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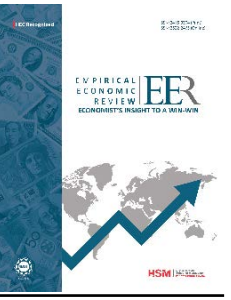

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| **Author (s):** | Reinhold Kamati, Anna William, Gerson Kadhikwa , Postrick Mushendami |
| **Affiliation (s):** | Bank of Namibia, Windhoek, Namibia |
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University of Management and Technology, Lahore, Pakistan

# Macro-Stress Testing of Non-Performing Loans (NPLs) in the Banking Sector of Namibia: A Vector Autoregressive Approach (VAR)

Reinhold Kamati*, Anna William, Gerson Kadhikwa, and Postrick Mushendami

Bank of Namibia, Windhoek, Namibia

## Abstract

The current paper aimed to examine the impact of macroeconomic variables, namely real GDP growth, house price growth, and changes in the repo rate on the non-performing loan (NPL) ratio in Namibia using the data from 2004Q1-2020Q1. The current study used a vector auto-regressive (VAR) model and impulse response analysis to estimate the impact of changes in macroeconomic conditions on NPLs. Furthermore, stress testing was conducted on the NPL ratio over 4–6 quarter horizons. Empirical evidence showed that macroeconomic variables, such as real GDP growth rate, house price growth rate, and the repo rate have a statistically significant and material impact on NPLs in the banking sector of Namibia. It was determined that a positive growth rate shock in a quarter would reduce the NPL ratio by more than half a percentage point over two quarters. Similarly, a positive shock of about 4.0% in a quarter would reduce the NPL ratio by more than 1.2% points over four quarter horizons. Macro-stress testing results revealed that a deterioration of the GDP growth rate by more than one standard deviation would increase the NPL ratio from 2.46% to 2.78% over four-quarter horizons. Meanwhile, the combined effects of deteriorating the GDP growth rate and falling house prices further exacerbated the banking sector's vulnerability. The current study contributes towards understanding the interplay between macroeconomic conditions and financial sector resilience in Namibia. It shows that macro-stress testing techniques help to study the importance of macro-financial and feedback effects from the financial sector to the real economy. Technically, central banks must develop models that capture essential macro-financial and feedback effects. Regulatory attention must be devoted to monitoring spill-over effects from worsening financial conditions in the real economy.

* Corresponding Author: reinhold.kamati@bon.com.na

***Keywords:*** financial stability, macroprudential oversight, macro-stress testing, non-performing loans, VAR

## Introduction

Since the global financial crisis of 2008–09, regulators and industry practitioners have integrated stress testing into their regulatory and managerial frameworks for financial stability. According to Bellini (2017), stress testing and "what-if analysis are cutting-edge tools qualifying a risk management practice operating in a global economy." For regulators, macro-stress testing tools enable supervisors to detect (ahead of time) the relevant transmission channels of extreme but still plausible events affecting the financial system's stability. Thus, the crucial role of macro-stress testing techniques cannot be over-emphasized, as these techniques allow analysts and regulators to assess feedback effects to conduct and formulate a forward-looking analysis of potential risks for the banking system (Amediku, 2006).

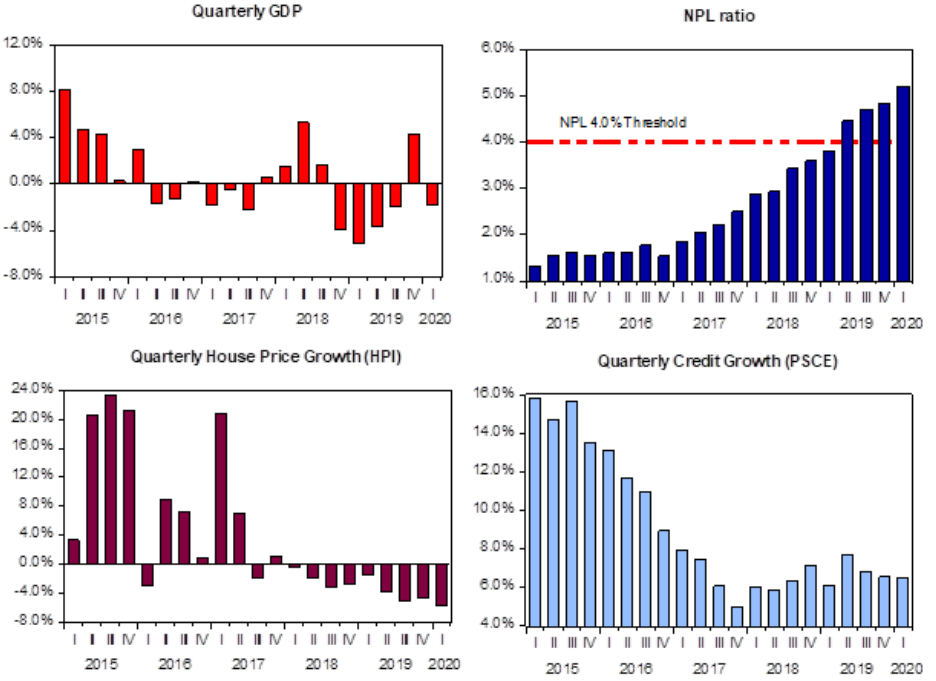
Macroeconomic conditions in Namibia have deteriorated with significant adverse effects on the economic and financial resilience of the domestic banking system. Figure 1 below shows the development of selected economic indicators in Namibia for the past four years. These macroeconomic indicators have deteriorated, with significant impacts on asset quality in the banking sector. This deterioration was triggered mainly by various demand and supply shocks that battered the economy from 2015-2020. These shocks include the severe rain drought recorded from 2015-2017, low commodity demand, and low international prices over the same period. As a result of these economic shocks, Namibia's average real GDP growth slowed into recession and remained far below the growth potential level from 2015 onwards. Meanwhile, the fiscal policy became unsustainable, and public debts increased from 37.2% in 2015 to an estimated 67.5% of the GDP in 2020; the later debt ratio is far above the fiscal target of 35%. Consequentially, credit to the private sector has slowed down from 15.8% in 2015Q1-6.5% in 2020Q1, and non-performing loans more than quadrupled from 1.0% in 2012Q1-5.3% in 2020Q1; again, this ratio is far above the 4.0% threshold for the NPL ratio in Namibia[1].

