Prudential Stress Test of Capital Adequacy of Quoted Commercial Banks in Nigeria: A Panel Data Approach

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Abstract
This study used prudential variables to stress test commercial banks capital adequacy in Nigeria. Cross sectional data were sourced from annual reports of commercial banks and Central Bank of Nigeria Statistical Bulletin from 2011-2020. Tier 1 and Tier 2 capital to risk weight was modeled as the function of assets quality, liquidity earnings, management quality, risk, exchange rate, gross domestic product, inflation rate monetary policy rate and money supply. Panel data methodology was employed while the fixed effects model was used as estimation technique at 5% level of significance. Fixed effects, random effects and pooled estimates were tested while the Hausman test was used to determine the best fit. Panel unit roots and panel cointegration analysis were conducted on the study. The model result proved that assets quality have negative and no significant effect on capital adequacy, liquidity have positive and no significant effect on capital adequacy, earnings and risk have negative and significant effect, management quality have positive and significant effect on capital adequacy while risk have negative and no significant effect on capital adequacy of the quoted commercial banks. Furthermore, the finding of the study established that commercial banks capital respond positively to exchange rate volatility, gross domestic product monetary policy rate but respond negatively to inflation rate and money supply over the periods covered in this study. The stress test results proved that commercial banks capital adequacy respond both positively and negatively to the prudential variables. We recommend that credit officers should undertake a proper loan appraisal and follow-up, careful loan screening procedure and timely disbursement of approved loans to minimize defaults. Credit administrators should take a lot of precautions in reducing credit risks by demanding for appropriate collateral security before granting loan, and ensuring effective loan supervision and monitoring by credit officer and the regulatory authorities should intensify effective and continuous monitoring of commercial banks onsite and offsite to ensure strict compliance to regulations.

Keywords: *Prudential Stress Test, Capital Adequacy, Quoted Commercial Banks, Nigeria, Panel Data Approach*

INTRODUCTION

Stress testing is an important tool in developing a complete picture of commercial banks capital adequacy. Basel III introduced in 2008 after the global financial crisis requires banks to be more stringent by refining capital structure and built mechanism for risk management such as liquidity coverage ratio, net stable finding ratio to manage liquidity risk and suggest an additional non risk based leverage ratio as a security measure against any capital requirement deficiencies (Dell'Ariccia& Marquez, 2004). It incorporate the lessons learned from the global financial crises which results in liquidity and credit crouch. This includes capital conservation buffer, countercyclical capital buffer, leverage ratio cover, liquidity cover ratio and risk weighted assets. Increase in Tier I and Tier II capital makes banks to be capitally adequate and able to withstand shocks in the operating environment.

Stress tests are major post-crisis innovations in supervision. The stress tests help prevent a repeat of the financial crisis by requiring banks to hold enough capital to continue to lend a hypothetical severe macroeconomic recession and to demonstrate strong risk management practices for capital planning. But stress tests are only one of the several reforms that are working in that direction which includes increases in capital requirements, new rules requiring banks to hold ample liquidity, and derivative market reforms (Stankova, 2014). One of the stress tests includes Macro prudential tools. Applying countercyclical Macro prudential tools to build up capital buffers in good times can be run down during bad times. To improve timing, authorities need to develop a comprehensive framework to monitor Macro prudential conditions and establish appropriate warning and trigger thresholds. Macro-prudential stress tests are strongly complementary to micro-prudential stress tests, because they allow regulators to assess the resilience of the financial system as a whole or a larger subset of it rather than that of individual financial institutions.

Adequately designed and properly implemented stress tests generate valuable information on a bank's capital adequacy profile that cannot be generated from a limited set of standardized capital adequacy metrics. In a stress test, shorter and longer horizons can be explored to assess whether a bank's outcomes are sensitive to this issue. Bank stress management in Nigeria is sensitive to total credit to both internal and external operating environment. Capital adequacy stress testing requires financial institutions to weigh the countercyclical capital buffer of the institution exposures under stressed scenarios against the available counterbalancing capacity (Rodriguez, Trucharte and Marcelo, 2018).Capital adequacy is assessed under stressed conditions against a variety of capital ratios including regulatory capital ratios, as well as ratios based on the bank's internal definition of capital resources. Stress testing constitute a central tool in identifying, measuring and controlling capital and liquidity risks, in particular for assessing the resiliency of the bank's liquidity profile and the adequacy of its liquidity buffers in case of both bank-specific and market-wide stress events. There are many studies on the factors that determine commercial banks capital adequacy and the effect of bank capital adequacy on performance. The study stress tested the prudential variables and the respond of commercial capital adequacy for the post global financial crisis.

