

AN ANALYSIS OF STRESS TESTING TECHNIQUES USED BY BANK OF UGANDA

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DEDICATION

I dedicate this dissertation to my guardians Mr. and Mrs. Rwakahanda in gratitude for the moral and financial support they have accorded me for most of my life so far. I am eternally grateful.

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I take this opportunity to thank the following people who have directly or indirectly made it possible for me to sail smoothly through Uganda Martyrs University and finally to carry out my research and finish this dissertation. I am forever indebted to my dear guardians Mr and Mrs. Paschal Rwakahanda who have supported me in all ways imaginable; financially and morally. I also owe so much to my supervisor Dr. Richard Awichi who has not only guided me in my research but has also been there to guide me and counsel me when I needed it the most. I also feel the greatest of gratitude towards all my lecturers who have done their work diligently in the three years I have spent at Uganda Marytrs. To my classmates Lee, Polly, Bridget, Warren, Clare, Precious, Ian, Cornelius, Emma and Rachel, as well as all the good friends I made while at Uganda Martyrs, you have been in one way or another a pillar of support all the way to the end.

God bless you all very abundantly.

LIST OF ABBREVIATIONS

1. BCBS	Basel Committee on Banking Supervision
2. BOU	Bank of Uganda
3. CA	Capital Adequacy
4. CAR	Capital Adequacy Ratio
5. IMF	International Monetary Fund
6. LLP	Loan Loss Provisions
7. LTCM	Long Term Capital Management
8. NBFII	Non-Bank Financial Institutions
9. NPL	Non-Performing Loan
10. OFI	Other Financial Institutions
11. OPEC	Organization of Petroleum Exporting Countries
12. RWA	Risk Weighted Assets
13. VAR	Vector Autoregression
14. CPI	Consumer Price Index
15. GDP	Gross Domestic Product
16. REER	Real Effective Exchange Rate
17. LST	Liquidity Stress Test
18. LCR	Liquidity Coverage Ratio

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ABSTRACT

Uganda's central bank – Bank of Uganda – is mandated with ensuring that the banking system remains in a healthy state so as to ensure that the economy runs smoothly and efficiently so as to foster economic growth and development. Stress tests form a crucial part of the repertoire used by banking sector regulators and supervisors – such as Bank of Uganda – use to assess the resilience of banks to macroeconomic shocks. Such shocks include factors that might affect loan performance such as fluctuations in the exchange rate, changes in oil prices and variations in the interest rate. Stress tests attempt to establish how resilient bank portfolios are by simulating shocks. It is the purpose of this dissertation to briefly analyze stress testing as carried out by Bank of Uganda.

The economic concept of scarcity implies that governments and corporate institutions and households will not always have adequate funds to achieve their different objectives. Such objectives may include investment in infrastructural development by governments, and business expansion by businesses. While the financial system — through financial institutions — makes it possible to channel much needed funds from surplus units to deficit units within the broader macro economy, effective financial intermediation is constantly faced with various risks. As evidenced by the 2008 banking crisis, commercial banks are at the risk of losing large amounts of assets and becoming insolvent if risk is not properly assessed.

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CHAPTER ONE

INTRODUCTION

1.0 General Introduction

In any human undertaking, it is of importance for the parties involved to know where they stand and where they expect to be in the future. It is important for these parties to be find ways of determining possible future obstacles in order to find remedies for them to ensure smooth running of affairs. Banks are not an exception to the rule and are faced with possibilities of adversity. As such, there have to be mechanisms in place to determine how resilient these institutions are capable of being during times of economic turbulence. Stress tests are one of the ways banking industry regulators around the world assess institutional resilience. Uganda's banking sector is not unique in this respect and it is the purpose of this dissertation to look at matters pertaining to financial stability and stress tests as used by Bank of Uganda to determine how healthy the financial system is.

This chapter includes background of the study, problem statement, objectives, research questions, purpose and significance of the study and the operational definition of terms.

1.1 Background

The need for a stable banking system in both Uganda's economy and the global economy cannot be overstated. In today's globalized world, this is particularly so because what happens in the global economies has spillover effects for developing countries like Uganda. Developing nations are very much dependent on the economic events in more advanced economies such as the United States, China and Europe. Domestically as well as internationally, banks are interconnected in a way that creates potential for massive financial disruptions. Gai (2013) makes mention of the interconnectedness of balance sheets among financial intermediaries as a result of an intricate web of interbank claims and obligations. Further mention is made of innovative banking products such as credit default swaps and collateralized debt obligations that have further complicated the interconnectedness of financial intermediaries.