[1] The threshold level of 4.0% is set by the Bank of Namibia as a point at which the level of NPLs should be deemed a concern to the banking sector.

Although the asset quality of the banking sector as measured by NPL has been historically stable, the recent upsurge in the NPLs ratio calls for a thorough interrogation of the macro-financial linkages between economic growth, house prices, and the banking sector's asset quality in Namibia. The pertinent question is, has the economic slowdown affected the banking sector's asset quality in Namibia? Looking ahead, what happens if the domestic macroeconomic environment is distressed further than that which has been observed so far? The current study addressed the selected questions from a macroprudential perspective without duelling the microprudential of individual institutions in the financial system in Namibia.

**Figure 1**

*Macroeconomic Conditions in Namibia, 2016Q1-2020Q1*




In the last decade, Namibia maintained real economic growth above the potential level; in response, the NPL ratio slowed to the lowest level over the same years but this ratio has drastically increased since 2017Q1. The deterioration of macroeconomic conditions and the acceleration of the NPL ratio is a cause for concern for the central Bank of Namibia and the public

at large. According to the Bank of Namibia (2020), on the assessment of financial stability, there is a high risk in asset quality in 2019 compared to the level of risk reported in December 2018. For example, Namibia's NPL ratio has risen by 2.9% from 1.6% in the second quarter of 2016-4.5% in the second quarter of 2019. This increase in NPLs could largely be attributed to the continued depression of actual economic activities that have characterized the Namibian economy for the last four years. In addition, with the onset of COVID-19 in late 2019, the real economic impact was further expected to continue the erosion of asset quality in the financial sector beyond 2020. This calls for a thorough understanding and conducting an analysis of macro-financial and feedback effects on the real economy.

## Objectives of the Study

The current study examined the impact of adverse macroeconomic shocks on NPLs in the banking sector in Namibia. Using the VAR technique, the NPL ratio was stress-tested by varying the degree of deterioration in macroeconomic variables such as real GDP and house price index at four to six-quarter horizons. The aim of employing the stress test scenario (i.e., the "What if analyses") was to get insights into the dynamic interactions between the NPL ratio and the changes in macroeconomic conditions. This study contributed rare empirical evidence on how asset quality (as measured by the NPL ratio) in Namibia responds to varying degrees of stress from macroeconomic indicators such as real economic growth and house prices. Macro-stress results showed that asset quality is resilient to standard shocks or historical averages within one standard deviation. However, results from varied scenarios showed that the NPL ratio increased when macro-stressed with a high deterioration in real growth rate and low house prices of more than two standard deviations over four quarter horizons. In addition, asset quality deteriorated more when these shocks were combined over the same period. Overall, this study fills the gap of the interplay between the financial sector and the real economy. The macro-stress testing techniques laid bare the importance of understanding the dynamics and transmission channels of macro-financial and feedback effects in the economy. Hence, understanding the macro-financial links and feedback effects would help the central banks to close the gap in a macroprudential mandate by designing effective regulations that prevent systemic risk in the economy.

The current paper is organized as follows: section 2 presents the literature review, which covers the importance of macro-stress testing and evidences from the previous studies of stress-testing the aggregate NPL ratio - a measure of asset quality in the banking sector. The current study follows a rationale of the vector autoregression (VAR) method used in the empirical analysis, data sources, and descriptive statistics of the elements in the dataset. The empirical results are reported in section 4, and lastly, the paper is concluded by summing up the empirical findings.

## Macro-Financial Stress Testing of NPLs: A Review

Since the Global Financial Crisis (GFC) of 2008–09, both regulators and industry practitioners have increased the role of macro-stress testing in their regulatory and managerial frameworks for the banking sector. According to Bellini (2017), stress testing or "what-if analysis" are cutting-edge tools qualifying a risk management practice operating in a global economy.' For regulators, stress testing tools enable supervisors to detect (ahead of time) the relevant transmission channels of extreme but still plausible events affecting the financial system's stability. For example, stress testing (as a way of producing counterfactuals) is exercised in the European Union, where systematically important banks are expected to participate annually in the EU-wide stress test exercises. Often ultimate aim of this exercise is to assess the resilience of financial institutions to adverse financial and economic shocks (European Systemic Risk Board, 2020). According to Borio et al. (2012), the analytical results from macro-stress have revealed potential risks to which financial sectors in various countries are exposed, and the nodes of vulnerability in those financial systems are established.

