces the possibility of bank failure and protects depositors and creditors during both normal operations and liquidation. According to Rose and Hudgins (2013), adequate capital is important for a bank to meet its business requirements, ensure safe operations, retain public confidence, and acquire the necessary infrastructure for sound banking operations.

Banks with a high capital adequacy ratio can continue to operate during periods of financial distress because they possess sufficient capital to absorb potential credit losses and other unforeseen financial shocks. On the other hand, banks with poor capital adequacy ratio may be exposed to financial shocks and the possibility of bank failure. Among the Nigerian DMBs with international authorization, GTBank Plc recorded the highest capital adequacy ratio (CAR) of 43.8% as at December 2025, which was considerably above the CBN minimum regulatory requirement of 15%. During the same period, Zenith Bank Plc, United Bank for Africa Plc, Access Bank Plc and First Bank of Nigeria Plc recorded capital adequacy ratios of 25%, 23.2%, 21% and 10.95% respectively (see individual banks' audited financial reports of 2025). First Bank of Nigeria (FBN) recorded a capital adequacy ratio of 10.95% as at December 2025, which was below the minimum regulatory requirement of 15% for DMBs with international authorization. The decline was ascribed to increased regulatory risk reserves and provisioning related to oil and gas sector exposures. However, the bank's CAR increased to 13.0 % in the first quarter of 2026, due to strong earnings performance during the period (FBN Q1 2026 financial report). These differences in CAR among DMBs with international authorization show that bank-specific characteristics such as bank size often play an important role in influencing DMBs' capital adequacy ratio.

Vonga and Trigueiros (2025) and Akinuli et al. (2024) noted that some of the operational and bank-specific factors that affect banks' capital adequacy ratios include liquidity position, asset quality, bank size, risk variables and profitability. Changes in these factors often affect the capital positions of banks. Banks with high asset quality and strong liquidity and profitability are more likely to maintain stronger capital positions. On the contrary, Abusharbeh (2025) noted that banks with high levels of non-performing loans/poor asset quality and low levels of liquidity and profitability may be exposed to financial shocks due to poor capital positions. Most empirical studies (see Md Shah Naoaj 2023; Berger 1995; Aza 2024; Senan et al. 2022 and Tran 2024) assume a linear relationship between capital adequacy ratio and its determinants. However, Pan and Wang (2023) and Novotná et al. (2024) found that the relationship may be nonlinear or asymmetric. For instance, a moderate increase in bank size may have little or no effect on capital adequacy because of improvements in operational efficiency. However, additional increase beyond a certain threshold, increase in non-performing loans, and reduction in profitability may reduce capital adequacy.

2.3: Bank Size and Capital Adequacy Ratio

Bank size is commonly used to evaluate economies and diseconomies of scale in the banking industry. The size of a bank is measured by the natural logarithm of total assets. The total assets of a bank consist mainly of loans and advances, cash and cash equivalents, investment securities, and other financial resources (Rose & Hudgins, 2021). Bank size plays an important role in predicting profitability when economies of scale are considered. Large banks can easily access the financial markets to raise additional capital for operations. Large banks often benefit from economies of scale and diversified sources of income. They also possess stronger risk management systems, which enhance their operational efficiency and competitiveness (Berger & Mester, 1997; Tran, 2024). Unlike small banks, larger banks also tend to have easy access to external funding and are often regarded by investors and depositors as more financially stable. According to several empirical studies (see Lucky & Tamunoiduabia 2022; Danisman & Tarazi 2024; Ullah et al. 2024), the size of a bank has a significant impact on its financial stability.

Isayas (2022) noted that while having many branches can attract more deposits, the cost of operating them can hurt financial performance if economies of scale are not properly utilized.
The combined total assets of the five largest Nigerian deposit money banks with international authorization increased to ₦161.3 trillion as at 31 December 2025. Access Bank increased its total assets by 24.2% from N41.50 trillion in 2024 to N52.57 trillion in 2025, driven by growth across the group's businesses in Nigeria, Africa and the rest of the world. During the same period, the total assets of United Bank for Africa Plc, Zenith Bank Plc, First Bank of Nigeria Plc, and GTBank Plc increased to ₦33.20 trillion, ₦31.46 trillion, ₦26.25 trillion, and ₦17.80 trillion respectively (See the audited annual reports of the respective banks, 2025; The Nation, 8 May 2026). However, studies such as Zhang et al. (2023) found that continuous growth in bank size may expose banks to high credit, market, operational, and liquidity risks. As banks increase their lending activities, there is a tendency for their risk-weighted assets to increase faster than their regulatory capital. If banks are unable to raise additional capital to support their expanding risk exposure, their capital adequacy may be negatively affected. Therefore, the impact of bank size on capital adequacy may not always be positive (Mehrotra et al., 2023). Several empirical studies, including Vonga & Trigueiros (2025), Usman (2022), and Aza (2024) have examined the link between bank size and capital adequacy using conventional linear econometric models. These studies assumed that changes in bank size produce proportional/equal changes in capital adequacy. However, in reality, the relationship between bank size and capital adequacy may vary across different levels of bank growth. Jadesola et al. (2025) noted that moderate increases in bank size may enhance capital adequacy through increases in operational efficiency, profitability and economies of scale. On the contrary, additional increases in the bank size beyond a certain threshold may cause risk-weighted assets to increase more rapidly than regulatory capital, therefore reducing capital adequacy ratios.

