Are Nigerian Banks Vulnerable to Oil Price Shocks? A Stress Test Approach

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Abstract

This study empirically examines the vulnerability of the Nigerian banking industry to extreme, but plausible, adverse oil price shocks. A structural vector autoregressive (SVAR-X) is adopted to achieve this objective. The study period covers 2007Q1 – 2020Q4. The simulations assess the asset quality performance of DMBs, using the NPLs, under three scenarios (baseline, adverse and severely adverse). The findings suggest that the entire banking industry, as well as individual DMBs, are vulnerable to adverse oil price shocks. Accordingly, the study recommends, strict compliance with the single obligor limit, by commercial banks, to mitigate adverse effects of volatilities in crude oil prices. However, due to data limitations the study cannot extend the analysis, to the impact of oil price shocks, on the capital adequacy of DMBs. Consequently, the need for further studies on this issue cannot be overemphasised.

I.   Introduction

Shocks to the financial system can lead to financial crises, and may have huge costs, in terms of foregone growth and deterioration in economy-wide balance sheets. Policymakers, all over the world, strive to strengthen the resilience of their financial systems. An essential aspect of this effort is risk analysis and the ability to detect vulnerabilities in the financial system. Consequently, bank stress test, a simulation process, performed at national level, by central banks and supervisory authorities, is a tool used to assess the resilience of banks to extreme, but plausible adverse shocks.

The events of the global financial crisis have popularised the use of bank stress tests, as a tool for regulation and supervision, not only for the banking industry, but also for other financial institutions. Central banks, and the supervisory authorities around the world, have used stress tests to assess the resilience of banks and other financial institutions and to underpin policy decisions, aimed at preserving or restoring financial system stability. The United States Federal Reserve's Supervisory Capital Assessment Program conducted in 2009, represents the first successful effort at implementing stress tests, in the post-global

financial crisis era. As a tool for bank regulation and supervision, stress tests have been used to compel banks to improve their risk management frameworks and internal business policies, requiring them to integrate adverse economic circumstances in their critical decision-making process.

Several studies on oil exporting countries, (Espinoza & Prasad, 2010; IMF, 2015; and Alodayni, 2016), have established a negative relationship between adverse oil price shocks and the asset quality of banks, proxied, by the ratio of non-performing loans to total loans and advances, (NPL), using stress test analysis. The level of exposure of DMBs to the oil sector, is usually cited as the linkage. The use of stress testing frameworks in these studies, is not unfounded, as stress-tests are the essential policy tool in the macroprudential literature, for assessing the vulnerability of the entire banking system, to adverse macroeconomic scenarios (ECB, 2013). They represent a dynamic and forward-looking method of assessing the financial system's risks and vulnerabilities, under extreme, but plausible circumstances (CEPR, 2016).

Most of the existing studies in Nigeria have centred on, finding the impact of oil price shocks on the capital adequacy of banks (Farayibi, 2016; and Adegoke & Oyedeko, 2018). Olusegun (2016) examines the impact of oil price shocks on the profitability of DMBs in Nigerian using a non-stress testing framework. His findings suggest, a positive relationship between oil price and return on assets (ROA) of DMBs. The vulnerabilities of bank asset qualities, to extreme, but plausible, negative swings in crude oil prices, has largely, not been explored. This is puzzling, given the significant exposure of Nigerian banks to the oil and gas sector[2]. Although the CBN, regularly conducts some sort of stress tests, to assess the vulnerability of banks to extreme shocks to capital and assets, this has been done, mainly in terms of sensitivity analysis, to determine the impacts of such shocks on capital adequacy of banks. The use of formal econometric models in stress testing banks vulnerabilities has generally, not been popular, either due to the complexities of such models or the lack of requisite skills and software to handle a rigorous assessment, like stress testing.

On this background, the objective of the study is to examine the vulnerability of the entire banking industry and different categories of DMBs to extreme, but plausible, adverse oil price shocks. Our stress testing framework uses the SVAR-X approach to investigate, how susceptible the banking sector is, to adverse and extreme oil price shocks. The study employs both micro and macro stress testing to assess bank-specific and sector-wide stability in the event of such adverse

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*Credit to the oil and gas sector by commercial banks, over the 2014-2017 period, constituted more than 22.0 per cent of the total credit to the private sector (CBN Database).

shocks. To the best of our knowledge, this represents a first attempt at applying a formal econometric model in stress testing banks vulnerability to extreme, but plausible adverse shocks in oil prices in Nigeria. The findings reveal that the asset quality of individual banks and the entire banking industry deteriorate significantly when oil price falls below $69pb for more than a year. The study recommends that commercial banks take cognisance of the volatility of crude oil prices and strictly comply with the single obligor limit due to the adverse effects of crude oil prices on asset quality.

The rest of the paper is organised as follows: Following the introduction, section two presents the literature review, highlighting both the theoretical and empirical discuss on the subject. Section three discussed the research methodology, and section four presents the results of the stress testing analysis, while section five summarises and concludes the study.

II.   Literature Review
II.1   Some Stylised Facts

The 2007/2008 global financial crisis, during which the price of crude oil crashed to $40 per barrel, from over $100 per barrel, revealed the vulnerabilities of the Nigerian banking industry to liquidity shocks, as the ratio of non-performing loans to total bank loans and advances (NPLs) rose significantly, to 37.35 per cent in 2009Q4, from 8.24 per cent in 2008Q1. Consequently, the CBN injected N620 billion, as tier 2 capital, in a bailout fund, for nine troubled banks. Nevertheless, the non-performing loan ratio, remained high, averaging about 33.29 per cent in 2010. This culminated in the establishment of the Asset Management Corporation of Nigeria (AMCON) in 2010, to take over banks' toxic assets, in order to improve their balance sheet positions. The NPL ratio, thereafter, dropped to 4.47 per cent in 2012Q1, from 16.25 per cent in 2011Q1, and remained within the regulatory benchmark of 5.0 per cent until 2016Q1 (CBN Database). However, following the re-occurrence of economic crisis in Nigeria, the NPL ratio rose to 9.72 per cent in 2016Q1, and 14.64 per cent in 2017Q1, remaining above the benchmark all through the intervening period. This, however, coincided with the fall in global crude oil prices to $20pb, from the historic highs of above $100 in 2014. However, when the oil prices declined, significantly, to $27.49pb in 2020Q2, due to COVID-19 pandemic, NPL ratio was relatively stable, averaging 6.15 per cent between 2020Q2 and 2020Q4. The stability in the NPL, was however, attributed to several monetary policy measures, including the regulatory forbearance, granted to banks to restructure facilities and reduce adverse effects of COVID-19 pandemic on the financial sector. This suggests that significant declines in crude oil price could be

associated with spikes in the NPL in DMBs, which could be attributed to the significant exposure of the banking industry to the oil and gas sector, as credit issued to the sector by DMBs over the 2014-2017 period constituted over 22.0 per cent of the total credit to the private sector (CBN Database).