Macro-stress tests are designed to stress the financial system as a whole, thereby understanding the impacts of systemic risk; the stress test results are often threefold. Marcelo et al. (2008) pointed out that these include but are not limited to: adding value to the internal controls exercised by banks concerning risk management; serving as a basis for fostering prudential techniques of protection against adverse situations; and facilitating the identification of macro-financial and systemic risks, providing early warning and helping to mete out the response tasks to deal with these adverse situations. Meanwhile, Borio et al. (2012) hypothesized that a stress-testing exercise must constitute three essential parts: (i) a *scenario with* (exogenous) shocks that stress the identified risk exposures (e.g. the bank balance sheets), and (ii) a well-defined *model* (VAR or DSGE) that

maps those shocks onto an outcome, and (iii) a measured *outcome* (e.g., NPLs). Stress tests (*when conducted through a well-defined model*), therefore, seek to determine the banking system's resilience to shocks to determine the financial system's health and stability.

A macroeconomic-based stress testing exercise aims to establish the links between macroeconomic variables and the financial system under adverse conditions. The stress testing exercise entails assessing the stability of groups of financial institutions by evaluating the responses of some aggregate sector indicators, such as the financial stability index or non-performing assets, to adverse shocks. Furthermore, this constitutes identifying the main risk drivers and possible sources of vulnerabilities that have the potential risk of generating financial sector instability. Generally, there are important variables for macro-stress testing exercises, which include: real GDP, inflation, equity prices, market volatility, real estate prices, and interest rates. Furthermore, essential indicators (*gap-measures*) such as the private sector credit gap, real effective exchange rate gap, and interest rate spread gap have been used to detect the build-up of bubbles in the financial sector ahead of time.

Numerous studies have been developed on the relationship between macroeconomic conditions and NPLs to explain the main drivers of non-performing loans over time. According to the Bank for International Settlements (2016), loans become non-performing when a borrower no more extends services to the debt for a determined time, usually a delinquency status (90 days past due) or the unlikeliness of repayment. Reviewing the literature, there is no common variance factor on what drives NPLs, because of differential initial conditions that prelude the pass-through from the real sector side of the economy to the banking sector. The set of drivers identified in various studies seems to evolve from region to region over time. Hence, it is imperative to revisit the questions: What are the drivers of NPLs and what are the theoretical underpinnings of NPLs within the banking sector? How do macro-financial risks impact the bank's asset quality before they become a systemic problem? Further, why is there a prevalence of NPLs during certain times compared to other times? Firm answers to these questions fill the gap in the interplay between the real economy and the financial sector, which has been largely neglected in macroeconomic studies.

The deterioration of macroeconomic variables such as output gap, economic growth, and inflation affects the performance of the banking sector; similarly, stress testing asset quality reveals the feedback effects on the real economy from the financial sector. The literature showed that this channel is bi-directional rather than uni-directional because consensus prevails that high NPLs negatively impact bank lending in the real sector economy. As argued by the European Central Bank (2017), deterioration of bank balance sheets, coupled with a low profitability ratio, constrains the capacity to lend, further reinforcing economic slowdown. Using quarterly data for 1995–2005, Amediku (2006) estimated the impact of changes in some macroeconomic variables on the NPL ratio of the Ghanaian banking system through a VAR model. The study found that the banks' NPL ratio increased following an adverse shock to output and an increase in inflation. This result was supported by the impulse response functions indicating that the NPL ratio increased after eight quarters following an unexpected increase in the output gap. In contrast, it increased after nine quarters due to an unexpected increase in inflation (Amediku, 2006). In addition, Amediku (2006) found that an unexpected increase in the prime lending rate led to a significant increase in the NPL ratio, at a maximum of six quarters post the prime lending rate shock.

Dovern and Vilsmeier (2008) indicated that monetary policy shocks strongly increase distress in the banking sector in Germany. The study used data that stretched over 36 years, including four complete business cycles, with the leading indicator being the write-off ratio. The study employed a structural VAR on macroeconomic variables such as real GDP, inflation, and the 3-month interest rate. The study identified and assumed a negative monetary policy shock, a negative demand shock, and a negative supply shock. Dovern and Vilsmeier (2008) found that a tightening monetary policy shock significantly worse the soundness of the banking sector, which is reflected in a substantial increase in write-offs and a considerable decrease in return on equity. On the contrary, both the demand and supply shocks caused limited and less severe declines in return on equity and did not cause remarkable changes in the level of write-offs. The results suggest that monetary policy decisions are of utmost importance for financial stability in the banking sector.