2.4: Theoretical Literature

2.5: Buffer Theory of Capital Adequacy

This study is anchored on the Buffer Theory of Capital Adequacy proposed by Calem and Rob (1996). The theory posits that banks maintain capital buffers above the minimum regulatory requirement to reduce the possibility of regulatory intervention and avoid the costs which may occur from breaching statutory capital requirements. According to the theory, banks maintain capital positions above the regulatory minimum capital requirements in order to reduce costs and risks of regulatory infractions. Milne and Whalley (2002) extended the theory by developing a dynamic model showing that banks continuously increase their capital positions as a result of changes in risk exposure and regulatory requirements. The theory predicts that capital buffers serve as a protective measure that enables banks to absorb unforeseen losses while maintaining stability in their operations. The core assumption of the Buffer Theory is that capital is one of the core determinants of financial risks that banks can absorb in their operations. Adequate capital positions enable banks to diversify their portfolios in order to mitigate risks and ensure stability (Aroghene & Ikeora, 2022). A low level of capital increases the risk of bank failure while adequate capital positions often lead to improved financing activities that have a positive impact on banks' profitability. Recent empirical findings also support the assumptions of the Buffer Theory. For instance, Nguyen (2024) examined the relationship between capital buffers and bank risk-taking and found a U-shaped nonlinear relationship between the two variables. The study revealed that higher capital buffers initially reduced banks' risk-taking. However, beyond a certain level, additional capital led to greater risk-taking. This finding suggests that the

relationship between capital and banking behavior may not be linear. The Buffer Theory is relevant to this study because as banks experience changes in their size, regulatory requirements and market expectations, they may choose to hold capital above the statutory minimum requirement.

2.6: Empirical Review

Several studies have examined the relationship between Bank size and capital adequacy of commercial banks across the globe. Ibrahim et al. (2026) examined the financial stability of commercial banks in Kenya and Ethiopia within the East African financial markets. The study data were obtained from twelve commercial banks between 2018 and 2022. The findings showed that banks in both countries maintained high capital positions. The results also confirmed that Kenyan banks recorded higher capital positions than their Ethiopian counterparts. The paper concludes and recommends that stronger capitalization enhances banking sector financial stability and monetary authorities should continue to monitor banks 'capital adequacy.

In South Africa, Msomi and Aliamutu (2026) investigated the bank-specific and macroeconomic factors affecting capital adequacy in commercial banks. The analysis covered eleven commercial banks. The empirical analysis was done using the Generalized Method of Moments from 2008 to 2019. The variables included in the paper were capital adequacy ratio, bank size, return on assets, broad money supply, monetary policy rate and leverage ratio. The findings indicated that profitability and broad money supply were the major determinants of the capital adequacy ratio, while large bank size and increased leverage levels negatively affected capital adequacy. The study highlights the need for banks to maintain adequate capital positions to enhance the stability of the banking sector especially in South Africa.

In the United States, Correia et al. (2025) carried out a historical panel study of commercial banks spanning the period from 1863 to 2024 using panel econometric techniques. The study found that weak capital positions and poor asset quality may lead to bank failure. The paper concludes that strong capitalization is one of the most important determinants of banking sector resilience. The authors recommend that banks should continue to strengthen their capital positions while maintaining prudent growth in total assets.

Across G7 countries, Kishibayeva et al. (2023) assessed the determinants of bank capital adequacy using panel data from 1999 to 2017. The paper employed the Dynamic Ordinary Least Squares panel regression technique. The findings suggest that bank capital, bank stability and real output growth have positive significant effects on capital adequacy, while return on assets adversely affected capital adequacy. The study concluded that both bank-specific and macroeconomic factors are the main determinants of capital adequacy. The study stressed the need for monetary authorities to carefully examine the costs and benefits of adjusting minimum capital requirements in order to maintain banking sector stability.

Onuabi and Obieche (2025) evaluated the effects of macroeconomic variables on capital adequacy in Nigeria from 2015 to 2024, using panel data from commercial banks. The study adopted the Panel Ordinary Least Squares (OLS) technique. The authors obtained the study data from financial statements of the commercial banks and Central Bank of Nigeria statistical bulletin. Capital adequacy ratio was modeled as the function of interest rate, real gross domestic product, inflation rate and exchange rate. The results showed that interest rate and exchange rate have positive significant effects on banks' capital adequacy. Inflation negatively affected capital adequacy, while economic growth improved banks' capital positions. Based on the findings, the study concludes that macroeconomic variables are important determinants of commercial banks'

capital adequacy in Nigeria. The paper recommends that the monetary authorities should maintain macroeconomic stability to enhance adequate bank capitalization.