LITERATURE REVIEW

Stress Testing

Financial institutions are at the heart of any financial stability analysis and form a key component of prudential stress tests. In most models they are represented by balance sheets filled out with a collection of financial contracts that are unique to that institution. Moreover, each institution comes with its own set of constraints and behavioral rules (Yuliya, Romanyuk, Castrén and Zaher, 2010). By endowing an institution with its unique collection of financial contracts, combination of constraints, and behavioral rules, various types of heterogeneous financial institutions such as banks, insurance companies, hedge funds, unlevered funds, and central clearing parties can be characterized.

Stress testing is used as a tool to alert bank management to adverse unexpected outcomes related to a variety of risks and provides an indication of how much capital might be needed to absorb losses should severe, yet plausible shocks occur. The Central Bank of Nigeria proposed that banks should operate stress testing framework that promotes comprehensive risk identification and control, provides a heightened risk perspective to other risk management actions, contribute to the formulation and pursuit of strategic and policy objectives and improve the overall quality of capital management (Orobah and Anwarul, 2020).

The current prudential stress tests have three related strengths. First, they provide insights into the interlinkages between financial institutions, mapping out how financial shocks transmit through individual balance sheets and affect other institutions. The data-driven methodology to establish the model setupprovides a promising avenue for future stress tests, but also for further data-driven research into the structure of the financial system (Aikman et al., 2009). Second, they capture the interactions between various financial institutions and contagion channels that can drive distress, and therefore capture the feedback effects that characterize the complex nature of the financial system. Financial Vulnerabilities makes an important contribution by including heterogeneous financial institutions, which is key to allow for emergent phenomena (Bookstaber, 2017). Third, in addition to capturing solvency risk, or separately investigating solvency and liquidity risk, the current prudential stress tests capture funding liquidity risk and the interactions between solvency and liquidity.Macro stress tests enable economies to assess how the financial sector as a whole responds to significant shocks such as interest rate and exchange rate movements (Lee, Gaspar, and Villaruel, 2017). Through Macro tests, interventions by regulators are drafted and implemented. However, it remains that these tests are posted on crisis interventions.

Stress tests are a rough estimation of a portfolio transformation due to changes in risk factors (Stankova, 2014). Stress testing is an approach to gauge the impact of a large shock on financial soundness and market functioning. Stress testing has the potential to support prudential policy in the design, calibration, and assessment of the impact of Macro prudential tools (Constancio, 2017). Regular stress testing should provide a more reliable and accurate assessment of the possible impact of adverse shocks in the form of extreme movements in variables liable to affect the economic setting and the main determinants of the stability, and therefore the soundness of the financial system. To address excessive credit growth and leverage, the countercyclical capital

buffer may be used to measure resilience in banks and to contribute to curbing excessive credit growth. The loan-to-value and loan-to-income cap may be used to measure the resilience of borrowers and banks to mitigate pro-cyclicality mortgage credit (Lee, Gaspar, and Villaruel, 2017). Increased level of capital and the higher capital buffers brought by the post-crisis regulatory reform, which makes banks safer, more resilient, put banks in a better position to lend more (Basset and Berrospide, 2018).

The progressive implementation of stress tests as a toll complementing traditional supervisory practices is making them increasingly valuable to financial authorities in monitoring and safeguarding the stability of the economic environment. The increasing use of stress tests highlights the need to establish basic principles and guidelines providing for a systematic approach to them that are rigorous and straightforward (Rodriguez, Trucharte, and Marcelo, 2018). The possible deficits of stress tests may be seen when it selects stress scenarios in a way that might leave many dangerous scenarios and thus create an illusion of safety, which might consider highly implausible scenarios and thus trigger a false alarm. Stress tests should include tools to analyze systemic risk arising from the interaction of banks with each other and with the markets (Breuer & Summer, 2018). Disclosure of stress-test results facilitates the coordination of risk decisions among banks by providing information about the likelihood of a bailout. The results may make risk decisions in the banking industry more extreme (Corona, Nan, and Zhang, 2019).

Theoretical Review

Portfolio Management Theory

According to Pyle (1971) arid Hart and Jaffee (1974) a bank's assets and liabilities nay a]] he viewed as securities As a result of this interpretation, the whole hank may actually he considered as a portfolio of securities. Once that view is postulated, it is possible to apply the portfolio theory developed in the 50's and 60's to the asset-liability management of a bank. The following simple in model, adapted From Freixas and Rochet (1997) illustrates the main ideas.

Assume for simplicity that there is only one risky financial security (which may he interpreted as loans), and one risk-free security (the liquid asset), with returns rL and r, respectively. Starting with initial wealth E + D) (equity and deposits, taken as all exogenously given amount here), the hank manager determines the amounts xL, to invest in the risky security, the rest being invested in the risk-free, liquid asset. A positive amount is interpreted as being on the asset side of the balance sheet, and a negative amount on the liability side. Assuming for simplicity that the interest rate on deposits is zero, the random payoff is equal to

$$\pi = r(E + D) + (rL - r)xL \quad (1)$$

The bank manager is risk averse, and assumed to have mean-variance preferences: $U(E(\pi), \text{var}\ (\pi))$ with U increasing in the expected profit, and decreasing in the variable. Given these premises, the following result obtains: if the expected returns are ordered in the following way, rL> r>0 then xL, >0

When it comes to the anion not invested in liquid assets, E + D - xL, the most important determinant is risk, i.e., both the level of risk aversion, and the riskiness of the returns on loans.