Banerjee and Murali (2015) analysed the soundness of banks in India by identifying factors that adversely influence banks' non-performing assets

(NPA). In this study, the authors examined the response of banks' NPA to unexpected shocks from external and domestic macroeconomic factors, namely the interest rate, GDP output gap, inflation rate, the cash reserve ratio (CRR) exchange rate, and net foreign institutional investor (FII) inflow. Banerjee and Murali (2015) found that interest rate significantly impairs asset quality for all banks in a two-way causality. In the case of public banks, the NPA was found to be Granger caused mainly by the exchange rate, net FII flow, and deposits. For old private and foreign banks, NPA was Granger caused by the GDP gap (Banerjee & Murali, 2015).

Morakinyo et al. (2018) investigated the role of non-performing loans in the Nigerian banking system and the macroeconomy. The study used a structural auto-regressive model with quarterly data from 1998-2014. Morakinyo et al. (2018) found a long-term impact on NPLs from the macroeconomic shocks in Nigeria. Furthermore, the study showed that the exchange rate did not significantly impact the NPL ratio; however, the authors found that NPLs rose significantly in response to a shock from the GDP growth rate, bank liquidity ratio, return on assets, lending rate, and the bank total credit to the private sector. From the variance decomposition results, Morakinyo's results showed that the NPL ratio explained about 5% of variations in the bank liquidity ratio and 5% in return on assets and exchange rate.

Jiang et al. (2018) found a significant relationship between macroeconomic variables and NPLs in China. The study adopted a VAR approach to stress test the NPL ratio using key macroeconomic factors from 2000Q1-2013Q3. Jiang's study analysed macroeconomic factors such as real GDP growth, unemployment, fixed investment, real estate price indexes, money supply, interest rates, exchange rate, and retail price index (RPI). Multivariate scenarios were mapped against potential risks to assess the banks' overall loan portfolio and mortgage exposures in China. For scenario design, these authors applied different macroeconomic shocks to replicate historical shocks that occurred in past financial crises. The analysis indicates a significant negative relationship between the NPL ratio and GDP growth, unemployment, interest, and exchange rates.

A study by Sheefeni (2015) found that Namibia's macroeconomic environment is critical for its non-performing loans performance. The study analysed the impact of macroeconomic determinants on NPLs in Namibia using quarterly data from 2001Q1-2014Q2, with the main variables of

NPLs, GDP, interest rate, and inflation rate. The impulse response functions revealed that NPL is significantly influenced by real GDP, inflation, and interest rates in the long term; however, in the short term, this is only true for the log of GDP and exchange rate. Sheefeni (2015) posited that the macroeconomic environment is therefore critical for the performance of NPLs and should continue to be monitored, given that it has a bearing on the performance of many economic sectors as well as the banking sector.

In summary, this literature review revealed a bi-directional relationship between changes in macroeconomic conditions and non-performing loans. There is a significant link between changes in macroeconomic conditions and financial system stability. When real growth in the domestic economy occurs, these changes increase financial system vulnerability. Furthermore, the effects of an economic slowdown are manifested in the decrease of credit supply, contraction of monetary conditions, and a prolonged economic recession. In addition, the loop-back effects show up in low profitability and inadequate capital ratios, further constrained lending, and heightened financial instability. Low profitability and inadequate capital in systematically critical financial institutions amplify the systemic risk in the economy. Thus, it is essential to carry out macro-stress testing exercises to identify the main areas at risk of the worsening macroeconomic environment in the domestic economy. Stress testing exercises date back many years, and stress testing methods have evolved from a value-at-risk approach to regression-based techniques such as vector auto-regressive models[2].

## Methodology: VAR Model Set-Up, Data and Estimation

The current study scrutinized the Vector Auto-regression (VAR) model to estimate the dynamic system for deriving the macroeconomics impacts on NPLs. Furthermore, the current research applied varying degrees of stress on the NPL ratio within the VAR system to examine how the NPL ratio responds to deterioration in real GDP and house price growth shocks. Procedurally, a VAR representation aimed to capture interrelations and produce significant joint dynamics among a set of variables of interest in the analysis. Thus, the VAR model is an appropriate technique to examine

[2] There are studies that provide a chronological genesis and the introduction of stress testing in the field of financial stability. These studies discussed stress-testing nature and its purpose (e.g., Blaschke et al., 2001; Cihak, 2007; Jones et al., 2004).

dynamic relationships where the estimated effects run both ways among variables of interest. One important condition to estimate the VAR model is that such a model should be representative; that is, the VAR must adequately describe the data generating processes of the endogenous variables involved in the system. Working with an adequate system is essential in VAR analysis because a representative system would produce good conditional and unconditional forecasts. This property is fundamental when the estimated VAR system is used in the stress testing exercise. In terms of deploying this modelling technique in the macro-stress testing analyses, a VAR model is appropriate because it allows for precise exogenous interventions such as the "What if analysis" illustrated in Bellini (2017). A VAR (p) with p-th lag length is a representation for a set of variables $y_{1t},...,y_{mt}$ grouped in the m↠1 *vector*: $y_t = (y_{1t},...,y_{mt})'$ is stated as follows:

$$y_t = \mu + \psi_1 y_{t-1} + \psi_p y_{t-p} + \varepsilon_t \quad (1)$$

whereby $\mu$ is $m \times 1$ vector of intercept and $\varepsilon_t$ is $m \times 1$ column vector of error terms grouped into $\varepsilon_t = (\varepsilon_{1t},...,\varepsilon_{mt})'$. Generally, $\varepsilon_t$ is assumed to be a white noise process, where $\Sigma$ stands for variance-co-variance matrix. Therefore, with mild conditions of $\varepsilon_t$, $y_t$ is stationary. VAR(p) can be written in the moving average (MA) form as follows:

$$y_t = \psi^{-1}(L)\varepsilon_t = \theta(L)\varepsilon_t, \varepsilon_t\ WN(0,\Sigma). \quad (2)$$