On the contrary, Yaaba and Sanusi (2024) explored the impact of capital adequacy requirements on bank behavior in Nigeria from 2007 to 2018. The study employed a system of simultaneous equations, using the Generalized Method of Moments (GMM) approach on bank-level annual data in Nigeria from 2007 to 2018. The findings showed that high capital adequacy requirements have significant effects on banks' lending behavior and risk-taking decisions. The study concludes that there is a strong need for regulatory authorities to often monitor banks' risk appetite, especially during periods of economic boom to avoid excessive risk that could have negative effects on their capital positions. The paper recommends effective monitoring of capital adequacy requirements to enhance banking sector stability in Nigeria.

In another Nigerian paper, Akinuli et al. (2024) analyzed the impact of bank-specific factors on capital adequacy in the banking sector from 2012 to 2022. Panel data from thirteen selected commercial banks were analyzed using the fixed effects and random effects regression models. The independent variables included in the model were return on assets, return on equity, asset quality, liquidity ratio, bank size and non-performing loans, while the dependent variable was the capital adequacy ratio. The paper found that asset quality and return on equity adversely affected the capital adequacy of Nigerian commercial banks during the study period. On the contrary, bank liquidity, bank size, non-performing loans and return on assets positively affected bank capital adequacy in Nigeria. The paper concludes that bank-specific factors, especially bank size and profitability are important determinants of the capital adequacy of Nigerian commercial banks. The authors recommend that the monetary authority should continue to enforce capital adequacy requirements.

In Ghana, Apau and Sibindi (2023) examined the impact of bank-level factors on the profitability of banks under changing economic conditions, using the dynamic panel system Generalized Method of Moments technique for panel data collected from eighteen universal banks between 2007 and 2021. The results showed that lagged return on assets, capital adequacy ratio, and deposit-to-total-assets ratio have positive significant effects on bank profitability, while lagged return on equity, bank size, expenditure, and asset quality negatively affected profitability. The results further revealed a negative relationship between economic growth and bank profitability. The authors recommend that banks should strengthen their capital positions while maintaining prudent asset quality and liquidity management. This study highlights the importance of bank-specific factors in determining banking sector profitability.

In Bangladesh, Md Shah Naoaj (2023) assessed the determinants of capital adequacy in commercial banks using panel data from twenty-eight banks over the period from 2013 to 2019. The paper adopted the Pooled Ordinary Least Square method in its empirical analysis. The findings showed that bank size has a negative significant effect on capital adequacy. Profitability, liquidity risk, and GDP have positive significant effects on capital adequacy, while inflation negatively affected capital adequacy. The study concluded that bank size does not always enhance capital adequacy, especially where asset growth exceeds capital accumulation. The paper highlighted the need for banks to sustain asset growth while maintaining adequate capital positions.

Finally, Wagdi et al. (2022) evaluated commercial banks' behavior before and after stress tests across nine African countries between 2009 and 2020 using panel data analysis. The results showed that banks with strong capital adequacy positions were better able to withstand financial stress and maintained more stable lending behavior, while banks with poor capital positions were

more vulnerable to macroeconomic shocks. The study concluded that adequate capitalization is essential for banking sector stability. The study underscores the need for monetary authorities to always conduct regular stress testing on commercial banks to strengthen banking sector stability. Summarily, the empirical review has examined the relationship between bank size, capital adequacy, and other banking variables across different countries. A common finding from the reviewed studies is that adequate capital positions are essential for maintaining banking sector stability. Several econometric methods such as Pooled Ordinary Least Squares (OLS), Ordinary Least Squares (OLS), Fixed Effects, Random Effects and the Dynamic Ordinary Least Squares have been used to explore the link between capital adequacy, bank size and other banking variables. However, to further the analysis, this paper adopts the Panel Threshold Regression and System GMM estimator to identify the existence of any bank size threshold and to account for the persistence of capital adequacy and potential endogeneity. The findings are expected to provide empirical evidence for the formulation of effective bank recapitalization policies aimed at enhancing banking sector stability in the country.

3.1: Method of study

Following Akinuli et al. (2024) and Msomi and Aliamutu (2026) this study set out an econometric framework within which bank size affect capital adequacy ratio. To this end, we proceed to write the relation as**:**

CAR = f (BS, ROA, NPLR, LR) (3.1)

In equation (3.1), Capital Adequacy Ratio (CAR) is the dependent variable, while the independent variables include Bank Size (BS), Return on Asset (ROA), Non-Performing Loan Ratio (NPLR) and liquidity ratio (LR)

3.2: Model Specification

The functional relationship among the variables is specified in linear form as follows:

$CAR_t = a_0 + a_1 BS_t + a_2 ROA_t + a_3 NPLR_t + a_4 LR_t + e_{1t}$ (3.2)

Where: CAR= Capital Adequacy Ratio, BS= Bank Size, ROA= Return on Asset, NPLR= Non-Performing Loan Ratio, LR=Liquidity Ratio, a_0= Constant terms; a_1-a_4 = Coefficients of the independent variables: e_{1t} = Random error terms.

3.3: Definition of variables in the model:

1: Capital Adequacy Ratio (CAR)

The capital adequacy ratio measures the proportion amount of capital a bank holds in relation to its risk-weighted assets such as loans and advances. It shows the level to which a bank's regulatory capital can absorb potential losses that may occur from its risk-bearing assets. Banks with a high capital adequacy ratio possess sufficient capital to absorb unexpected credit losses and other unforeseen financial shocks. On the contrary, banks with low capital adequacy ratio may be exposed to financial distress and possible liquidation. In this study, capital adequacy ratio is the dependent variable because its behavior is explained by changes in bank size and other control variables.