Figure 1: Crude Oil Price and Ratio of Non-Performing Loans in Nigeria
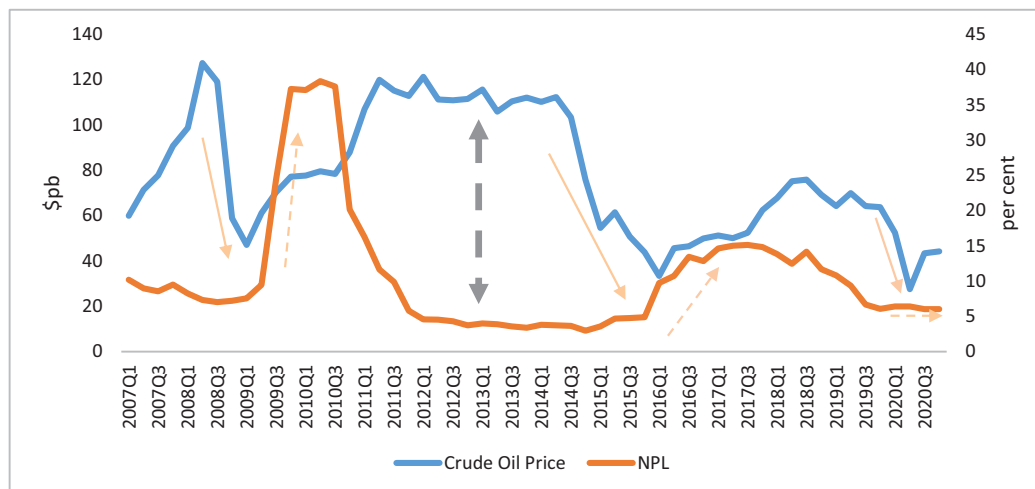
Source: CBN Database, 2021.

Consequently, this study poses the following questions: are Nigerian banks vulnerable to addressing crude oil prices? What is the impact of oil price shocks on the quality of banks assets in Nigeria? Given that the exposure of the banks to the oil and gas sector makes them susceptible to the vagaries of price developments in the international oil market, it is important to understand the transmission mechanism of oil price shocks to the Nigerian banking sector and how the asset quality is affected. This is crucial to financial stability. It is also important to understand the link between adverse shocks in crude oil prices and asset quality of banks in Nigeria within a stress-testing framework. This requires conducting both micro and macro stress tests to ascertain whether the financial soundness of the individual DMBs in Nigeria equates to the soundness of the banking industry. This will guide policy and regulations in this direction.

II.1.1   Understanding Stress Testing and Prudential Policies

Stress testing is a forward-looking, quantitative approach to estimating the losses that would likely occur in a portfolio or financial institution if it were exposed to very adverse conditions in the future (CEPR, 2016). Stress tests can be divided into micro and macro-stress tests. Sorge (2004), described a macro stress test, as a range of techniques which assess the financial system vulnerability to extreme, but plausible adverse macroeconomic shocks. Different types of stress test

techniques exist, including the single factor sensitivity tests, Vector Autoregressive (VAR) model stress tests, and dynamic stochastic general equilibrium (DSGE) stress tests. There are, however, two principal macro-stress testing methodologies, the piecewise approach, and the integrated approach. The former assesses the vulnerability of the financial system to a single risk factor by forecasting numerous financial soundness indicators under various macroeconomic stress scenarios. The integrated approach on the other hand, combines the analysis of the sensitivity of the financial system to many risk factors into a single estimate of the probability distribution of total losses, which could materialise from any stress scenario.

Table 1: Characteristics of Macro Stress-Testing Methodologies

	Piecewise Approach	*Integrated Approach*
Main Modelling Options	• Time series or panel data • Reduced form or structural models	• Macro-econometric risk model • Micro-structural risk model
Pros	• Intuitive and with a low computational burden • Broader characterisation of stress scenario • Monetary policy trade-offs	• Integrates analysis of market and credit risks • Simulates shift in entire loss distribution driven by the impact of macroeconomic shocks on individual risk components • Has been applied to capture the nonlinear effects of macro shocks on credit risk
Cons	• Mostly linear functional forms have been used • Parameter instability over longer horizons • No feedback effects • Loan loss provisions and non-performing loans may be noisy indicators of credit risk	• Non-additivity of value-at-risk measures across institutions • Most models so far have focused on credit risk only, usually limited to a short-term horizon • Available studies have not dealt with feedback effects or parameter instability over a longer horizon

Source: Sorge(2004).

Macro-prudential policy, primarily, refers to the use of prudential tools to limit systemic risk. In other words, it aims at identifying, containing, and preventing the build-up of systemic risk. Unlike micro-prudential policy, which seek to limit the possibility of collapse of individual financial institutions, macro-prudential policy aims to limit economic losses from financial crisis, including those due to policy induced moral hazards (Crockett, 2000).

Table 2: Key Differences between Micro-Prudential and Macro-Prudential Policies

	Micro-prudential	*Macro-Prudential*
Policy objective	Limit distress of individual institutions	Limit financial system-wide distress
Ultimate goal	Consumer (investor/depositor) protection	Avoid output (GDP) costs
Model of Risk	Dependent on individual agents' behaviours (Exogenous)	Dependent on collective behaviour (Endogenous)
Correlations and Common Exposures across Firms	Irrelevant	Important
Calibration of Prudential Instruments	In terms of firm risks; bottom-up	In terms of system-wide risk; top-down
Expertise	Micro-finance	Macro-finance
Governance	Supervisor (including colleges of supervisors for cross-border banks)	Macro-prudential authority (including coordination at national and international levels)
Monitoring	**Bottom-up**: Institution-specific indicators Micro-stress test Supervisory Review and Evaluation Process (SREP)	**Top down**: Macro-indicators Macro-stress test

Sources: Borio (2003) and ESRB (2014).

II.1.2   Evolution of Stress Testing Frameworks

Traditionally, stress testing was developed by banks as a risk management tool for individual portfolio applications, but more techniques are being used by authorities as supervisory and macroprudential tools, after the Asian Crisis and the Global Financial Crisis. For example, the IMF began using stress testing after the Asian Crisis when it launched its 1999 Financial Sector Assessment Program (FSAP) as a forward-looking way to assess the financial system's risks and vulnerabilities. Prior to that, such vulnerability analysis was conducted using limited backward-looking indicators, such as the Financial Soundness Indicators (FSIs) (CEPR, 2016).

By this time, conducting stress test on market risks by large international banks had become a standard practice, yet stress tests that account for credit risks were significantly lagging. By 2005, significant progress had not been made in this regard as reported by the committee on the Global Financial System (CGFS). The first significant step towards conducting credit risk stress tests was the international regulatory capital regime (Basel II) published in 2004, which required banks to use their internal models to determine credit risk for regulatory capital purposes and to have a stress testing programme in place. However, advanced economies did not universally implement Basel II prior to the Global Financial Crisis, and banks' stress-testing models were still developing in most cases. Moreover, one of the drawbacks of the Basel II was that within the framework, there were no clear guidelines on how adverse scenarios should be chosen, thus leaving this to the banks and supervisors' judgement. The financial crisis thus proved that all the adverse scenarios used prior to the crisis were significantly benign relative to the crisis in terms of losses experienced (Dent et al., 2016).

As the financial crisis began to unfold, global interest in stress testing began to grow, giving rise to the Basel Committee's Principles of Sound Stress Testing Practices and Supervision (BCBS 155) in 2009 and the de Larosière Report', which called for testing under more adverse scenarios (de Larosière Group, 2009). These calls led to the prominent use of stress tests in Basel III under pillar 1 in calculating regulatory capital and in pillar 2 in reviewing bank's Internal Capital Adequacy Assessment Process (ICAAP) (CEPR, 2016).