Since $\Sigma$ is a positive definite, there exists a non-singular matrix P such that $P \Sigma P' = I$. Using this identity, we can therefore write Equation (2) as:

$$y_t = \theta(L)P^{-1}P\varepsilon_t = \psi(L)\upsilon_t \quad (3)$$

Note:

$$\upsilon_t = P\upsilon_t \quad (4)$$

$$E(\upsilon_t) = 0, E\left(\upsilon_t, \upsilon_t'\right) = P\,\Sigma P' = I. \quad (5)$$

The orthogonal errors in the matrix $\upsilon_t$ represent the economic shocks in the VAR model and largely depend on matrix P, which is not unique. Typically, matrix P is chosen as a triangular matrix, which in this study took a lower triangular form. The impulse response of variable k to the shock j, which shows how the variables within the system under analysis react to economic shocks, is given by the impulse response function (IRF):

$$\frac{\partial y_{k,t+i}}{\partial v_{j,t+1}} \quad (6)$$

Specifications: the VAR model's main specification includes variables such as real GDP growth rate, house price growth rate, non-performing loans ratio, and repo rate measured quarterly. The real GDP growth rate represents the aggregate demand environment, which influences the banking sector with a lag, thus ordered first in the VAR model. Next, the house price growth rate is an indicator that captures the housing sector dynamics and responds to macroeconomic changes from the real growth rate but affects the banking sector with a lag. The house price growth rate variable was ordered before NPL in the VAR model. Meanwhile, repo rate and non-performing loans are high-frequency variables, with no preference on which variable enters the system before the other. The deterministic component includes constant and seasonal dummy variables for Q1, Q2, and Q3. Furthermore, two structural dummy variables were included to capture significant structural breaks in 2009Q2 and 2016Q1; these exogenous variables stabilized the estimated dynamic system as observed from the residual plots.

For the purpose of stress testing, the variables used to stress test the NPLs in this exercise were real GDP and house price growth rates. After estimating the impulse response functions, the current study used the same model to stress test the NPL ratio by varying the conditions of real GDP and house price growth rates over the four to six-quarter horizons. This model examined the banking sector asset quality (NPL) variable response to different stresses applied through changing conditions of real GDP and house prices individually and combined in a predetermined sequence. The NPL ratio was put under stress beyond 2–3 standard deviations or, alternatively, the highest historical shock observed over the sample period, as a negative growth rate for real GDP and house prices over the forecast horizon. These scenarios are reasonable and plausible given the sample size and the historical developments of real GDP, house price growth rate since 2004Q1, and the sluggish responses of NPL ratio over the sample period.

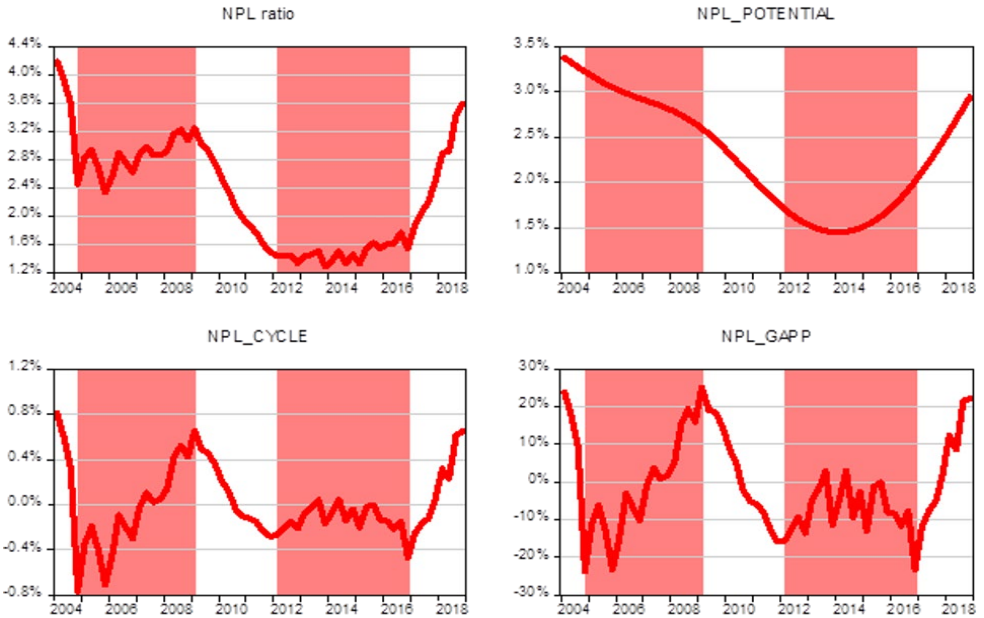
## Data and Descriptive Analysis

The primary data set consists of the following variables: quarterly GDP (QGDP), quarterly house price index (HPI), non-performing loans (NPL) ratio, repo rate, output gap, NPL gap, NPL cycle, and NPL trend. Theoretically, increases in QGDP, HPI, and positive output gaps are