The capital adequacy ratio is calculated as: $\text{CAR} = \frac{\text{Total Regulatory Capital}}{\text{Risk–Weighted Assets}} * 100$

Where: CAR = Capital Adequacy Ratio Total Regulatory Capital = Tier 1 Capital + Tier 2 Capital Risk-Weighted Assets = Total assets adjusted for their respective risk weights.

2: Bank Size (BS)

The size of a bank is measured by the natural logarithm of total assets. The total assets of a bank include loans and advances, cash and cash equivalents, investment securities, and other financial resources. Bank size plays a vital role in predicting profitability when economies of scale are considered. Unlike small banks, larger banks often have easy access to external funding and financial markets to raise additional capital for operations. However, undue expansion may increase risk-weighted assets and reduce capital adequacy if additional capital is not raised. In this study, bank size is the main independent variable used to examine whether its impact on capital adequacy is nonlinear.

Bank size is measured as: BS=ln(Total Assets)

Where: BS = Bank Size ln = Natural logarithm

Total Assets = Total value of loans, investments, cash, fixed assets, and other assets owned by the bank.

3: Non-Performing Loan Ratio (NPLR)

The non-performing loan ratio measures the percentage of total loans that have not been repaid for a period of ninety days and above in line with regulatory guidelines. It shows the quality of a bank's loan collections and its level of credit risk. Banks with high non-performing loan ratios are usually required to increase provisions for loan losses, which may have negative effect on their profitability and capital adequacy. In this study, the non-performing loan ratio acts as a control variable because asset quality directly affects banks' capital positions.

The non-performing loan ratio is calculated as: $\text{NPLR} = \frac{\text{Non-Performing Loans}}{\text{Total Gross Loans}} * 100$

Where: NPLR = Non-performing loan ratio Non-Performing Loans = Loans unpaid for ninety days or more Total Gross Loans = Total outstanding loans before provisions.

4: Profitability (ROA)

Profitability refers to the ability of a bank to generate income from its total assets. It is commonly measured using Return on Assets, which shows how efficiently a business (bank) utilizes its assets to generate profits. Banks that are profitable are better able to retain earnings and increase their capital base, which usually enhances their capital adequacy. In this study, profitability is included as a control variable because it may influence banks' capital positions independently of bank size.

Return on Assets is calculated as: $\text{ROA} = \frac{\text{Net Profit After Tax}}{\text{Total Assets}} * 100$

Where: ROA = Return on Assets Net Profit after Tax = Profit remaining after taxes Total Assets = Total assets of the bank.

5: Liquidity Ratio (LR)

Banks require sufficient liquidity to meet their day-to-day operational commitments, including customers' withdrawal requests, interbank settlement obligations, and other short-term financial commitments as they occur. The liquidity ratio is used to measure the ability of a bank to meet these day-to-day operational activities. The a priori expectation is that banks with sufficient liquidity are better positioned to cope with short-term financial crises and maintain stable operations.. In this study, the liquidity ratio is included as a control variable because liquidity conditions may influence capital adequacy independently of bank size.

The liquidity ratio is calculated as: $\text{LR} = \frac{\text{Liquid Assets}}{\text{Short-Term Liabilities}} * 100$

Where: LR = Liquidity ratio Liquid Assets = Cash, cash equivalents, treasury bills, balances with the central bank, and other highly liquid securities Short-Term liabilities = Customers' deposits and other current financial obligations.

3.4: Method and Techniques of Data Analysis

The Panel Threshold Regression (PTR) model developed by Hansen (1999) was used in the study to assess whether the effect of bank size on capital adequacy changes once bank size exceeds an estimated threshold. Also, the Dynamic System Generalized Method of Moments (System GMM) estimator developed by Blundell and Bond (1998) was used to address the potential endogeneity of the explanatory variables and the dynamic persistence of the capital adequacy ratio. The Panel Threshold Regression (PTR) and the Dynamic System Generalized Method of Moments (System GMM) estimator for this study are specified as follows:

Panel Threshold Regression (PTR) Model (Hansen, 1999)

$CAR_{it} = \mu_i + \beta_1 BS_{it}\ I(BS_{it} \leq \gamma) + \beta_2 BS_{it}\ I(BS_{it} > \gamma) + \beta_3 ROA_{it} + \beta_4 NPLR_{it} + \beta_5 LR_{it} + \epsilon_{1t}$

Where: CAR = Capital Adequacy Ratio BS = Bank Size (Threshold variable) γ = Estimated threshold value I (.)= Indicator function ROA = Return on Assets NPLR = Non-performing Loan Ratio LR = Liquidity Ratio μ_i = Bank-specific fixed effects ϵ_{1t}= Error term

Dynamic System GMM Model (Blundell & Bond, 1998)

$CAR_{it} = \alpha + pCAR_{t-i} + \beta_1 BS_{it} + \beta_2 BS^2{}_{it} + \beta_3 ROA_{it} + \beta_4 NPLR_{it} + \beta_5 LR_{it} + \mu_i + \epsilon_{1t}$

Where: CAR_{t-i} = Lagged capital adequacy ratio BS^2= Squared bank size to capture nonlinearity μ_i = Unobserved bank-specific effects ϵ_{1t} = Error term

4.1: Results and Discussion

4.2: Panel Unit Root Tests

The study utilized the Im-Pesaran-Shin and Levin Lin and Chu (LLC) panel unit root tests to examine the stationarity element of the variables. The results of the various stationary tests are displayed in Table 4.1.