Due to the inability of previous stress tests to forestall the insolvency of financial institutions such as Fannie Mae and Freddy Mac which had stress tests as part of their regulatory framework, a new wave of more robust stress tests began to emerge. The first was the Supervisory Capital Assessment Program (SCAP) conducted by the Federal Reserve in early 2009. The SCAP evaluated the capacity of large US banks to absorb losses and continue operations under adverse conditions. Unlike previous tests, the results were publicly disclosed on an individual bank basis. The errant banks were mandated to raise capital within six months, while the USA Treasury provided a backstop; should any be unable to raise capital in private markets. The test results were positively received and adjudged to have stabilised the US financial system and restored market confidence. Drawing from the SCAP experience, stress testing came to occupy a central role in the supervision of systemically important institutions in the USA, with modifications made to its methodology. Following SCAP, two other stress tests currently play significant roles in ensuring financial system stability in the USA; the Comprehensive Capital Assessment Review (CCAR) and the Dodd-Frank Act Stress Test of 2010 (DFAST) (CEPR, 2016).

The success of the SCAP in the US led to the proliferation of stress testing frameworks across central banks and supervisory institutions globally. In May 2009, shortly after the announcement of SCAP results, the Committee of European Bank Supervisors (CEBS) (an advisory body with no direct authority to supervise any bank) conducted the first EU-wide stress test. However, the results were discounted due to the lack of transparency and linkage to notable supervisory actions. Following the problems of Irish banks after the CEBS stress test results were released, concerns grew about the health of European banks. The CEBS was then commissioned to conduct another stress test with direct support from ECB. The scope of this test covered ninety-one banks in twenty EU member nations, and only seven banks failed the test. The third round of tests was conducted in 2011 by the new European Banking Authority (EBA), which replaced the CEBS and had more extraordinary supervisory powers (Dent et al., 2016).

The EU-wide stress tests conducted in 2014 covered one hundred and twenty-three banks, accounting for 70.0 per cent of European banking assets. The test methodology was explicitly explained in relation to disclosure, and the results were reported in detail on a bank-by-bank basis. As a result, twenty-three banks failed to meet the required threshold of 5.5 per cent CET1 under the stress scenario and were required to take remedial actions with the ECB. In 2017, the ECB initiated a new EU-wide stress testing exercise called STAMPE (Stress Test Analytics for Macroprudential Purposes in the Euro Area) to complement other stress testing efforts. CEPR (2016) highlights transparency and credible backstop to deal with shortfalls in the capital as the main lessons learnt from the US and EU experiences.

According to Sorge (2004), in addition to these institutional efforts, individual researchers have conducted stress tests globally since the turn of the 20th century using different methodologies ranging from time series analysis, panel regressions, structural models and a combination of macro-fundamentals into value-at-risk measures. For example, in relation to time series analysis, Hoggart and Zicchino (2004) conducted a stress test for the UK economy using a parsimonious VAR approach, while Delgado and Saurina (2004) used cointegration techniques. Under the panel regressions, examples include Carling et al. (2003), Quagliariello (2004) and Pain and Vesala (2004). In addition, Hoggart et al. (2005) modified the Bank of England's Medium-Term Macroeconometric models to conduct stress tests for the UK. Similar efforts were carried out by Oung (2004) for France.

II.2   Theoretical Literature Review

Some of the theories reviewed include monetary policy transmission channel, theory of moral hazard and adverse selection, and frameworks for regulatory intervention.

II.2.1   Credit View of the Monetary Policy Transmission Channel
Bank Lending Channel

The transmission through the credit channel, is predicated on some assumptions. First, central banks can determine the quantity of bank credit through their operations. Second, Bank loans are an integral source of funds for households and businesses and they have no close substitutes. Finally, economic agents are dependent on banks and can only source their credits from them. The legal reserve requirement ensures that monetary authorities exercise significant influence over the quantity of funds in the banking system and as such, changes in the reserve requirements lead to changes in the banking system liquidity. An increase in the reserve requirement ratio reduces the real quantity of credit that banks can issue. Limited liquidity within the system induces banks to reduce lending, leading to higher interest rates, consequently, reducing the borrowing capacity of economic agents. This constrains the capacity of households and businesses to purchase goods and services, prompting a fall in aggregate demand (AD) and output.

Liquidity in the banking system could also be affected by adverse shocks and as such the reduction in the loanable funds pool, which affects the capacity of banks to provide credit to the economic agents. As a result, they prioritise the credit worthy borrowers over those with a higher risk of default, leading to crowding out in different sectors of the economy, ultimately leading to a fall in AD (Lawal, 2017).

Economic shock ⟶ ↓ liquidity ⟶ ↑ interest rate ⟶ ↓ investment and consumption ⟶ ↓ AD
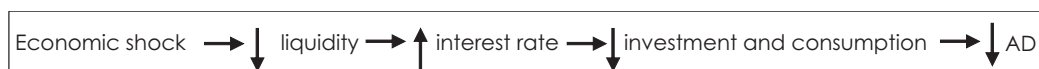
Source: (Lawal, 2017)

This study assumes that the economic shock in question is the oil price shock.

Balance Sheet Channel

Similar to the bank lending channel, financial frictions in the credit market are transmitted through the balance sheet channel. Negative economic downturns affect the net worth of firms, and the lower the net worth of firms, the higher the

adverse selection and moral hazard challenges in lending to these firms. The decline in value of the firms affects their capacity to provide collateral for loans and increases the adverse selection problem, reducing lending to the economy's productive sectors, and stimulating a fall in AD and total output.

The lower net worth of firms and banks also increases the moral hazard problem as owners are incentivised to engage in riskier ventures with the promise of higher returns. These risky investments reduce the probability of loan repayment, leading to further reductions in lending (Lawal, 2017).

II.2.2   Moral Hazard and Adverse Selection

The two major assumptions upon which the theory of adverse selection is based are that lenders cannot adequately distinguish between borrowers with different degrees of risk (that is, asymmetric information); and that loan contracts are limited in supply.

This analysis is restricted to cases of involuntary default, where borrowers default on payments only when funds are unavailable. When debt contracts exist between risk-neutral borrowers and lenders, limited liability borrowers are inclined to have a higher risk preference, unlike lenders who tend to be more risk-averse. This is because lenders bear all the downside risks in cases of default. Conversely, returns in excess of the loan repayment obligation accrue to the borrowers. This scenario incentivises borrowers to make wrong choices in terms of investment, which may affect their capacity to repay loans, leading to higher non-performing loans. This information asymmetry, which exists between lenders and borrowers leads to financial frictions, as lenders are unaware of borrowers' creditworthiness and cannot detect borrowers' inefficient behaviour post-lending (Diltokka, 2016).

Banks are in business to lend, and doing so under asymmetric information raises opportunistic behaviour, hence, the risk of default (moral hazard and adverse selection). Banks are also inherently risky due to maturity mismatch, as they borrow short-term and lend long-term, prompting the need for regulation. Consequently, banks need to have large enough capital relative to their lending/deposit (or risk) to absorb the default (counterparty risk) shocks. A key form of regulation includes ensuring capital adequacy, and regulation has to be forward-looking (preventative). Stress testing is thus one of the tools for diagnosing risks of failure.