First, F + 1) is increasing in the degree of risk aversion of the ii an age r (for low degrees of risk aversion, it may he negative). Hence, banks with relatively more liquid assets should be more risk averse. Furthermore, for a given function U, and for given excess retnms (Pr, — r) , the amount invested in liquid assets is increasing in varfr) , keeping !f constant. An empirical implication is that, when the volatility of interest rates increases, banks should decrease the am on ii t of loans, and iii crease the holdings of liquid assets.

Another important implication of this theory is that, if deposits and equity are also interpreted as securities (if F and I) are endogenized), then the size of the bank is indeterminate. This follows simply from the fact that in that case, ally multiple of the portfolio which is optional for a given level of equity and deposits, is also optional. As a result, size should be more doing variable, and the proportion of liquid assets to total assets should be independent of size.

Buffer Theory of Capital Adequacy

The objective of ensuring that bank capital is adequate is to withstand and absorb monetary and macro-economic shocks which bank operation is very sensitive. However, banks may prefer to hold a buffer of excess capital to reduce the profitability of falling under the legal capital requirements, especially if their capital adequacy ratio is very volatile (Ikpefan, 2013). Capital adequacy has in recent time gone beyond that of banking supervision instrument and become a monetary policy tool of achieving financial stability. Section 7 (2) of BOFIA states that any banks that fail to comply with the capital adequacy within such period as may be determined by the CBN shall be a ground for revocation of license. Section 13 states that bank shall maintain at all times capital funds unimpaired by losses in such ratio to all or any assets or to all or nay liabilities or both such assets and liabilities of the bank and all its offices in and outside Nigeria as may be specified by CBN. The revocation of some banks license in 2005 after the consolidation and recapitalization reforms were reference to these section (Akani and Lucky, 2015). The buffer theory of Calem and Rob (1996) predicts that a bank approaching the regulatory minimum capital ratio may have an incentive to boost capital and reduce risk in order to avoid the regulatory costs triggered by a breach of the capital requirement. The collapse of some Nigerian Banks has been traced to high risk taking couple with poor capitalization.

Empirical Review

Leesi (2021) developed a stress test framework that facilitates the analysis of the direct effects of monetary policy shocks on the asset quality of Nigeria commercial banks and feedback effects of assets quality on monetary policy variables using causality test. The framework ensures consistency in the key relationships between monetary policy variables and asset quality. This is accomplished by embedding a standard stress-testing framework based on aggregate commercial banks' data in a semi-structural monetary policy model. The framework has numerous applications that can strengthen stress testing and macro financial analysis. The paper found that asset quality respond strongly to volatility of prime lending rate and monetary policy but weak respond to volatility of Treasury bill rate, reserve requirement and maximum lending rate. The paper recommends that commercial bank managers formulate policies that will managed the volatility of the variables.

Farayibi(2016) examined stress testing in the Nigerian banking sector from 2004-2014 using error correctionmechanism (ECM) and Ordinary Least Square (OLS) methodologies. The study adopted the bottom-upapproach to stress management. Evidence from the analysis showed that stress testing is important tobuilding a strong and viable financial system in the country. Bank's going concern depends on profitability,solvency and liquidity whereas banks performance index depends on the behaviours of macroeconomicvariables. The study found that Nigerian banking system is susceptible to various risks both within andoutside the country. They are also exposed to macroeconomic risks as their performance index is based onthese variables. The study concluded that how banks respond to risks determines the going concern and theviability of the nation's financial system. Thus, a thorough credit risk management framework championedby the major stakeholders involved in the credit disbursement was recommended

Orobahand Anwarul(2020) examined the literature on financial stability implication of stress testing for risk-taking and credit growth in banks. Macro prudential considered one of the most stress testing tools by Applying countercyclical Macro prudential tools to build up capital buffers in good times that can be run down during bad times. But to improve timing, monitories authorities may need to develop a comprehensive framework to monitor Macro prudential conditions and establish appropriate warning and trigger thresholds. Regarding scope, they examine the entire financial system. This entity contributes to fire sales whose default has follow-on effects, or which can exacerbate a credit crunch that is included. Liability Considerations contain a Scale of wholesale funding that is run-prone is paramount. Capital adequacy depends on the health of the overall financial system. For asset Considerations, the test indicates whether the financial system is vulnerable to deleveraging that might amplify adverse shocks, at the end authorities' development guidance about whether to close a bank and when to sell its assets to maximize taxpayer recovery. The authors concluded that the financial stability implications of stress tests for risk-taking and credit growth among banks are the following: A reduction in credit is a feature on stress tests. Post-crisis reforms traded the expectation of lower credit growth for reducing the probability that the larger banks would fail. This has a high negative impact on the economy. Higher capital requirements for the larger banks have prompted a reduction in the supply of credit, especially to riskier borrowers. Smaller banks have increased their share of local market-wide lending, and larger businesses have seen quite generous credit availability in bond and leveraged loan markets. Consider the structure of the financial system and its complexity long the levels of economic integration and openness.