Table 4.1: Unit root test results (Im-Pesaran-Shin and Levin, Lin and Chu)

	Im-Pesaran-Shin		**Levin-Lin-Chu**		
Variables	Level P -Value	First Difference P -Value	Level P Value	First Difference P -Value	Integration Order
CAR	----	0.000	-----	0.000	I(1)
Bank Size	0.999	0.000	0.993	0.000	I(1)
LR	0.000	0.100	0.000	0.100	I(0)
ROA	----	0.000	-----	0.000	I(1)
NPLR	0.000	----	0.000	----	I(0)

Source: Researcher's Computation Using Stata

The stationarity tests displayed in Table 4.1 were carried out using both the Im-Pesaran-Shin and Levin Lin and Chu unit root tests. The panel unit-root results show a mixed order of integration among the variables. CAR, BS and ROA are mostly integrated of order one, I(1), while LR and NPLR are stationary at level, I(0). The results therefore indicate that the variables are a mixture

of I(0) and I(1) processes. This mixed order of integration supports the use of estimation techniques that can cater for dynamic nature and potential endogeneity of the panel data, especially the System GMM estimator.

4.3 Panel Cointegration Test

In order to examine whether a long run relationship exist among the variables, we used the Westerlund and Pedroni tests for cointegration. The Pedroni cointegration test is a robust test that has two main dimensions of within and between dimensions. And these two dimensions present three test statistics of null hypothesis of no cointegration. To make inference, the null hypothesis is rejected if the p-value is equal to or less than 5% significance level. The cointegration test result for this study is presented in Table 4.2.

Table 4.2: Westerlund and Pedroni Residual Cointegration Tests

Tests	Statistic	P-value
Modified Phillips–Perron Test	3.9182	0.0000
Phillips–Perron test	-10.6468	0.0000
Augmented Dickey–Fuller Test	-5.6263	0.0000
Westerlund Test	-0.4524	0.3255

Source: Researcher's Computation Using Stata

The Pedroni panel cointegration tests show strong proof of a long-run equilibrium relationship among the variables, with the Modified Phillips-Perron, Phillips-Perron and ADF statistics all statistically significant at the 5% level. However, the Westerlund test fails to reject the null hypothesis of no cointegration ($p = 0.354$). While the Westerlund result shows no evidence of cointegration, the three Pedroni statistics indicate the existence of a long-run equilibrium relationship among the variables.

4.4: Estimation of the Panel Threshold Regression Model

The results of the panel threshold regression, as proposed by Hansen (1999), which examines whether the impact of the explanatory variables on the dependent variables changes once key variables exceed certain threshold levels is shown in Tables 4.3.

Table 4.3: Panel Threshold Regression Results

Regimes	Variable	Bank-size regime	Coefficient	P-value	Interpretation
Low Regime	BANK SIZE	BS ≤ 18.80	0.02708	0.000	Positive significant
High Regime	BANK SIZE	BS > 18.80	0.00876	0.028	Positive significant
	NPLR		0.14719	0.253	Not significant
	Liq. Ratio		0.00461	0.417	Not significant
	ROA		1.21968	0.000	Positive significant
Bank Size Threshold	18.8				
Model diagnostics					

Number of regimes	2				
F-statistic	12.63	p = 0.000			
R- Square	0.2697				

Source: Researcher's Computation Using Stata

Summary of Key Findings:
Table 4.3 presents the panel threshold regression results. It shows the effect of bank size on capital adequacy across different bank-size regimes. The estimated threshold point of bank size is 18.80. Below this point, bank size has a positive significant effect on capital adequacy ($\beta = 0.0271$, $p < 0.01$), while above the threshold, the effect is positive but decreases significantly ($\beta = 0.0088$, $p < 0.05$). The results suggest that the contribution of bank size to capital adequacy reduces as banks become larger. For instance, a one-unit increase in bank size is associated with a 3%-point increase in CAR for banks below the threshold, compared with a 0.88% point increase for banks above the threshold. The results therefore suggest a nonlinear regime-dependent relationship between bank size and capital adequacy.

4.5: Estimation of the System Generalized Method of Moments
The results of the System Generalized Method of Moments developed by Blundell and Bond (1998), which addresses the potential endogeneity of the explanatory variables and the dynamic persistence of the capital adequacy ratio is displayed in Table 4.4.