After the 2007/2008 global financial crisis, the activities of financial institutions are particularly intertwined with the concept of financial stability. This crisis was the result of risky lending practices which led to a situation of insolvency in global commercial banks. Explanations have been put forth as to what could have gone wrong. The causes of the crisis have been placed into two categories namely; state failure and market failure (Priewe, 2010). It has since become clear that financial institutions need to be properly regulated if they are to be able to adequately carry out their role of financial intermediation and at the same time honor client withdrawals.

According to Bank of Uganda (June 2012), Financial Stability refers to when the financial system can maintain its fundamental functions and is also resilient to disruptions that threaten these functions. Accordingly, the financial system should be able to withstand shocks without major disruption in financial intermediation and in the general supply of financial services. Indeed, shocks such as unexpected changes in interest rates and/or exchange rates can result in situations that may disrupt the activities of financial institutions such as insolvency, where an indebted commercial bank is not able to pay its debtors and credit crunch where there is a reluctance to lend by commercial banks due to lack of credit.

It is against this background that the importance of the supervisory role of Bank of Uganda can be better understood. According to Neretina et al (2014), bank supervisors expect and must ensure that banks hold sufficient capital to cover losses under adverse economic conditions. They further point out stress testing as an important tool for banking industry regulators to achieve this objective (Neretina et al, 2014). It is for this reason that this research is to be carried out in order to examine the supervisory importance of carrying out stress tests in Uganda's banking industry.

1.2 Statement of the Problem

In recent times both emerging and developed economies have experienced periods of financial crisis. In fresh memory are the Mexican peso crisis in 1994, the East Asian financial crisis of 1997, the dot com bubble burst in 2000 and the global financial crisis of 2008 (Quagliariello, 2009). All these crises arose as a result of a shock or shocks within the financial industry. Such economic shocks include unexpected and adverse changes in important market variables such in interest rates, exchange rates and commodity prices. In reference to the 2008 crisis, Siddique et al (2013) agree that unusually stressful events or combinations of events can and do occur within the

financial sector and that there is therefore a need to assess the potential impact of those events in order to guide appropriate preparation and response.

It cannot therefore be overstated that an analysis of the resilience of financial systems is of core importance. Stress testing is one of the tools that can be employed to assess the vulnerability of portfolios to abnormal shocks and market conditions (Blaschke et al, 2001). It is because of this that in order to assess the resilience of the banking sector to systemic risks, the Bank of Uganda carries out quarterly stress tests. (Bank of Uganda, June 2012). It follows that there is a need to examine the role of different stress tests in assessing Uganda's financial stability prospects in both the short term and the long run.

1.3. Objective of the Study

The study seeks to explore the concepts and techniques of stress testing employed by Uganda's banking sector regulator, Bank of Uganda to determine the banking system's resilience to different shocks.

1.3.1. Specific Objectives

1. To examine Bank of Uganda's Stress testing framework in line with ensuring macroeconomic stability..
2. To determine how various variables influence loan performance in the Ugandan banking system.

1.4. Research Questions

1. What are the regulatory obligations of Bank of Uganda?
2. What are the different shocks that have the capacity disrupt the activities of Uganda's banking sector and the economy at large?
3. What is the role of stress tests in establishing the resilience of Uganda's commercial banks in the face of these shocks?
4. What stress testing techniques are currently employed by Bank of Uganda to determine banking sector resilience?
5. What are the core implications of stress testing results for banking sector supervision and regulation?

1.5. Scope of the study.

1.5.1 Geographical scope

The study is based on Uganda's banking system and this includes the regulatory central bank which is Bank of Uganda and the various commercial banks regulated and supervised by it. Bank of Uganda is located on plots 37-45 Kampala Road in Uganda's capital Kampala.

1.5.2 Subject scope

The study focuses on the role of Bank of Uganda in ensuring that the commercial banks have adequate capital to be able to carry out their role of financial intermediation and facilitating payments even in the event of adverse economic conditions. As such, the scope of the study includes the stress testing concepts and techniques used by the central bank to determine the capital adequacy of the commercial banks supervised by it. The study looks at the regulatory implications of stress test results.