Kithinji (2010) assessed the effect of credit risk management on the profitability ofcommercial banks in Kenya using data on the amount of credit, level of non-performing loans and profitsfrom 2004 to 2008. His findings revealed that the bulk of the profits of commercial banks were notinfluenced by the amount of credit and non-performing loans, and therefore suggested that other variablesother than credit and non-performing loans impact on profits. Chen and Pan (2012) examined the creditrisk efficiency of 34 Taiwanese commercial banks over the period 2005-2008. Their study employedfinancial ratio to assess the credit risk and was analyzed using Data Envelopment Analysis (DEA). Thecredit risk parameters were credit risk technical efficiency (CR-

TE), credit risk allocative efficiency (CR-AE), and credit risk cost efficiency (CR-CE). Their findings showed that only one bank was efficient in alltypes of efficiencies over the evaluated periods. Based on their result, they concluded that banks in Taiwanshowed relatively low average efficiency levels in CR-TE, CR-AE and CR-CE in 2008.

Poudel et al. (2009) studied the factors affecting commercial bank performance in Nepal for the period of2001 to 2012 and followed a linear regression analysis technique. The study revealed a significant inverserelationship between commercial bank performance measured by ROA and credit risk measured by defaultrate and capital ratio. Poudel (2012) further analyzed the impact of the credit risk management in bank'sfinancial performance in Nepal using time series data from 2001 to 2011. The results of the study indicatedthat credit risk management is an important predictor of bank's financial performance.

Boahene (2012) found a positive and significance relationship of commercial banks performance and creditrisk in his study of six Ghanaian commercial banks covering a period of 2005-2009. The panel dataanalysis model employed in the study revealed that indicators of credit risk, namely: non-performing loanrate, net charge-off rate, and the pre-provision profit as a percentage of net total loans and advances werepositively related with profitability measured by ROE. The author suggested that Ghanaian commercialbanks enjoy high profitability at time when the levels of credit risk variables are high. It is reasoned out onthis study that this might be, because of prohibitively lending/interest rate, fees and commissions.Whileexisting studies focus on prudential stress test of commercial capital adequacy; this study stress tested prudential variables and the responses of commercial banks capital adequacy in the post global financial crisis.

METHODOLOGY

The researcher employed ex-facto research approach to see the regression result analysis with respective empirical literature on the prudential stress test of commercial banks capital adequacy.The study used secondary data; the data is preferred in this study due to the nature of the study which is time series based. Secondary data were sourced from Annual Reports of quoted commercial banks ad Central Bank of Nigeria Statistical Bulletin.

Model Specification

CAR = f (AQ, LIQ, ER, MQ, RISK) (2)
CAR = f (EXR, GDP, INFR, MPR, MS) (3)

Where:

CAR = Capital adequacy ratio measured by tier 1 an Tier 2 capital to risk weight assets

AQ = Assets quality measured by the ratio of nonperforming loans to loans and advances
LIQ = Liquidity measured by total liquid assets to loans and advances
ER = Earnings measured by return on equity
MQ = Management quality measured by ratio of nonperforming loans to total assets

RISK = Risk measured by variation in nonperforming loans
EXR = Exchange rate per US dollar
GDP = Gross domestic product
INFR = Inflation rate
MPR = Monetary policy rate
MS = Money supply

Pooled OLS Regression or Constant Coefficients Model

$$CAR_{tt} = \beta_1 + \beta_1 AQ + \beta_2 LIQ_{tt} + \beta_3 ER_{tt} + +\beta_2 MQ_{tt} + \beta_3 RISK_{tt} + \mu_{tt} \quad (4)$$

$$CAR_{tt} = \beta_1 + \beta_1 EXR + \beta_2 GDP_{tt} + \beta_3 INFR_{tt} + +\beta_2 MPR_{tt} + \beta_3 MS_{tt} + \mu_{tt} \quad (5)$$

Where i = ith subject and t = period of time for the linear cost variables. Then function for better understanding is selected. The assumption here is that the dependent variables are non-stochastic and that's true then they are not correlated with the error term. There are times when the assumption that the dependent variables which are also the explanatory variables are strictly exogenous meaning the variables do not rely on present, past or future values of the error term u_{it},.