Table 4.4: Panel System GMM Regression Results

Variable	**Coefficient**	**P-value**	**Decision**
L.CAR	0.82698	0	Significant
BS	-0.00163	0.633	Not significant
ROA	0.20224	0.673	Not significant
NPLR	0.01564	0.904	Not significant
LR	0.0062	0.074	Significant at 10%
Model diagnostics			
Arellano-Bond test for AR(1)	P-value=0.032		
Arellano-Bond test for AR(2)	P-value=0.126		
Hansen test	P-value=0.684		
Wald $\chi^2 = 4220.56$	P-value=0.000		

Source: Researcher's Computation Using Stata

Summary of Key Findings:
Table 4.4 presents the findings of the system GMM results. It shows that capital adequacy of Nigerian deposit money banks is highly persistent over time. The coefficient of lagged capital adequacy ratio (L.CAR) is positive and statistically significant; it shows that previous capital positions have strong influence on current capital adequacy levels. This confirms the dynamic nature of bank capital decisions. The AR(2) and Hansen tests confirm the validity of the model and instruments, supporting the reliability of the System GMM estimates.

5.1: Discussion of Findings

The core objectives of this study were to examine whether bank size has nonlinear effects on capital adequacy and to identify the critical threshold level beyond which the positive effect of bank size on capital adequacy begins to decline. The findings show that bank size has a nonlinear relationship with capital adequacy among Nigerian deposit money banks. The threshold regression identifies a bank-size threshold of 18.80. Below this threshold, bank size has a positive significant effect on capital adequacy ratio ($\beta = 0.0271$, $p < 0.01$), while above the threshold, the effect was positive but declined to a coefficient of 0.0088 ($p < 0.05$). This shows that the contribution of bank size to capital adequacy reduces as banks become larger. The threshold finding suggests that larger bank size does not necessarily lead to higher capital adequacy. At lower levels of bank size, expansion may improve banks' ability to generate earnings, diversify risks and increase their capital position. However, if they exceed the estimated threshold of 18.80, further expansion may produce smaller improvements in capital adequacy. This may be linked with higher risk exposure and high capital requirements that go with the expansion of large banking institutions. While Sanyaolu et al. (2020) found a negative relationship between bank size and capital adequacy among Nigerian banks, the present study finds that bank size has a positive effect on capital adequacy in both regimes, although the magnitude of the effect declines beyond the threshold of 18.80.

The differences in the findings may partly due to the different study periods and estimation techniques. Also, the conventional linear approach adopted by Sanyaolu et al. (2020) assumes that the effect of bank size is constant across all levels of bank size, while the present study allows the effect to vary across different size regimes

The System GMM results further show that capital adequacy is highly persistent over time. The coefficient of lagged CAR is positive and highly significant ($\beta = 0.827$, $p < 0.01$). It shows that previous capital adequacy has strong influence on current capital adequacy. This means that banks tend to adjust their capital positions gradually rather than making immediate and substantial changes. The result is consistent with the dynamic nature of bank capital management, where banks consider their existing capital position when making current capital decisions. The present finding is however consistent with recent findings including Adekalu et al, (2025) who found that bank size can positively influence capital adequacy among Nigerian banks**.** This supports the argument that larger banks may benefit from economies of scale, income diversification and easier access to capital markets, which can boost their capital positions. An important contribution of the present study is that the positive effect does not remain constant as banks become larger**.** The estimated threshold of 18.80 shows that the effect of bank size declines from 0.0271 below the threshold to 0.0088 above the threshold. Therefore, while the result supports the argument that larger banks can have stronger capital positions, it also shows that the gains of expansion diminish beyond a certain level. This provides a possible explanation for the mixed findings in previous studies, as studies using linear models may fail to capture differences in the effect of bank size across different size levels.

5.2: Conclusion

This study examined the nonlinear effect of bank size on capital adequacy of deposit money banks in Nigeria using a panel threshold regression and System GMM approaches. The panel threshold regression revealed a nonlinear relationship, with a bank-size threshold of 18.80. Bank size has positive influence on capital adequacy below and above the threshold, but its effect declines as banks become larger. The estimated threshold of 18.80 shows that bank expansion

should not be regarded as an unlimited means of strengthening capital adequacy. Beyond this level, additional increases in bank size produce smaller improvements in capital adequacy. The System GMM results further show that capital adequacy is highly persistent, with previous capital position having a significant influence on current capital levels. The results suggest that bank expansion improves capital strength, but the benefits decline beyond a certain size level. Banks should therefore pursue growth strategies while maintaining adequate capital buffers and effective risk management practices.

5.3: Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. Given that the positive effect of bank size on capital adequacy declines beyond the threshold of 18.80, banks should avoid excessive expansion that may reduce the marginal benefit of size on capital strength.
2. The Central Bank of Nigeria should continue to monitor large banks and ensure that they maintain adequate capital position to address the risks associated with excessive growth.
3. Given the strong persistence of CAR, banks should focus on long-term capital planning and retained earnings that boost stable capital positions.
4. Large banks should enhance credit risk monitoring and operational controls to prevent growth-related risks from having an adverse effect on capital adequacy.

References

Abdurrahman Setiawan, & Susy Muchtar. (2021). Factor Affecting The Capital Adequacy Ratio Of Banks Listed In Indonesia Stock Exchange. Jurnal Ekonomi, 26(1), 153–169.

Abusharbeh, M. (2025). Determinants of bank capital adequacy: Empirical insights from Arab countries. Banks and Bank Systems, 20(1), 221–230.