1.5.3. Time Scope

Ideally, the study should have employed data over a long period of time say ten years in order to capture trends more accurately. However, Bank of Uganda's confidentiality policy meant that the only data available to the researcher was data from recent financial stability reports as well as data publicly available on the central bank's website. The study therefore used data from 2011 to 2016

1.7 Conceptual Framework

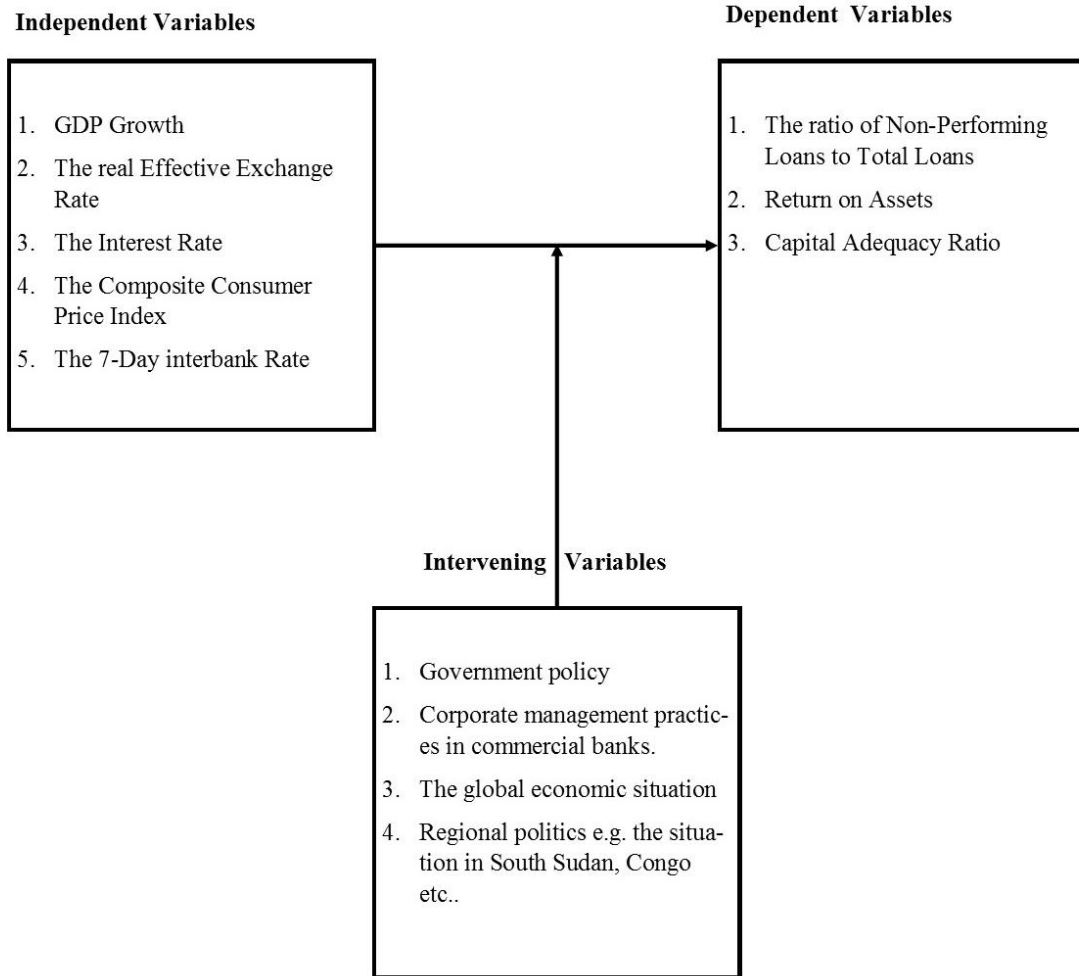


Figure 1.1. Conceptual framework showing the different variables

Source: Author

1.8 Significance of the study

While the researcher found a body of knowledge about stress testing in literature published by authors from all over the world, it was of concern that hardly any research work could be traced concerning stress testing and financial stability with respect to the Ugandan situation. As such, the study is significant in the sense that it looks at financial stability and stress testing in relation to the Ugandan Banking System.

The study is important as it will add to the body of existing knowledge. Of importance is the fact that the study attempts as much as possible to simplify concepts about financial stability and stress tests which can be of use to academicians at different levels. Academicians who wish to undertake

further research on the subject will also find the literature arising from the study to be of great value

The study is important as it will increase the researcher's understanding of banking. Knowledge acquired from the study may be applicable to the researcher's career.