The Fixed Effect Least-Square Dummy Variable (LSDV) Model

Using the least squares dummy variable (LSDV) model, there is an allowance for heterogeneity among subjects by permitting every entity to possess its own value of intercept, as expressed in the model.

$$CAR_{tt} = \beta_1 + \beta_1 AQ + \beta_2 LIQ_{tt} + \beta_3 ER_{tt} + +\beta_2 MQ_{tt} + \beta_3 RISK_{tt} + \mu_{tt} \quad (6)$$

$$CAR_{tt} = \beta_1 + \beta_1 EXR + \beta_2 GDP_{tt} + \beta_3 INFR_{tt} + +\beta_2 MPR_{tt} + \beta_3 MS_{tt} + \mu_{tt} \quad (7)$$

Notice that we have put the subscript i on the intercept term to suggest that the intercepts of the regression model

$$CAR_{tt} = \beta_1 + \beta_1 AQ + \beta_2 LIQ_{tt} + \beta_3 ER_{tt}^{\mu} + +\beta_2 MQ_{tt} + \beta_3 RISK_{tt} + \mu_{tt} \quad (8)$$

$$CAR_{tt} = \beta_1 + \beta_1 EXR + \beta_2 GDP_{tt} + \beta_3 INFR_{tt} + +\beta_2 MPR_{tt} + \beta_3 MS_{tt} + \mu_{tt} \quad (9)$$

Where α_1 = regression intercept, α_2 = oil price, α_3 = exchange rate.

The Random Effects Model (REM)

If the dummy variables indicate that there is knowledge lacking about the (true) model, then it is precisely the method as recommended by the proponents of the so-called error components model (ECM) or random effects model (REM)which is being illustrated with our firm variables.

The idea is to start with Equation

$$CAR_{tt} = \beta_1 + \beta_1 AQ + \beta_2 LIQ_{tt} + \beta_3 ER_{tt} + +\beta_2 MQ_{tt} + \beta_3 RISK_{tt} + \mu_{tt} \quad (10)$$

$$CAR_{tt} = \beta_1 + \beta_1 EXR + \beta_2 GDP_{tt} + \beta_3 INFR_{tt} + +\beta_2 MPR_{tt} + \beta_3 MS_{tt} + \mu_{tt} \quad (11)$$

Instead of treating β_1 as fixed, we assume that it is a random variable with a mean value of β_1 (no subscript) here). The intercept value for the variables can be expressed as:

$$\beta_{1i} = \beta_1 + \varepsilon_i \quad (12)$$

Where ε_i is a random error term with a mean value of zero and a variance of σ_ε^2.

RESULTS AND DISCUSSION OF FINDINGS

Table 1:Presentation of Panel Unit Root Results

Panel A: Micro prudential variables			**Panel B: Macro prudential variables**		
Method: D(CAR,2)	Statistic	Prob.**	Method: D(CAR,2)	Statistic	Prob.**
Levin, Lin & Chu t*	-3.42821	0.0003	Levin, Lin & Chu t*	-3.42821	0.0003
Im, Pesaran and Shin W-stat	-2.51859	0.0059	Im, Pesaran and Shin W-stat	-2.51859	0.0059
ADF - Fisher Chi-square	54.9690	0.0008	ADF - Fisher Chi-square	54.9690	0.0008
PP - Fisher Chi-square	151.391	0.0000	PP - Fisher Chi-square	151.391	0.0000
Series: D(AQ,2)			D(EXR,2)		
Levin, Lin & Chu t*	-10.0947	0.0000	Levin, Lin & Chu t*	-23.6912	0.0000
Im, Pesaran and Shin W-stat	-2.65649	0.0039	Im, Pesaran and Shin W-stat	-8.35581	0.0000
ADF - Fisher Chi-square	54.0322	0.0010	ADF - Fisher Chi-square	119.556	0.0000
PP - Fisher Chi-square	109.427	0.0000	PP - Fisher Chi-square	20.6539	0.0006
Series: D(ER,2)			D(GDP,2)		
Levin, Lin & Chu t*	-32.6358	0.0000	Levin, Lin & Chu t*	-12.7371	0.0000
Im, Pesaran and Shin W-stat	-9.66816	0.0000	Im, Pesaran and Shin W-stat	-4.60361	0.0000
ADF - Fisher Chi-square	106.370	0.0000	ADF - Fisher Chi-square	77.6089	0.0000
PP - Fisher Chi-square	217.396	0.0000	PP - Fisher Chi-square	132.109	0.0000
Series: D(LIQ,2)			D(INFR,2)		
Levin, Lin & Chu t*	-41.6524	0.0000	Levin, Lin & Chu t*	10.7163	0.0000