Access Bank Plc (2026). Annual Report and Accounts 2025

Adekalu, J. R., Adebesi, J. F., Mbatuegwu, D. C., & Adekalu, S. O. (2025). Moderating effect of bank size on the relationship between monetary policy and capital adequacy of listed deposit money banks in Nigeria. ANUK College of Private Sector Accounting Journal, 2(4), 336–349

Adesola, Adebisi, Christopher, & Adekalu. (2025). Monetary Policy, bank size, and capital adequacy: a conceptual framework for financial stability in Nigeria. ANUK College of Private Sector Accounting Journal, *2*(4), 301-311

Akinuli, B. O., Adedayo, O. C., Olu O, Olawale C.A.; Clement C. Olkemi E.; Remi E and Bankole O.A. (2024). Impact of bank-specific factors on capital adequacy in the Nigerian banking sector: An empirical analysis. *I*OSR Journal of Economics and Finance, 15(5), 1–8.

Apau, R., & Sibindi, A. B. (2023). Bank-level determinants of profitability under changing economic conditions: Evidence from Ghana. Cogent Economics & Finance, 11(1).

Aroghene, K. G., & Ikeora, J. J. E. (2022). Effect of non-performing loans (npls), capital adequacy (ca) and corporate governance (cg) on bank stability in Nigeria. Finance & Accounting Research Journal, 4(4), 180-192.

Athanasoglou, P. P.,Brissimis, S. N., & Delis, M. D. (2008). Bank-specific, industry-specific and macroeconomic determinants of bank profitability. Journal of International Financial Markets, Institutions and Money, 18(2), 121–136

Aza, I. E. (2024). Determinants of capital adequacy of deposit money banks listed on the Nigeria Stock Exchange. International Journal of Banking and Finance Research, 10(7), 1–16.

Berger, A. N. (1995). The relationship between capital and earnings in banking. Journal of Money, Credit and Banking, 27(2), 432–456.

Berger, A. N., & Bouwman, C. H. S. (2013). How does capital affect bank performance during financial crises? Journal of Financial Economics, 109*(*1), 146–176.

Berger, A. N., & Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions? Journal of Banking & Finance*, 21*(7), 895–947

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics, 87*(*1), 115-143.

Calem, P. S., & Rob, R.(1996). The impact of capital-based regulation on bank risk-taking: A dynamic model. Board of Governors of the Federal Reserve System, Finance and Economics Discussion Series (FEDS) 1996-12.

CBN statistical bulletin, 2005 & 2025

Central Bank of Nigeria. (2024). Economic Report: Fourth Quarter 2024. Abuja: Central Bank of Nigeria.

Correia, S., Luck, S., & Verner, E. (2025). Failing banks. arXiv. https://arxiv.org/abs/2506.06082

Danisman, G. O., & Tarazi, A. (2024). Economic policy uncertainty and bank stability: Size, capital, and liquidity matter. The Quarterly Review of Economics and Finance*, 93*, 102–118.

FBN Holdings (2026). Annual Report and Accounts 2025

FBN Q1 annual reports of 2026.

Fransiska, V., & Siswanti, I. (2024). Determinants of capital adequacy ratio: Empirical study of banks listed on the Indonesian Stock Exchange for the period 2017–2022. International Journal of Economics, Accounting and Management, *1*(3), 146–158.

Guaranty Trust Holding Company Plc (2026). Annual Report and Accounts 2025

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. Journal of Econometrics, 93(2), 345-368.

Hirtle, B., & Plosser, M. (2025). Bank economic capital (FRB of New York Staff Report No. 1144). Federal Reserve Bank of New York

Ibrahim, A. M., Öcal, H., & Yilmaz, T. (2026). Financial stability analysis of commercial banks in East African financial markets: The cases of Kenya and Ethiopia. JOEEP: Journal of Emerging Economies and Policy, 11(1), 23-29.

Isayas, Yonas Nigussie (2022) : Determinants of banks' profitability: Empirical evidence from banks in Ethiopia, Cogent Economics & Finance, ISSN 2332-2039, Taylor & Francis, Abingdon, Vol. 10, Iss. 1, pp. 1-15,

Iskender, E. S., Seal, K., & Carvalho, A. (2026). Prudential capital requirements for banks: Buffers and the Pillar 2 capital assessment. International Monetary Fund Technical Notes and Manuals, 2026(002)

Jadesola, R. A., Adebisi, J. F., Christopher, M. D., & Adekalu, S. O. (2025). Moderating effect of bank size on the relationship between monetary policy and capital adequacy of listed deposit money banks in Nigeria. ANUK College of Private Sector Accounting Journal, 2(4), 336–349.

Kang, X., Huang, X., Wu, Y., & Liu, Z. (2024). Measurement of risk-weighted assets of commercial banks under the new Basel accord and capital management approach. Advances in Economics, Management and Political Sciences, *92*, 336–356

Kishibayeva, B., Jaxybekova, G., Nurgalieva, G., Wada, I., & Faizulayev, A. (2023). Determinants of bank capital adequacy: International evidence from G7 countries**.** International Social Science Journal, 73(249–250), 737–752.