II.2.3   Frameworks for Regulatory Intervention

There are numerous frameworks for early intervention, which are differentiated by the triggers used to activate the intervention and the degree of discretion in choosing measures applied to banks (BIS, 2018). Regulatory authorities conduct early interventions to prompt banks to address observed weaknesses in a timely manner. This is done to remedy the consequences of a failure or run-on bank.

Regulatory interventions can be conducted under formal intervention regimes or regular supervisory frameworks. Formal intervention regimes are developed to improve supervisors' ability to resolve issues posed by weak banks. There are two variants of the formal intervention regime: the prompt corrective action and the early intervention measure. The former uses leverage ratios as triggers, while the latter uses early warning indicators such as supervisory ratings. Early intervention usually measures state-specific triggers for supervisory actions. They include a range of powers to be used and measures to be implemented by banks once triggers are hit. Some of these measures are capital restoration, recovery plans approved by the authorities and deadlines for completing and reporting them. These regimes limit the scope for discretion and judgement, hence, reducing the risk of forbearance. However, the level of discretion is greater when a broader set of triggers (quantitative and qualitative) are considered (BIS, 2018).

Regular supervisory frameworks, on the other hand, are decided by regular on and off-site supervision assessments, which are consolidated through supervisory risk assessment systems. Supervisory powers are activated on a discretionary basis when the soundness of banks is adjudged to be at risk. The performance of banks is rated by assessment systems, which are developed by the supervisory authorities. The assessment involves examining some of the following indicators; capital adequacy; asset quality, liquidity, earnings/profitability and sensitivity to risks. Each financial soundness indicator is rated differently and combined to compute a composite rating (BIS, 2018).

Under both frameworks, stress tests are valuable as they indicate the conditions under which certain triggers are hit. They provide supervisory authorities with the necessary information to conduct timely interventions.

II.3   Empirical Literature Review

From the extant literature, banks' asset quality can be determined by either endogenous or exogenous factors. The endogenous factors are also termed bank-specific factors, including banking operations, efficiency, bank size,

balance sheet and income statements. The exogenous determinants are factors within the macroeconomic environment and competitive factors that affect the banks' operations. Some of these exogenous factors include; lending rate, unemployment rate, business cycles, exchange rate pressure and oil price (Alodayni, 2016; Olusegun, 2016).

Empirical evidence has shown the relationship between varying measures of bank stability and oil price shocks, macroeconomic and bank-specific determinants at both global and domestic levels. For example, Espinoza and Prasad (2010), IMF (2015), Alodayni (2016), and Khandelwal et al. (2016) found a negative relationship between downturns in oil prices and the ratios of NPLs of Banks in the Gulf Cooperation Council (GCC) countries. Olusegun (2016), however, established a positive relationship between oil price shocks and the profitability of DMBs in Nigeria. These studies suggest the existence of a direct and indirect transmission channel between oil prices and the banking sector. Oil price dynamics are directly transmitted to the banking sector through their impact on DMBs' loan portfolios and intermediation activities and indirectly via general changes in the macroeconomy, including government expenditure, exchange rate, interest rates, consumption and investment.

Several studies, including Hoggarth et al. (2005); Dovern et al. (2008); Singh and Majumder (2013); Farayibi (2016); and Adegoke and Oyedeko (2018), assessed the capacity of DMBs to withstand adverse changes to output, exchange rate and interest rates. The findings of Hoggart et al. (2005), Singh and Majumdar (2013), and Farayibi (2016) suggest that the stability of DMBs is adversely affected by negative output shocks. In addition, Dovern et al. (2008) find a positive relationship between the loan write-off ratio and monetary policy rate (MPR) and exchange rate risk.

Numerous approaches and methodologies have been used to conduct stress tests globally, such as Credit Portfolio Flow View, OLS, ECM, VAR, GMM and LASSO principal component estimation techniques. In comparison, Boss (2002) and Adegoke and Oyedeko (2018) used variants of the McKinsey and Co. CreditPortfolioView, Hoggart et al. (2005); Filosa (2007); Dovern et al. (2008); Espinoza and Prasad (2010); and Singh and Majumdar (2013) used different types of VAR models. IMF (2015), Alodayni (2016), and Khandelwal et al. (2016) estimated systems of equations by GMM. Farayibi (2016), on the other hand, made use of OLS and ECM, while Kapinos and Mitnik (2015) employed the LASSO approach alongside a principal component technique. However, most of the VAR-based studies used impulse responses to account for feedback effects from the bank stress back to the macroeconomy. The studies reviewed also used different variables to represent bank stress, such as the loan write-off ratio, return

on equity, slippage ratio, bank profits, the pre-provision net revenue (PPNR) and net charge-offs (NCO) on all loans and leases.

Different scenarios of extreme but realistic events are typically assumed to capture bank stress in the reviewed studies. These are the historical crisis scenarios (Boss, 2002), hypothetical (Filosa, 2007), and tests conducted by supervisory authorities (Kapinos & Mitnik, 2015), while some used sign restrictions. In relation to the macroeconomic variables used, most studies concentrated on output growth, nominal short-term interest rate and the real effective exchange rate.

II.4   Gaps in the Literature

A significant weakness of studies conducted in Nigeria on stress testing of DMBs is that they do not account for the impact of oil price shocks on the banking sector's performance. Given the high level of exposure of Nigerian DMBs to the oil sector, it is essential to evaluate the impact of adverse oil price shocks on the quality of banks' assets. Olusegun (2016), however, assessed the impact of oil price shocks on the profitability of Nigerian DMBs in a non-stress testing framework and found a positive relationship, contrary to the findings from studies on other oil exporters.

Besides, most of the studies reviewed either focused on micro-stress or macro-stress testing without combining both tests to assess the system-wide stability and bank-specific stability. This study attempts to fill this gap by combining both tests and conducting a micro stress test of Nigerian banks to complement a macro study of the banking industry's capacity to withstand adverse shocks.

From the reviewed studies on Nigeria, scenarios of bank stress were not clearly outlined; only the relationship between the proxy of bank stress and risk factors was outlined. Drawing from the characteristics of a well-designed stress test, at least three scenarios should be presented: baseline, adverse and severely adverse scenarios. This study, therefore, incorporates the movement of macroeconomic variables in historical crisis periods when designing its adverse scenarios. This study also conducts out-of-sample forecasts of the variables of interest to provide the magnitude and direction under the different stress scenarios and in-sample projections conducted by the studies reviewed.

III.   Methodology
III.1   Empirical Framework

The bank lending channel of the transmission mechanism provides the theoretical underpinning for this study as it adequately describes how shocks are

transmitted within the economy and how they influence the banking system. Consequently, given the high level of exposure of Nigerian DMBs to the oil and gas sector, a significant fall in crude oil prices is expected to affect the revenues of oil and gas firms, which in turn is expected to affect their capacity to service existing loans. This inability to adequately service loans is expected to adversely affect the balance sheets of DMBs by increasing the value of their NPLs, which has implications for capital adequacy after making provisions. In addition, significant increases in the value of NPLs will cause DMBs to be more risk-averse and issue credit only to credit-worthy borrowers.