Im, Pesaran and Shin W-stat	-11.2483	0.0000	Im, Pesaran and Shin W-stat	51.7032	0.0000
ADF - Fisher Chi-square	97.3563	0.0000	ADF - Fisher Chi-square	57.7258	0.0000
PP - Fisher Chi-square	214.908	0.0000	PP - Fisher Chi-square	76.3279	0.0000
Series: D(MQ,2)			D(MPR,2)		
Levin, Lin & Chu t*	-27.8519	0.0000	Levin, Lin & Chu t*	-21.0830	0.0000
Im, Pesaran and Shin W-stat	-11.5078	0.0000	Im, Pesaran and Shin W-stat	-7.44350	0.0000
ADF - Fisher Chi-square	125.156	0.0000	ADF - Fisher Chi-square	109.912	0.0000
PP - Fisher Chi-square	210.337	0.0000	PP - Fisher Chi-square	139.360	0.0000
Series: D(RISK,2)			D(MS,2)		
Levin, Lin & Chu t*	-20.7716	0.0000	Levin, Lin & Chu t*	-23.4015	0.0000
Im, Pesaran and Shin W-stat	-7.63959	0.0000	Im, Pesaran and Shin W-stat	-8.42655	0.0000
ADF - Fisher Chi-square	101.342	0.0000	ADF - Fisher Chi-square	120.264	0.0000
PP - Fisher Chi-square	208.454	0.0000	PP - Fisher Chi-square	5.37828	0.0000

Source: Computed from E-view 9.0, 2021
Null: Unit root
Levin Lin & Chu Test: Assumes common unit root process
Im, Pesaran and Shin: Assumes individual unit root process
ADF-Fisher chi-square: Assumes individual unit root process
PP-Fisher chi-square: Assumes individual unit root process
** Probabilities for fisher tests are computed using an asymptotic chi-Square distribution.

To check stationarity of data through panel unit root test. Panel unit root test are not similar to unitroottest. There are two types of panel unit root processes. When the persistence parameters are common across cross-section then this type of processes is called a common unit root process. Levin, Lin and Chu (LLC) employ this assumption. When the persistent parameters freely move across cross section then this type of unit root processis called an individual unit root process. The Im, Pesaran and Shin (IPS), Fisher-ADF and Fisher-PP test are based on this form. At first difference, we reject null hypothesis and conclude that the variables are stationary at 5 percent level of significance, this implies that at first difference of the series at 5% level of significance in all case reject null hypothesis, from the table, we conclude that the variables are integrated in the order of 1(1).

Table 2: Pedroni Residual Cointegration Test

	Statistic	Prob.	Weighted Statistic	Prob.
Panel A: Micro prudential variables				
Panel v-Statistic	4.056015	0.0077	-2.829414	0.9977
Panel rho-Statistic	5.047422	0.0000	3.479795	0.9997
Panel PP-Statistic	2.937206	0.9983	-2.122659	0.0169
Panel ADF-Statistic	-1.699451	0.0446	1.951009	0.9745
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	5.453544	1.0000		
Group PP-Statistic	-3.671363	0.0001		
Group ADF-Statistic	1.955214	0.9747		
Panel B: Macro prudential variables				
Panel v-Statistic	1.356720	0.0874	-0.634423	0.7371
Panel rho-Statistic	3.025889	0.9988	2.928311	0.9983
Panel PP-Statistic	2.609405	0.9955	-2.307519	0.0105
Panel ADF-Statistic	6.098558	1.0000	4.190353	1.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	4.450194	1.0000		
Group PP-Statistic	-5.983019	0.0000		
Group ADF-Statistic	5.670070	1.0000		

Source: Computed from E-view 9.0, 2021
Null Hypothesis: No cointegration
Trend Assumption: No deterministic intercept or trend
Automatic lag length selection based on SIC
The results of the cointegration test proved that the variables are cointegrated as the probability coefficient of the variables are less than 0.05, we accept the alternate hypothesesthat there is presence of long run relationship between the dependent and the independent variables.