Kishore, K. (2022). Interrelationship of deposits and borrowings with capital adequacy ratio empirical analysis of Indian banks. Journal of Information and Optimization Sciences, 43(7), 1623–1634.

Lucky, A. L., & Tamunoiduabia, I.F, (2022). Prudential stress test of capital adequacy of quoted commercial banks in Nigeria: A panel data approach: IIARD International Journal of Banking and Finance, 8 (4), 48 –66

Md Shah Naoaj (2023). Exploring the determinants of capital adequacy in commercial banks: A study of Bangladesh's banking sector. arXiv. https://arxiv.org/abs/2304.05935

Mehrotra, P., Vyas, V., & Naik, P. K. (2023). Behaviour of capital and risk under Basel regulations: A simultaneous equations model study of Indian commercial banks. Global Business Review. https://doi.org/10.1177/09721509221146059

Mensi, S., & Zouari, A. (2010). Efficient structure versus market power: Theories and empirical evidence. International Journal of Economics and Finance, *2*(4), 151–166.

Milne, A., & Whalley, A. E. (2001). Bank capital regulation and incentives for risk-taking. Cass Business School Working Paper.

Msomi T. S. and Aliamutu K. F. (2026). Determinants of capital adequacy of commercial banks in South Africa: A panel and dynamic approach. International Journal of Business Ecosystem & Strategy (2687-2293), 7(6), 390-398

Nguyen, T. H. (2024). Capital buffer and bank risk-taking: The moderating role of capital regulation and shadow banking. Journal of International Financial Markets, Institutions and Money, 90, 101915.

Nguyen, H.T. and Nguyen, A.H. (2020) The Impact of Capital Structure on Firm Performance: Evidence from Vietnam. The Journal of Asian Finance, Economics and Business, 7, 97-105.

Novotná, A., Štiblárová, Ľ., & Kočišová, K. (2024). The bank capitalization and the nonlinear concentration–stability nexus in the Euro Area: The PSTR approach. Ekonomický časopis/Journal of Economics, 72(5–6), 235–260

Obeid, R. (2023). Determinants of capital adequacy ratio in the banking sector: Evidence from the Arab region. International Journal of Business and Management, 18*(5),* 63–71.

Onuabi, E. J., & Obieche, P. N. (2025). Macroeconomic variables and quoted commercial banks' capital adequacy ratio in Nigeria. International Journal of Economics and Financial Management, 10**(**2).

Pan, H., & Wang, C. (2023). Threshold effects of bank capital, liquidity, and profitability on bank risk. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4410230

Rose, P. S., & Hudgins, S. C. (2013). Bank management and financial services *(*9th ed.). McGraw-Hill Education.

Rose, P. S., & Hudgins, S. C. (2021). Bank management and financial services (10th ed.). McGraw-Hill Education.

Sanyaolu, W. A., Alao, A. A., & Yunusa, L. A. (2020**).** Determinants of capital adequacy of Nigerian banks. Market Forces Research Journal, 15*(1).*

Senan, N. A. M., Belhaj, F. A., Al-Matari, E. M., Al-Faryan, M. A. S., & Al-Homaidi, E. A. (2022). Capital adequacy determinants of Indian banks listed on the Bombay Stock Exchange. Investment Management and Financial Innovations, 19(2), 167–179.

Sufian, F., & Habibullah, M. S. (2009). Bank specific and macroeconomic determinants of bank profitability: Empirical evidence from the China banking sector. Frontiers of Economics in China, 4(2), 274–291.

Tan, Y. (2016). The impacts of risk and competition on bank profitability in China. Journal of International Financial Markets, Institutions and Money, 40, 85–110.

The Nation News Paper 8th May, 2026

Tran, T. N. (2024). Exploring influencing factors on capital adequacy in commercial banks. Emerging Science Journal, 8(2). https://doi.org/10.28991/ESJ-2024-08-02-010

Ullah, S., Ullah, A., & Zaman, M. (2024). Nexus of governance, macroeconomic conditions, and financial stability of banks: A comparison of developed and emerging countries. Financial Innovation, 10, Article 30.

United Bank for Africa PlC (2026). Annual Report and Accounts 2025

Usman, A. (2022**).** Determinants of capital adequacy in listed deposit money banks in Nigeria. UMYU Journal of Accounting and Finance Research, 2(2), 29–53

Vonga, A. P. I., & Trigueiros, D. (2025). Improved methods for identifying the operational determinants of a bank's capital ratio. Applied Economics, 57(33), 5001–5014.

Wagdi, O., Ahmed, N. S., & Yassin, M. (2022). Stress tests, bank behaviour and capital adequacy: Evidence from Africa. Review of Economics and Finance, 20, 1336–1345.

Yaaba, B. N., & Sanusi, L. G. (2024). Capital adequacy requirement and bank behaviour in Nigeria. Bullion, Central Bank of Nigeria.

Zenith Bank Plc (2026). Annual Report and Accounts 2025

Zhang, Y., Gu, H., & Xiong, F. (2023). Does bank branch expansion increase bank risk taking? Intermediary channels of loan-deposit spread. Applied Economics Letters, Taylor & Francis Journals, vol. 32(4), pages 487-490