In this study, the vulnerability of DMBs is assessed within a simulation framework, where their NPLs are exposed to different levels of oil price shocks, and the projected NPLs under each scenario and forecast horizons are presented. When there is a significant deterioration in the simulated asset quality of the DMBs due to the fall in crude oil price, the DMB will be vulnerable to oil price shocks. If adequate provisions are made, the capital of the DMB remains unaffected; however, if the provisions are inadequate, it will affect the capital. The analysis will be conducted on both the entire banking industry (Macro-stress test) and a sample of 6 DMBs (Micro-stress test) using the NPL ratio due to data unavailability on all the DMBs and on the provisions and capital adequacy ratios (CAR) of the DMBs.

III.1.1 Macro-Stress Test

In line with Hoggart et al. (2005) and Singh and Majumdar (2013), this study models the interaction between the macroeconomy and the banking sector using a structural VAR(X) model. Previous studies investigating the interaction of macroeconomic variables and the banking sector used mainly output growth, inflation and exchange rate as endogenous variables in the VAR model. This study augments theirs by incorporating the ratio of non-performing loans (NPLs) in the Nigerian banking sector as an endogenous variable, while the crude oil price is added as an exogenous variable.

The adoption of the SVAR(X) model for this study is due to its ability to adequately capture the interaction between the real economy and the financial sector using scenario-based simulations generated from exogenous variables. There are various proxies for bank performance, but this study adopted the non-performing loans ratio since it adequately reflects the dynamics of the banking sector and readily available data. When NPLs rise above certain thresholds, they signal impending distress in the financial system, constricting banks' ability to lend in the future. NPLs are also highly sensitive to the business cycle and are expected to reduce during booms since economic agents are economically

empowered to repay loans (Singh & Majumdar, 2013).

Unlike Olusegun (2016), who computed measures of oil price shock, this study utilises adverse movements in the crude oil price to capture shock in oil prices and see how it is transmitted to the performance of the NPLs of banks in the different scenarios envisaged. Therefore, the models in this study are designed to project the NPLs of banks over a future period of 8 quarters (the stress test horizon) under different adverse scenarios in line with the period when crude oil price maintained an average value of less than $50 (2015Q4-2017Q3), which is similar to Hirtle et al. (2015).

Macro-Stress Test Model Specification

We begin by assuming that the following structural form equation can represent the Nigerian economy.

$$Ay_t = \alpha_0 + C(L)y_{t-1} + B\varepsilon_t \tag{1}$$

Where y_t is an n x 1 vector of endogenous variables, y_{t-1} represents a vector of lagged values of the endogenous variables, ε_t is an n x 1 vector of structural disturbances that captures exogenous factors, $C(L)$ refers to a matrix polynomial in the lag operator L, with length p. A is a n x n matrix and B is a column vector with n x 1 dimension, containing the contemporaneous response to the innovations.

Equation 1 can be transformed into its reduced form by multiplying the equation by inverse of matrix A (A^{-1}):

$$y_t = A^{-1}\alpha_0 + A^{-1}C(L)y_{t-1} + A^{-1}B\varepsilon_t \tag{2}$$

Equation 2 can be simplified as seen below:

$$y_t = \varphi_0 + D(L)y_{t-1} + e_t \tag{3}$$

Where: $\varphi_0 = A^{-1}\alpha_0$, $D(L) = A^{-1}C(L)$ and $e_t = A^{-1}B\varepsilon_t$ In order to obtain the underlying structural disturbances from equation 3 above, $A^{-1}B\varepsilon_t$ is estimated from the residual (e_t) of the unrestricted VAR.

$$A^{-1}B\varepsilon_t = e_t \tag{4}$$

Equation 4 can be written as $A^{-1}B\varepsilon_t\varepsilon_t'B'A'^{-1} = e_t e_t'$ and given that $e_t e_t' = 1$, equation 5 is transformed as follows:

$$A^{-1}BB'A'^{-1} = e_t e_t' \tag{5}$$

Restrictions are imposed on the VAR model above to convert it to a structural model. The non-recursive technique of imposing restrictions was employed based on economic theory and knowledge of the economy, and we have the

equation below in which e_t is the source of variation in the VAR analysis:

$$Ae_t = B\varepsilon_t \tag{6}$$

Equation 6 can be further simplified as:

$$y_t = \delta + \sum_{j=1}^{p} \Phi_j \, y_{t-1} + \omega_j d_{t-1} + e_t \tag{7}$$

Where δ is a constant vector, Φ_j are matrices and e_t is a vector of shocks, y_{t-1} represents a vector of endogenous variables and d_{t-1} is a vector of endogenous variables. The endogenous variables include LEXR (log of Bureaux de Change (BDC) exchange rate), YG (output growth), INF (inflation rate) and NPL (non-performing loans), while the crude oil price is the exogenous variable.

In relation to restrictions and ordering, exchange rate is placed first in the VAR model and is influenced by only output growth contemporaneously (Zubair et al., 2013). Inflation is contemporaneously affected by BDC and output, while BDC and inflation determine output growth. NPL is placed fourth to allow for the effect of the BDC, inflation and output growth. As seen below, the oil price shocks will be captured by nominal changes in the crude oil price. These restrictions are imposed on the models to reflect the economic interactions between the variables and to limit the impact of NPL on the other variables.

Therefore, the restrictions above can be presented in a 4 X 4 matrix as seen below:

$$y_t = \begin{bmatrix} 1 & 0 & a_{13} & 0 \\ a_{21} & 1 & a_{23} & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & a_{43} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{LEXR} \\ \mu_t^{INF} \\ \mu_t^{YG} \\ \mu_t^{NPL} \end{bmatrix} = \begin{bmatrix} \beta_{11} & 0 & 0 & 0 \\ 0 & \beta_{22} & 0 & 0 \\ 0 & 0 & \beta_{33} & 0 \\ 0 & 0 & 0 & \beta_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{LEXR} \\ \varepsilon_t^{INF} \\ \varepsilon_t^{YG} \\ \varepsilon_t^{NPL} \end{bmatrix} \tag{8}$$

Where $\mu_t^{LEXR}, \mu_t^{INF}, \mu_t^{YG}$ and μ_t^{NPL} are structural disturbances relating to the exchange rate, inflation, output growth and non-performing loans, respectively. On the other hand, $\varepsilon_t^{LEXR}, \varepsilon_t^{INF}, \varepsilon_t^{YG}$ and ε_t^{NPL} are the reduced form residuals that describe the unanticipaed movement of each regressor. The estimations are conducted for the period 2007Q1-2020Q4 and projections of the NPLs are obtained for the period 2021Q1-2022Q4 used for the vulnerability analysis. For robustness and to assess the model's sensitivity to a change in sample size, a similar analysis is also conducted over the 2007Q1-2016Q4 period, with projections over the 2017Q1-2018Q4 period for robustness.

III.1.2 Micro-Stress Test (Individual Banks)

Due to the sensitive nature of data involved, the results of stress tests do not explicitly identify individual banks because of ethical and legal considerations.

To avoid this risk, the CBN, in the bi-annual Financial Stability Report (FSR), groups the DMBs into large, medium-sized, and small banks, depending on their asset size. Therefore, the DMBs will not be identified by name to circumvent this challenge in this study. Instead, in the presentation of results, the identity of the banks will be represented by randomly chosen alphabets.

The consolidation and recapitalisation exercises of 2015 led to several mergers and acquisitions among the DMBs, as such, extensive datasets on some banks are non-existent and represent a major limitation of the study. This drawback is addressed by focusing on banks with an extensive dataset covering the entire study period. The end period of the estimation is 2020Q4, which is chosen so that the findings of this study have no direct bearing on the current financial state of the studied banks and to circumvent the challenge of data paucity. As such, the micro-stress tests will cover six (6) DMBs in Nigeria (4 with international[3] banking license and 2 with national bank license).