1.9. Operational Definition of Terms

1. **Stress tests** are quantitative tools used by banking supervisors and central banks for assessing the soundness of financial systems in the event of extreme, but still plausible, shocks (Quagliariello, 2009).
2. **Financial Stability** refers to when the financial system can maintain its fundamental functions and is also resilient to disruptions that threaten these functions (BOU, June 2012).
3. **A Non-Performing Loan (NPL)** is the sum of borrowed money for which a debtor has not made the scheduled payments for at least 90 days (Haas, 2004).
4. **Capital Adequacy Ratio (CAR)** is a measure of a bank's capital expressed as a percentage of the bank's risk-weighted credit exposures (Haas, 2004).

CHAPTER TWO

LITERATURE REVIEW

2.0. Introduction

This chapter reviews literature in order to create generate a broader understanding of the financial system, financial stability, financial regulation and stress testing.

2.1. The Financial System

The International Monetary Fund (IMF) defines the financial system as consisting of institutional units and markets that interact, typically in a complex manner, for the purpose of mobilizing funds for investment and providing facilities, including payment systems, for the financing of commercial activity. (IMF, 2006). Financial institutions are further described as having two primary roles. The first role is financial intermediation, that is, to pool funds from depositors and lend them to individuals, governments, or businesses that need them. The second role is to facilitate payments.

The Central Bank of Sri Lanka describes the financial system as having five components namely: the regulatory authorities such as the central bank, financial institutions, financial markets, financial instruments and payment and settlement infrastructure. (Central Bank of Sri Lanka, 2010). IMF (2006) categorizes financial institutions into deposit takers and other financial institutions. Deposit takers, or banks are then described as financial institutions whose principal activity is to take deposits and on-lend or otherwise invest these funds on their own account while other financial institutions are defined as financial corporations that are primarily engaged in financial intermediation or in auxiliary financial activities that are closely related to financial intermediation but are not classified as deposit takers. Other financial institutions include insurance corporations, pension funds, other financial intermediaries, and financial auxiliaries. Other financial intermediaries include securities dealers, investment funds. (IMF, 2006).

IMF (2006) goes on to describe a financial market as a market in which entities can trade financial claims under some established rules of conduct and includes money markets, bond markets, equity markets, derivatives markets, commodity markets, and the foreign exchange market as examples of financial markets. Central Bank of Sri Lanka (2010) gives the following as examples of financial instruments; deposits, loans, treasury bills and bonds, repurchase agreements, commercial paper,

corporate bonds and debentures, asset backed securities, financial leases, shares and financial derivatives.

IMF (2006) describes payment and settlement infrastructure as instruments, banking procedures, and interbank fund transfer systems that ensure the circulation of money and expresses pessimism that the payment system is a channel through which shocks can be transmitted across financial systems and markets and highlights the importance of a robust payment system as a key requirement in maintaining and promoting financial stability.

2.2. The Financial Stability Concept

Crockett (1997) describes a commercial bank's portfolio as being stable when withdrawals by depositors take place randomly and assets such as loans are held to term. Such a bank is one with a stable deposit base and enough liquidity to meet normal withdrawals, and invest the rest of its assets in less liquid but higher yielding assets, thereby remaining competitive and maintaining public confidence. Instability according to Crockett (1997) occurs when for some reason, something happens to accelerate the rate of deposit withdrawals, making it rational for all depositors to seek to withdraw their deposits, thereby forcing the bank to sell illiquid assets, incurring losses and eroding its capital.

Brunnermeier et al. (2009) in put forth the generally accepted idea that financial crises do not happen randomly but usually follow a period of economic boom. They contend that in the up-phase of the economic cycle, price-based measures of asset values rise, price-based measures of risk fall and competition to grow bank profits increases. This is consistent with the view of Crockett (1997) that risk generally builds up when a favourable event triggers bidding up of asset prices, leading to further buying in anticipation of a consistent price trend. Eventually, the bubble bursts as happened during the dot com crash of 1997 and the financial crisis of 2008, causing problems in the financial system. During periods of economic prosperity, banks finance seemingly prosperous businesses that turn out to be vulnerable when economic conditions change (Crockett, 1997). As a result the bank suffers from asset deterioration, thereby making it incapable of meeting its obligations towards creditors. It is precisely this that triggers panic in form of a bank run. This goes to show how prone the financial system is to failure and therefore a need for a robust regulatory framework.

Determination and prediction of the factors affecting the financial stability is important for sustainability of financial stability. At this stage, reasons causing financial stability should be detected. If factors causing the financial instability are determined correctly, better precautions can be taken. Systematic risk factors such as an increase in interest rates, deterioration of bank's balance sheets, collapse of stock exchange and rising uncertainty are considered as the main reasons causing financial instability (Basarir & Toraman, 2014). The main reason of the deterioration of bank's balance sheets is risky loans. In the following phases of financial instability, loan losses are expected to increase due to the crises and the economic recession. More deterioration of bank's balance sheets causes the crisis to expand and deepen (Altıntaş, 2012).