Table 3: Regression Results

Variable	Pooled Effect			Fixed effect			Random effect		
	β coefficient	T. stat	p. value	β coefficient	T. stat	p. value	β coefficient	T. stat	p. value
				Panel A: Micro prudential variables					
AQ	-0.400041	-0.052051	0.9586	-7.782048	-0.853462	0.3954	0.206966	0.023793	0.9811
LIQ	7.371058	1.344773	0.1812	3.882483	0.636870	0.5256	8.758237	1.561503	0.1212
ER	-17.80595	-2.345656	0.0206	-0.427323	-2.137167	0.0350	-19.77886	-2.559480	0.0118
MQ	15.75359	1.800561	0.0742	13.85588	2.442891	0.0321	12.04782	1.332388	0.1854
RISK	-5.107204	-0.814699	0.4168	-0.854250	-0.123947	0.9016	-1.317866	-0.198490	0.8430
C	22.43910	0.185351	0.8533	148.3492	1.025796	0.3074	38.96086	0.288434	0.7735
R-squared	0.450391			0.717522			0.547890		
AdjR²	**0.312101**			**0.520003**			**0.318552**		
F-statistic	1.316022			5.101271			3.143437		
F- Prob	0.261558			0.000131			0.023231		
D W	1.955651			1.949447			1.985970		
	Correlated Random Effects - Hausman Test								
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.						
Cross-section random	5.285843	5	0.0020						
				Panel A: Macro prudential variables					
Variable	Pooled Effect			Fixed effect			Random effect		
	β coefficient	T. stat	p. value	β coefficient	T. stat	p. value	β coefficient	T. stat	p. value
EXR	0.721753	1.532665	0.1279	0.721753	3.533092	0.0000	0.721753	1.533092	0.1278
GDP	7.884627	0.907973	0.3657	0.884627	0.908226	0.3657	0.884627	0.908226	0.3655
INFR	-0.498249	-0.071355	0.9432	-0.498249	-0.071375	0.9432	-0.498249	-0.071375	0.9432
MPR	9.009914	0.826161	0.4103	0.009914	2.826391	0.0003	9.009914	0.826391	0.4102
MS	-19.48932	-0.993011	0.3226	-0.489932	-2.993287	0.0001	-0.481932	-0.993287	0.3225
C	183.8136	0.526948	0.5992	0.812636	0.527095	0.5992	0.893136	0.527093	0.5991
R-squared	0.333386			0.727415			0.333404		
AdjR²	**0.205591**			**0.505031**			**0.205572**		
F-statistic	0.856566			6.962015			0.857043		
F- Prob	0.512471			0.000035			0.512147		
D W	1.997483			2.007155			1.998004		
Correlated Random Effects - Hausman Test									

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	6.278393	5	0.0000

Source: Computed from E-view 9.0, 2021

Hausman specification test has been used to determine which one of the alternative panel analysis methods (fixed effects model and random effects model) among the 3 panel regression models should be applied. From table 2 fixed effect model is significant for both micro and macro prudential variables.

Table 3 shows that the overall significance of the OLS regression results for the model shows that it is statistically significant at 1 percent level of significance. More so, about 52 percent of the total variation in capital adequacy is explained by micro-prudential stress test variables while 50.5 percent can be traced to macro-prudential stress test.

The model result tells us that assets quality have negative and no significant effect on capital adequacy, liquidity have positive and no significant effect on capital adequacy, earnings and risk have negative and significant effect, management quality have positive and significant effect on capital adequacy while risk have negative and no significant effect on capital adequacy of the quoted commercial banks within the periods covered in this study. This implies that bank stress as proxy by commercial banks capital adequacy is seriously influenced by micro prudential variables affect banks capital adequacy within the periods covered in this study. The positive effect of the variables implies that effect management strategies and compliance to rules and regulations such Basel III countercyclical capital buffer and counterparty risk management. The finding implies that commercial banks capital respond negatively to poor assets quality, decrease in earnings and increase in risk while bank capital responds positively to liquidity shocks and management quality.

The findings confirm the findings of Kithinji (2010) that only one bank was efficient in alltypes of efficiencies over the evaluated period and concluded that banks in Taiwanshowed relatively low average efficiency levels in CR-TE, CR-AE and CR-CE in 2008. The findings of Poudel et al. (2009) that significant inverserelationship between commercial bank performance measured by ROA and credit risk measured by default rate and capital ratio and the findings of Poudel (2012) that credit risk management is an important predictor of bank's financial performance.Furthermore, the finding of the study established that commercial banks capital respond positively to exchange rate volatility, gross domestic product monetary policy rate but respond negatively to inflation rate and money supply over the periods covered in this study. The findings confirm the findings of Leesi (2021) that asset quality respond strongly to volatility of prime lending rate and monetary policy but weak respond to volatility of Treasury bill rate, reserve requirement and maximum lending rate. The findings of Farayibi(2016) that Nigerian banking system is susceptible to various risks both within and outside the country and noted that macroeconomic risks as their performance index is based onthese variables. the findings of Orobahand Anwarul(2020) that the financial stability implications of stress tests for risk-taking and credit growth among banks reduction in credit is a feature on stress tests.

Table 4 Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
Panel A: Micro Prudential Variables			
AQ does not Granger Cause CAR	104	0.00260	0.9974
CAR does not Granger Cause AQ		2.19960	0.1162
LIQ does not Granger Cause CAR	104	1.04707	0.3548
CAR does not Granger Cause LIQ		0.02800	0.9724
ER does not Granger Cause CAR	104	0.71823	0.4901
CAR does not Granger Cause ER		0.01881	0.9814
MQ does not Granger Cause CAR	104	0.29805	0.7429
CAR does not Granger Cause MQ		0.19473	0.8234
RISK does not Granger Cause CAR	104	0.00756	0.9925
CAR does not Granger Cause RISK		0.65747	0.5204
Panel B: Macro Prudential Variables			
EXR does not Granger Cause CAR	104	2.62211	0.0777
CAR does not Granger Cause EXR		0.32774	0.7213
GDP does not Granger Cause CAR	104	1.93246	0.1502
CAR does not Granger Cause GDP		0.29982	0.7416
INFR does not Granger Cause CAR	104	1.55153	0.2170
CAR does not Granger Cause INFR		0.81207	0.4469
MPR does not Granger Cause CAR	104	0.61003	0.5454
CAR does not Granger Cause MPR		0.37064	0.6912
MS does not Granger Cause CAR	104	1.23046	0.2966
CAR does not Granger Cause MS		0.74188	0.4788

Source: Computed from E-view 9.0, 2021

From the causality test presented in the above table, there is independent relationship from both the micro and the macro-prudential variables we accept the null hypothesis that there is no causal relationship between among the variables.