Scenario Design

The scenarios are divided into three: baseline, adverse and severely adverse. The baseline scenario will reflect the last recorded values of the variable to be shocked to observe the interaction between the variables ceteris paribus. The scenarios are designed using a combination of historical and hypothetical propositions. The oil price value during the severely adverse scenario is based on the lowest crude oil price recorded during the sample period (January 2016), while the adverse scenario is a 50% increase over the severely adverse scenario. This fall is projected to last for two years (8 quarters), similar to the scenarios in the studies conducted by Boss (2002) and Hirtle et al. (2015). This duration is also the same as the 2015Q4 – 2017Q3 period when the average oil price was below $50 per barrel.

Table 3: Stress Testing Scenarios

Variable	Baseline	Adverse	Severely Adverse
Oil Price	$69.3	$45	$30

Source: Authors' Conception.

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[3]National Banks are authorised to conduct business on a national basis (within every State of the Federation), while international banks are to conduct business on an international basis (within all the States of the Federation, as well as to establish and maintain offshore banking operations in jurisdictions of its choice, subject to CBN approval). National and International banks are required to have a minimum capital base of N25 billion and N50 billion, respectively.

III.2 Data and preliminary tests

The data used in both the micro and macro stress tests were sourced from the Central Bank of Nigeria database. The required variables include GDP growth rate, inflation rate, BDC exchange rate, oil price, industry wide NPLs and bank specific NPLs for six DMBs. The analyses are conducted over two data sample periods for robustness and to assess the sensitivity of the results to change in the sample sizes (2007Q1-2020Q4 and 2007Q1-2016Q4).

The unit root properties of the variables using both the Augmented Dickey-Fuller (ADF) and Philips-Peron (PP) unit root tests are presented in Table 2

Table 4: Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) Tests

	LEVELS		*FIRST DIFFERRENCE*	
Variable	*ADF*	*PP*	*ADF*	*PP*
LOP	-1.78	-2.00	-5.16***	-4.99***
LEXR	-0.64	-0.38	-4.67***	-4.58***
INF	-2.65	-2.21	-5.84***	-5.75***
YG	-1.12	-1.32	-6.35***	-6.40***
NPL	-2.25	-1.98	-4.63***	-4.64***

The asterisk *** and ** indicated statistical significance at 1% and 5% levels, respectively.

Following the ADF and PP tests, we do not reject the null hypothesis of nonstationary at the 5.0 per cent significance level in their level forms, implying the variables were not stationary in their level forms. However, in their differenced form, we rejected the null hypothesis on nonstationary at the 5.0 per cent significance level and concluded that the variables are first difference stationary. In sum, the log of oil price (LOP), log of exchange rate (LEXR), inflation rate (INF) and GDP growth rate (YG) and non-performing loans ratio (NPL) were all found to be the first difference stationary.

Before conducting the simulations, the SVAR-X system of equations was subjected to the stability and lag length criteria tests. All the traditional lag length criteria, except the Schwartz Criteria, suggested an optimum lag length (see Appendix). Again, the stability test results show that all the inverse roots of the characteristic polynomial of the differenced primitive VAR are within the unit circle. As such, the model is considered stable (see Appendix).

IV.0 Results and Interpretations
IV.1 Results of the Macro Stress-Test with SVAR-X
IV.1.1 Impact of Oil Price on Industry NPLs (Macro Simulation Results)

In relation to the impact of adverse oil price shocks on the NPL ratio of the banking system, three scenarios were created. The first is the baseline scenario in which the crude oil price of $69 was sustained through the 2021Q1-2022Q4 period. In the second and third scenarios, the crude oil price fell to $45 and $30, respectively, through the 2021Q1-2022Q4 period.

The results suggest that in the baseline scenario, the NPL ratio will decline to 4.84 per cent in 2021Q1 from 6.02 per cent in 2020Q4 and remain below the regulatory benchmark through the forecast horizon. However, in scenario 1, when the oil price falls to $45, the NPL ratio would initially decline to 5.39 per cent in 2021Q1 and start rising from 5.85 per cent in 2021Q2 to 12.76 per cent in 2022Q4.

Figure 1: Impact of Crude Oil Price on the Banking Industry's NPLs
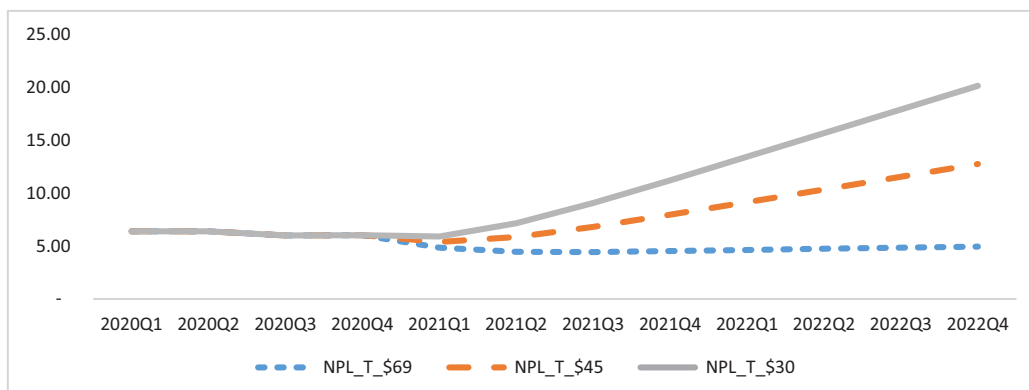
Source: Authors' Compilation.

However, in scenario 3 the NPL ratio is observed to rise all through the forecast horizon, recording 20.17 per cent in 2022Q4. In relation to the magnitude of the NPL ratio across scenarios, it can be observed that for corresponding periods, a fall in crude oil price led to a rise in the NPL ratio by a higher amount, with the $30 crude oil price scenario recording the highest NPL value, followed by the $45 scenario and the $69 scenario. The findings connote that adverse crude oil price shocks will cause NPLs to remain above the regulatory benchmarks, implying distress in the banking sector if nothing is done. These results corroborate the findings by the IMF (2015) and Olusegun (2016), further revealing the level of exposure of the entire banking system to oil price shocks. As such, when oil price declines substantially, some level of distress in the banking industry should be

expected. The results of the simulations using the baseline scenario are similar to the outcomes using actual values of NPL in 2021, when the NPLs averaged 5.84 per cent with average crude oil price of $70 pb.

To assess the sensitivity of the results to variations in scope, the same analysis was conducted over the sample size of the period 2007Q1-2016Q4, and similar results were obtained (Appendix D).

IV.2   Micro SVAR-X Results

The stress tests were conducted on the individual banks as depicted in figure 2 (panels A – F) with different banking license categories. In relation to the impact of adverse oil price shocks on the NPL ratio of the individual banks, three scenarios were created akin to the macro analysis conducted earlier in Section 4.1. The results are analysed based on the banking license category of the DMBs (national and international license). Banks A and B possess national banking licenses while banks C-F possess international banking licenses.