expected to reduce the NPL ratio. Meanwhile, the negative output gap and rising repo rate are expected to increase the NPL ratio, all things being equal. The estimation sample starts from 2004Q1-2017Q4, while the prediction sample was from 2018Q1-2019Q4. All non-observable and observable variables (output gap and NPL gap) and the real GDP growth rate and house price growth rate gravitate around the mean zero over time, suggesting that these variables are stable over the sample period. Figure 2 below shows the NPL ratio's time series, NPL cycle, NPL gap, and NPL trend; these are non-observable variables derived from the NPL ratio. As can be seen in Figure 1, the NPL ratio seems to have gone through different regimes from 2004Q1-2018Q4. The Hodrick Prescott (HP) filter is commonly applied when analyzing non-observable variables and short-term fluctuations associated with the business cycle. Disaggregating short-term fluctuations revealed long-term trends which are helpful in stress testing and conditional forecasting associated with the business cycle (Phillips & Shi, 2019)

**Figure 2**

*Actual NPL ratio, NPL-Potential (HP filtered trend), NPL-GAP, and NPL cycle from HP filter*



## Results: VAR (4) Impulse Responses Analysis

In most multivariate time series analyses, the dynamic interaction between key variables as estimated by the impulse response functions is the primary result of interest. Hence, in this section, we discussed the (IFRs) with a particular focus on the objective of this paper. Figure 3 shows the dynamic responses represented by a solid line within one standard deviation band over the forecast horizon.

Figure 3 shows the main results of the impulse responses of the NPL ratio to an economic growth shock, house price shock, and interest rate shock. The IRFs from the VAR (4) have an NPL response to a QGDP shock, an NPL impulse response to a repo rate shock, a second-row impulse response for NPL to a house price shock, a house price growth rate impulse response to a QGDP shock, house price growth impulse response to a repo rate shock and, finally, house price response to its own shock.

A positive demand and house price shocks both reduce the NPL ratio**.** As expected, better macroeconomic conditions and robust housing demand are inversely correlated to the NPL ratio in Namibia. Thus, a one standard deviation increase in real economic growth and house prices in Namibia would reduce the non-performing loans by 0.6% points and would raise house prices by 4.0% points over a 4-quarter horizon. The latter reduced non-performing loans by more than 1.2% points over the four-quarter horizon. This implies that positive macroeconomic conditions have significant effects on the banking sector. These results are similar to other empirical studies such as Hoggarth et al. (2005). They found that an increase in real economic growth over consumer income levels improves borrowers' financial capacity with a significant spin-on effect on the banking sector. However, recessions lead to unemployment and financial difficulties for borrowers, ultimately impacting the banking sector.