Table 5: Phillips-Peron results (non-parametric)

Cross ID	AR(1)	Variance	HAC	Bandwidth	Obs
ACCESS	-0.743	1.600357	0.885068	2.00	9
ECOBANK	-0.184	165981.2	165981.2	0.00	9
FCMB	-0.719	9.381685	10.26412	1.00	9
FIDELITY	-0.157	6.059786	6.715432	1.00	9
GTB	-0.120	5.379616	4.975613	2.00	9
FIRST BANK	-0.725	1.545623	1.545623	0.00	9
POLARISE	-0.476	1.166648	1.166648	0.00	9

STANBIC	-0.337	4.298322	3.984955	2.00	9
UBA	0.090	1.274010	1.138735	2.00	9
UNION	0.213	1.852109	1.852109	0.00	9
UNITY	-0.077	1.103920	0.225540	6.00	9
WEMA	-0.760	2.166687	2.972846	1.00	9
ZENITH	0.154	10.87191	10.87191	0.00	9

Source: Computed from E-view 9.0, 2021

The analysis of we employ the Phillips-Peron results non-parametric was carried out in the first generation panel unit root tests which allow for cross-sectional independence between firms. As displayed in Table 5 the results suggest that the firms' null hypothesis cannot be rejected by all the first generation tests (LLC, IPS, MW and Choi tests). This finding of stationarity is not in line with Song and Wu (1998) who reported the absence of hysteresis in the firms for the annual data of 20 firms by using Levin and Lin (1992) panel unit root test. However, the cross-sectional (CD) dependence test rejects the presence of cross-sectional independence and hence, the first generation unit root test is not applicable. Therefore, the failure of the these tests to reject the null of the firms hysteresis is due to the fact that the first generation panel unit root tests do not allow neither for cross-sectional dependence nor for possible structural breaks.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study has provided evidence on prudential stress testing of quoted commercial banks using panel data and Ordinary Least Square (OLS) methodologies. It is clear from the analysis that stress testing is important to building a strong and viable financial system in the country. Bank's going concern depends on profitability, solvency and liquidity. Using a bottom-up approach to stress management, commercial banks capital adequacy index depends on the behaviours of micro and macroeconomic variables. How banks respond to shocks within the operating environment determines the going concern and the viability of the nation's financial system.

This implies that bank stress as proxy by commercial banks capital adequacy is seriously influenced by the micro and macro-prudential variables.Consequently, bank stress management in Nigeria is sensitive to assets quality measured by the ratio of nonperforming loans to loans and advances, liquidity measured by total liquid assets to loans and advances, earnings measured by return on equity, management quality measured by ratio of nonperforming loans to total assets, risk measured by variation in nonperforming loans, exchange rate per us dollar, gross domestic product, inflation rate, monetary policy rate and money supply.

Recommendations

i. Credit officers should undertake a proper loan appraisal and follow-up, careful loan screening procedure and timely disbursement of approved loans to minimize defaults. Credit administrators should take a lot of precautions in reducing credit risks by demanding

for appropriate collateral security before granting loan, and ensuring effective loan supervision and monitoring by credit officer.

ii. Credit risk managers should adopt global best practices in monitoring the performance and suitability of the bank's credit risk management methods and strategies. Central bank of Nigeria as the apex financial sector regulator should reinforce the performance evaluation department by critically assessing the stress associated macroeconomic variables from time to time, using different approaches to avoid liquidation and weakening the financial intermediation role of the Nigerian banks.

iii. The Central Bank of Nigeria should effectively and thoroughly consider the use of money supply as an instrument to affect the commercial bank soundness in Nigeria. This is because this study showed that money supply has significant relationship capital adequacy indicators used as proxies for commercial capital adequacy within the period of this study.

iv. The regulatory authorities should intensify effective and continuous monitoring of commercial banks onsite and offsite to ensure strict compliance to regulations. Such continuous supervisory exercise will guide against any policy abuse and manipulation of financial reports.

v. Government and regulatory authorities of commercial banks should look beyond monetary policy and strive towards creating a conducive business climate as a way of improving bank performances. Government eases of doing business initiative and provisions in the Finance Act 2020, which makes provisions reduction of tax rates for some profit threshold is good steps in the right direction.

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