The results in Figure 2a suggest that the asset quality of banks A and B are sensitive to oil price changes, similar to the findings by the IMF (2015). The baseline scenario for bank A suggested that the NPL ratio would decline if the crude price remained unchanged. However, successive declines in the crude oil price to $45 and $30 would result in a corresponding increase in the NPL ratio across the two banks, with the decline to $30 recording the highest NPL ratio across the banks above the regulatory benchmark.

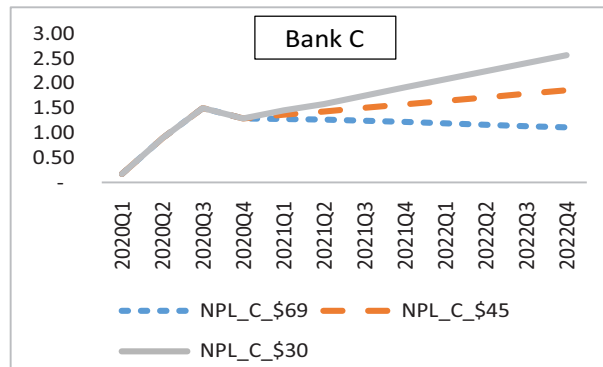**Figure 2a: Impact of Oil Price Shocks on Banks A and B**
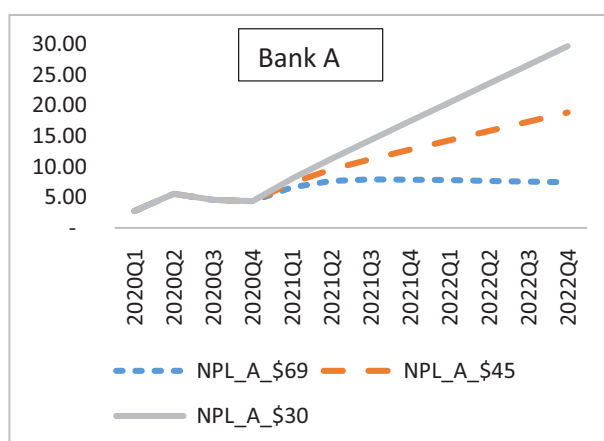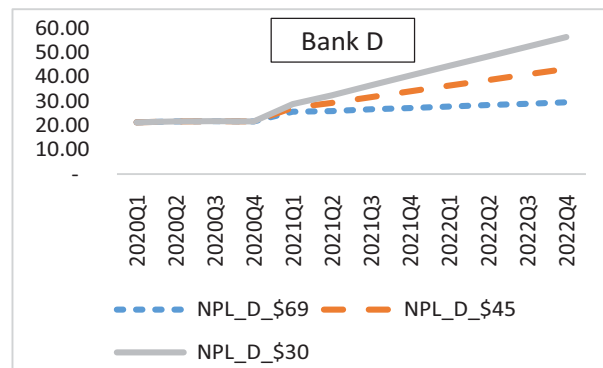

Source: Authors' Compilation.
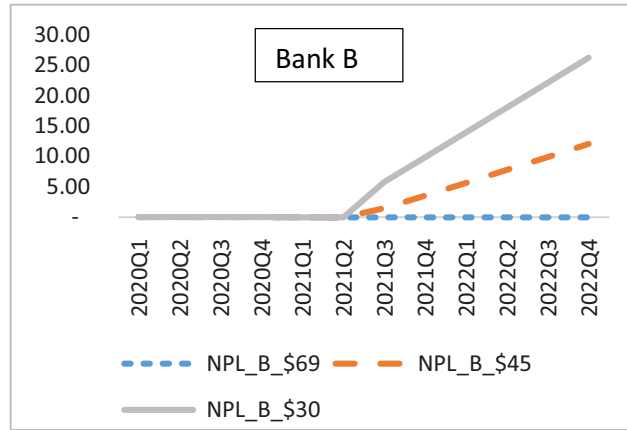
Source: Authors' Compilation.

In relation to the DMBs with international banking licenses (banks C, D, E and F in Figures 2 b&c), the baseline scenario led to an increase in the NPL ratio across the banks. When crude oil price declines to $45 and $30, the NPL ratio across the four banks increased significantly, with the highest ratio decline recorded when the crude oil price falls to $30, relative to the baseline scenario.
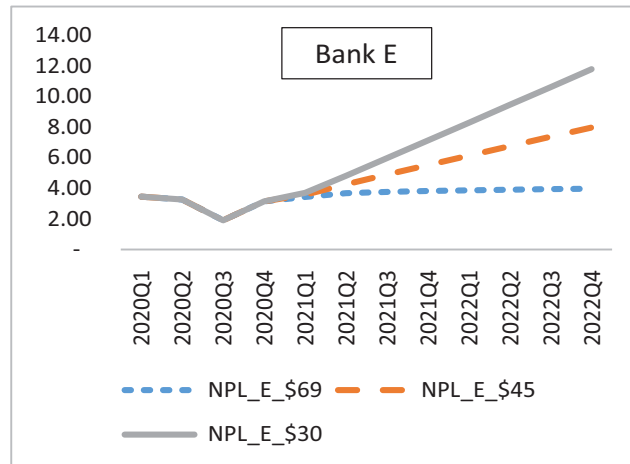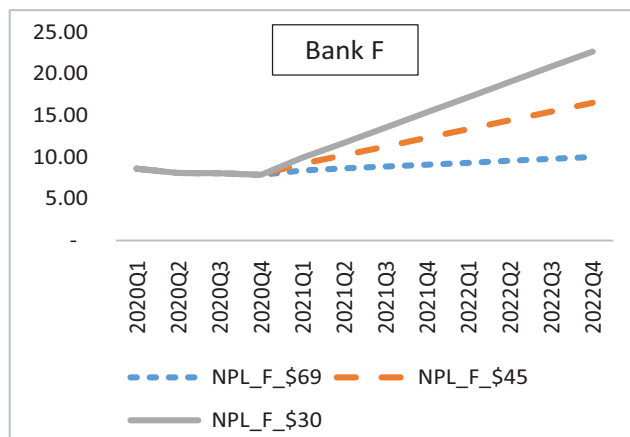
Figure 2b: Impact of Oil Price Shocks on Banks C and D

Source: Authors' Compilation.

Source: Authors' Compilation.

Figure 2c: Impact of Oil Price Shocks on Banks E and F

Source: Authors' Compilation.

Source: Authors' Compilation.

The results showed that banks with both license categories were susceptible to oil price shocks at varying degrees, implying that bank size does not insulate DMBs from oil price shocks. The heterogeneous reaction of the banks to changes in oil price could be because of the varying levels of exposure of the banks to the oil sector; as such, an in-depth analysis of the loan profile of each bank would provide further details. To assess the robustness of the results, the same analysis was conducted over the 2007Q1-2016Q4 sub-sample in the period, and similar outcomes were obtained (See Appendix E).

V.   Summary Conclusion and Recommendations

The objective of this study was to examine the vulnerability of the entire banking industry and individual banks to adverse oil price shocks. A stress testing framework was adapted using the Structural VAR-X technique to achieve this

objective. The SVAR-X technique was adopted due to its ability to capture the interaction between the real and financial sectors using scenario-based simulations and exogenise the shock variables. The framework involved simulating adverse shocks' impact on banks' asset quality using three different scenarios. The findings of this study established the vulnerability of the entire banking industry and individual banks to adverse oil price shocks. Across all the scenarios assessed, banks' asset quality was found to deteriorate when oil prices fell. In relation to the micro analysis, both categories of DMBs (national and international licenses) were found to be susceptible to oil price shocks at varying degrees due to their high exposure to the oil and gas sector.