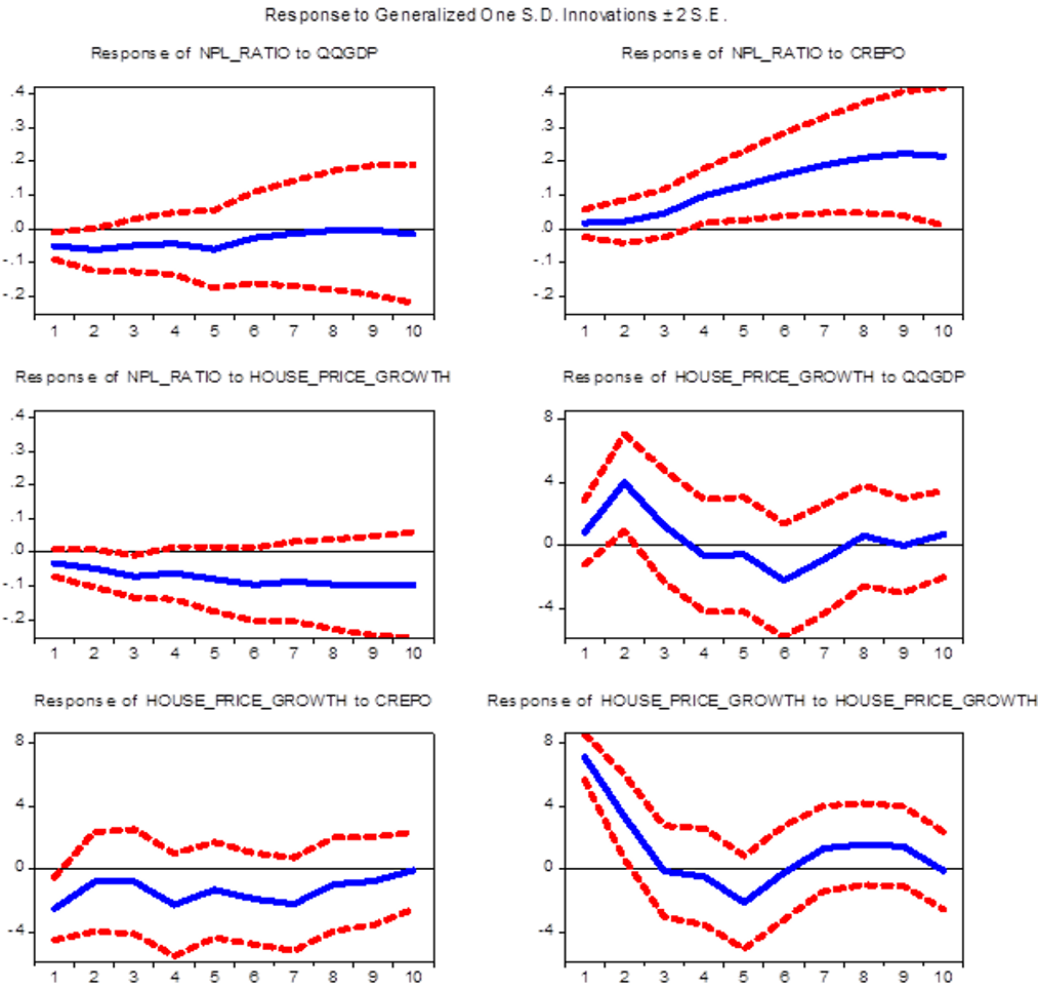
### Macro-Stress Testing Scenarios

Before turning to the macro-stress testing results, it is important to note that the macro-stress simulations are illustrative of the "what if analysis", such as a deterioration in real GDP and the housing price index. How could such deviations affect asset quality in the banking sector? Of course, these results are subject to limitations because we cannot completely reproduce reality. Nevertheless, stress testing based on VAR models provides important insights into the complex transmission of shocks and the dynamic

behaviour of macro-financial variables in response to changes in macroeconomic conditions. For example, when a macroeconomic environment changes, there are no distinct periods where each deterioration starts and ends, as assumed in the combined scenario. Therefore, these results represent the most likely path that would prevail when the Namibian banking sector is stressed by real economic activity and the housing sector.

**Figure 3**

*Impulse Response from VAR (4) Model with Ordering (real QGDP, HPL, NPL, Changes in the repo rate (Repo)*



Turning to the scenario designs in this study, the quarterly real GDP growth rate has varied between -6.7% and 15.2%, with an average of 3.8% over the sample period. Meanwhile, the quarterly growth rate of house prices varied widely between -8.8% and 33.5%, averaging 11.8% over the sample period. Hence, the first and second scenarios were set with a contraction of 1-3 standard deviations in the quarterly real GDP and house price index over the 4-quarter horizon, i.e., a year.

**Table 1**

*Descriptive Statistics of Macroeconomic Variables, Sample 2004Q1–2018Q4*

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| RGDP | 56 | 3.77 | 5.07 | -6.72 | 15.21 |
| NPL | 56 | 2.21 | 0.69 | 1.28 | 3.59 |
| HPGrowth | 56 | 11.81 | 10.01 | -8.82 | 33.58 |
| Repo | 56 | 7.10 | 1.44 | 5.5 | 10.5 |

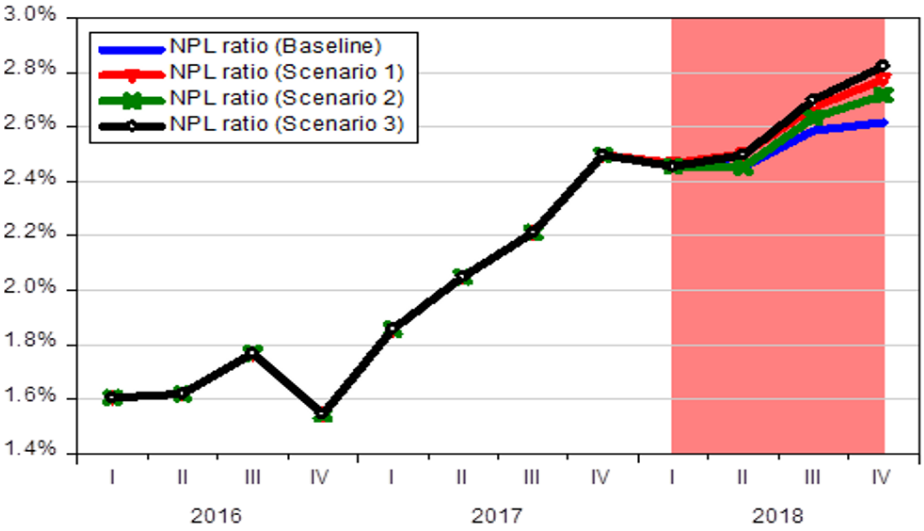
*Scenario 1:* Deterioration of real GDP growth rate by one standard deviation = 5.1% points over the four quarters. Past historical descriptions of the macroeconomic environment concerning real GDP were used to show the following: quarterly growth over the sample averaged 3.5%, with a minimum of -6.7% decline in a quarter, and a maximum growth of 15.0% in a quarter, with a standard deviation of about 5.1%.[3] The current study, therefore, assumes a plausible one standard deviation shock every quarter over the forecast horizon. A deterioration of one standard deviation would leads to the NPL ratio rising from 2.47% ratio-2.78% over the four-quarter horizon (see scenario 1 in Figure 4). Figure 4 shows that a deterioration in macroeconomic conditions increases the NPL ratio, as illustrated by the impulse response function as a result of a shock in real GDP. This means that real growth first impacted the housing sector, leading to a decline in house prices and feedback effects from the housing sector to the banking sector.