The findings of this study indicate that the asset quality of individual banks and the entire banking industry are sensitive to crude oil prices and that lower crude oil prices negatively affect the NPL ratio of both individual banks and the entire banking industry. Implying that the high obligor concentration towards the oil sector has a significant bearing on banking system's stability. Thus, appropriate financial policy is required to ensure that the banking sector and individual banks remain resilient.

The findings also suggest that the financial stability of some DMBs does not equate to the stability of the entire banking industry. This lends further credence to the argument that macro and micro prudential characterisation of risks is important for assessing financial system stability. This accounts for the shift in emphasis from micro-prudential analysis to macro prudential analysis. This study recommends that the CBN and DMBs take cognisance of the banking systems' vulnerability to oil price shocks by ensuring strict compliance with the single obligor limit to restrict their exposure to oil and gas companies. Further studies on the impact of the deterioration in asset quality on the capital adequacy of DMBs[4] are also recommended.

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[4]This analysis was not conducted in this study due to data limitations.

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Appendices

Appendix A: Lag Length Criteria Test

VAR Lag Order Selection Criteria						
Endogenous variables: D(LEXR) D(YG) D(NPL_T)						
Exogenous variables: C D(LOG(COP))						
Included observations: 43						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-137.75	NA	0.16	6.69	6.93*	6.78
1	-124.7	23.05*	0.13*	6.50*	7.11	6.72*
2	-116.99	12.56	0.14	6.56	7.54	6.92
3	-114.6	3.71	0.20	6.86	8.21	7.36
4	-103.8	14.43	0.19	6.78	8.50	7.42

LR: sequential modified LR test statistic (each test at 5% level)
 FPE: Final prediction error, AIC: Akaike information criterion
SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

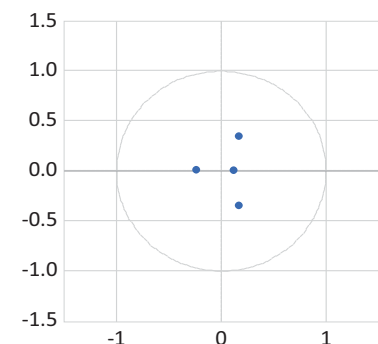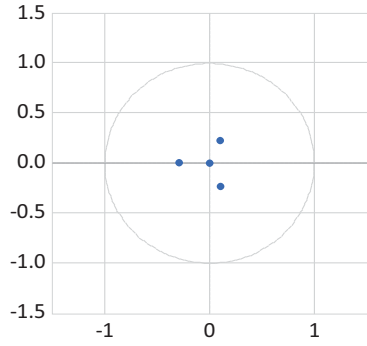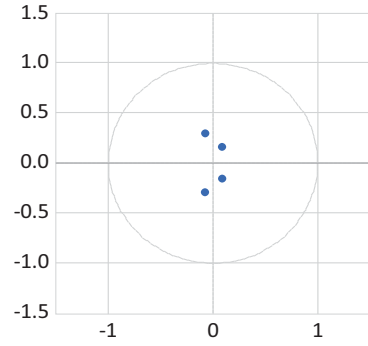### Appendix B: Model 1 VAR Stability Test

Inverse Roots of AR Characteristic Polynomial
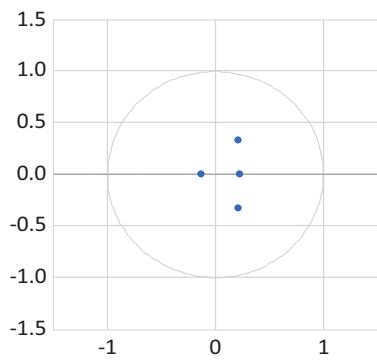
Inverse Roots of AR Characteristic Polynomial
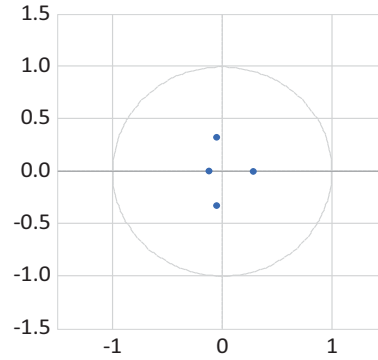
Inverse Roots of AR Characteristic Polynomial
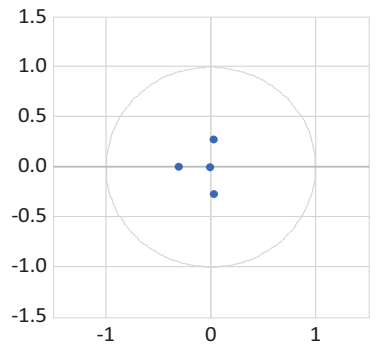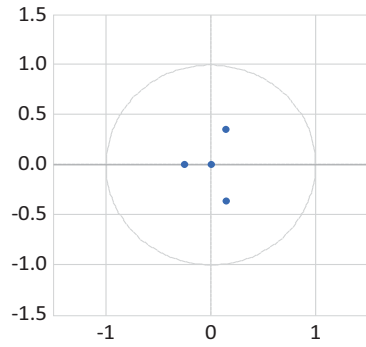

Inverse Roots of AR Characteristic Polynomial

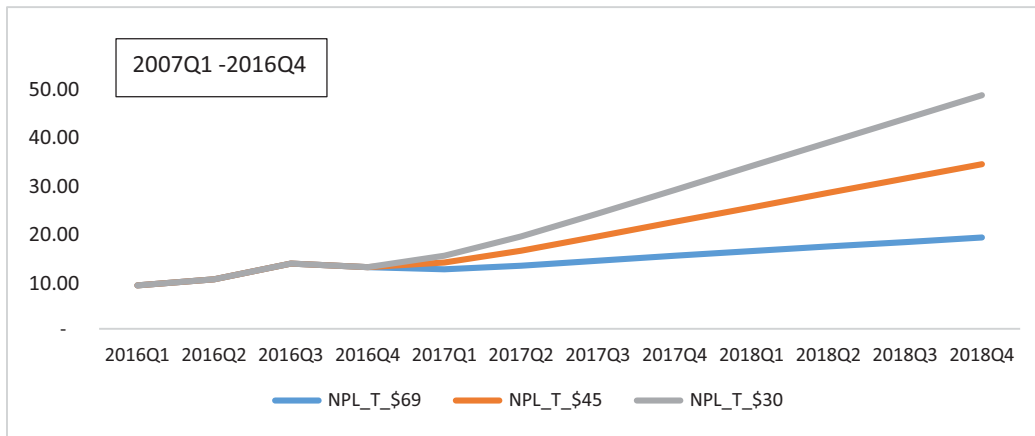Inverse Roots of AR Characteristic Polynomial

Inverse Roots of AR Characteristic Polynomial

Inverse Roots of AR Characteristic Polynomial

Appendix D: Impact of Crude Oil Price on the Banking Industry's NPLs

2007Q1 -2016Q4

Appendix E: Impact of Crude Oil Price on NPLs of DMBs (2007Q1-2016Q4)

Bank A

Bank B

Bank C

Bank D

Bank E

Bank F