[3] This represents a cumulative effect of an approximately 20 percentage point deviation below the average growth level over the sample period.

*Scenario 2:* Deterioration of house price growth rate by one standard deviation = 10.0% points over the four quarters. Over the sample period, house price growth has been volatile, with the minimum and maximum rates ranging between -8.8% and 33.6% points.

**Figure 4**

*Macro Stress Testing Scenarios baseline, Scenario 1, Scenario 2, and Scenario 3 Results*




The maximum growth rate in house prices of 33.6% occurred during the second quarter of 2011, underpinned by robust GDP growth. The lowest rate was recorded in the second quarter of 2018 due to depressed economic activities. In this scenario, house price growth deteriorated by 10.1% over the four-quarter horizon. This is about one standard deviation in a quarter and cumulatively three quarters over the forecast horizon. In response to the stressing conditions from the housing sector, the real growth in GDP would fall, and the NPL ratio would rise significantly from 2.47%-2.72% over the four-quarter horizon. These results indicated that a decline in house prices created macro-financial risks that would significantly affect the banking sector.

*Scenario 3:* Combining the deterioration of real GDP growth, followed by a decline in the house price growth rate by one standard deviation over the four quarters. In scenario 3, the simultaneous deterioration of the real GDP growth and the house price growth rate of one standard deviation over

the four-quarter horizon would increase the NPL ratio from 2.46%- 2.82%. This macro-stress testing scenario has essentially given a macro-financial feedback loop that could intensify the effect of shocks between macroeconomic conditions and developments in the banking sector. According to the International Monetary Fund (2019), due to macro-financial linkages, lower credit to the private sector could potentially lead to lower real GDP growth, further contractions in real house price growth, and faster increases in NPLs, and thus, ultimately, the overall deterioration in asset quality in the banking sector. Therefore, it is believed that house price growth deceleration, coupled with a contracting economy, as observed in the recent past, provides a robust explanation for why the NPL ratio has increased. Furthermore, this drastic increase in the NPL ratio manifested the response to sustained macroeconomic shocks in the domestic economy (Basarir, 2016). In summary, the macro-stress results showed a sizeable effect on the NPL ratio; therefore, there is a need to monitor and continuously assess macro-financial risks through macro-prudential analyses.

## Conclusion

The current study was a purposeful attempt to investigate the macroeconomic conditions concerning the banking sector. Empirical evidence concerning the effects of macroeconomic conditions and changes in Namibia's banking sector is very rare. Although, the asset quality of the banking sector as measured by the NPL has remained historically stable, the recent drastic increase in the number of NPLs calls for a thorough interrogation of the macro-financial linkages between economic growth and the banking sector's asset quality.

Empirical evidence gathered in the current study showed that macroeconomic variables such as real GDP growth, house price growth rate, and benchmark interest rates significantly impact the NPLs. This study revealed that a random positive shock to the real growth in GDP tends to decrease the NPL ratio by 0.6% and increases house prices by 4.0%. On the contrary, the macro-stress testing results revealed that a deterioration of the GDP growth by more than one standard deviation tends to increase the NPL ratio from 2.46 to 2.78. Meanwhile, the combined effects of deteriorating GDP growth and falling house prices further exacerbated the banking sector's vulnerability. The stress testing results are consistent with the findings of the other studies, which found that changes in macroeconomic

conditions strongly influence developments in the banking sector. Although there are few historical lessons and events to guide stress testing in Namibia, the macro-stress test scenarios applied in this study were deemed adequate to determine the effects of macroeconomic conditions on the banking sector. The macro-prudential policy in Namibia through the LTV regulation is seemingly adequate for moderating house prices

## Future Recommendations

Macroeconomic stabilisation should maintain real growth close to the potential level, as this would limit persistent negative output gaps on financial stability. Meanwhile, the impact of persistent positive output gaps must also receive continuous monitoring and appropriate macro-prudential tools must be employed to tame their impact on real estate prices. Technically, central banks must develop empirical models that capture essential macro-financial and feedback effects in the economy. Furthermore, regulatory attention must be devoted to monitoring spill-over effects from the worsening financial conditions to the real economy. Future macro-stress testing research would benefit from including high-frequency data on indicators such as the unemployment rate, nowcasting real GDP, and public debt. Including these variables would only be feasible when the statistical office addresses deficiency in high-frequency data. Moreover, further research may consider using new econometric techniques at different time frequencies (e.g., the Mixed-data sampling-MIDAS model). This would allow financial market variables (e.g., stock price, value at risk, volatility index, and term spread) to be included in the analysis. Going forward, macro-prudential regulation should be enacted through a well-designed, effective macro-prudential tool kit for Namibia's financial sector.

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