2.3 Review of Stress Testing

Stress testing is a tool used in many fields, particularly where failure of some component of a complex system can have seriously adverse consequences and high costs for example in aircraft wings, highway bridges, coronary arteries and financial institutions (Siddique et al, 2013). However, the scope of this research is limited to stress testing of banks. In the context of banking, stress testing may be defined as a range of techniques used to assess the vulnerability of a portfolio to major changes in the macroeconomic environment (Blaschke et al, 2001). Stress tests are quantitative tools used by banking supervisors and central banks for assessing the soundness of financial systems in the event of extreme, but still plausible, shocks (Quagliariello, 2009). These abnormal economic conditions or dramatic events for the portfolio of a single credit institute or a complete market may be of political and/or economic nature (Gundlach, 2006). Stress tests are therefore used in risk management by banks in order to determine how certain crisis scenarios would affect the value of their portfolios, and by banking sector regulators for financial stability purposes (Quagliariello, 2009). However, the focus of this research is the use of stress testing by regulators as a tool to attain financial stability. In this context, stress tests are carried out by banking regulators in a bid to assess the resilience of the banking sector to systemic risks (Bank of Uganda, June 2012).

2.4. Classification of Stress Tests

Blaschke et al (2001) put it forth that stress testing begins with the specification of the types of risk to be considered such as credit risk, liquidity risk or market risk. This is followed by the

specification of risk factors. According to them, stress tests may be classified into sensitivity tests that involve a change in a single risk factor and tests involving scenario analysis where there is a simultaneous move in a group of risk factors (Blaschke et al, 2001). Risk factors include interest rates, inflation rates, stock market indices, credit spreads, exchange rates, annual growth in GDP and oil price (Kalirai and Scheicher, 2002).

2.4.1 Scenerio Analysis versus Sensitivity Analysis

When setting up the framework for stress-testing exercises, it is necessary to identify the kind of risks that have to be considered and the range of factors to be included. In the first place, stress tests can be used to analyze either the impact of changes in a single risk factor (e.g., a decline of equity prices) or the effect of a multivariate scenario, where simultaneous changes in several risk factors are combined (e.g., a fall in gross domestic product (GDP) together with a decline of equity prices and a rise of interest rates). These typologies of simulation are defined sensitivity analyses and scenario analyses respectively (Quagliariello, 2009)

2.4.2 Bottom-Up versus Top-Down Stress Tests

In particular, a major challenge is to determine the most appropriate way for quantifying the aggregate impact of the shock on intermediaries' portfolios. In that respect, two solutions are available for obtaining system-wide results. A first option is that authorities define the macroeconomic shock (or a set of shocks), let the intermediaries evaluate its impact on their balance sheets and then aggregate the bank-level outcomes in order to get the overall effect. This kind of approach to stress testing is usually called bottom-up. An alternative way for system-wide stress tests is the top-down approach, where the authorities themselves (typically, central banks or supervisory authorities) apply the shock – either to individual bank data or to an aggregated banking system portfolio – and analyse its effect on the banking system as a whole. (Quagliariello, 2009)

The bottom-up methodologies tend to be more tailor-made, since each bank will reflect the shock on its own portfolio more accurately. Also, the datasets used in the simulations are generally richer and the possibility to break the impact of a given shock into several sub-portfolios makes the results more realistic. Since single institutions have a comparative advantage in terms of data availability,

the use of their own data and internal models helps optimise the information flows and enhances the quality of the results (IMF and World Bank, 2005).

However, the cross-section comparability of bottom-up stress tests may be seriously impaired since each intermediary will likely employ different methodologies and modelling assumptions, making the aggregation less meaningful. Also, the aggregation of individual results, if done at all, cannot take into account the possible interdependencies across institutions. From a more practical perspective, the direct involvement of banks in this kind of simulation is rather costly, especially for the intermediaries, which precludes frequent running of such exercises. In addition, while banks' internal models can be easily adapted to run sensitivity tests, they are generally much less well-suited for scenario analyses (Quagliariello, 2009).

Conversely, the top-down approach enhances the comparability of results, but it is often less accurate – especially when carried out on aggregated system wide data. Authorities may indeed apply top-down approaches, working on institution-level data in order to avoid possible loss of information arising from the aggregation, and analyse the dispersion of the results around the average figures (Cihak, 2004)

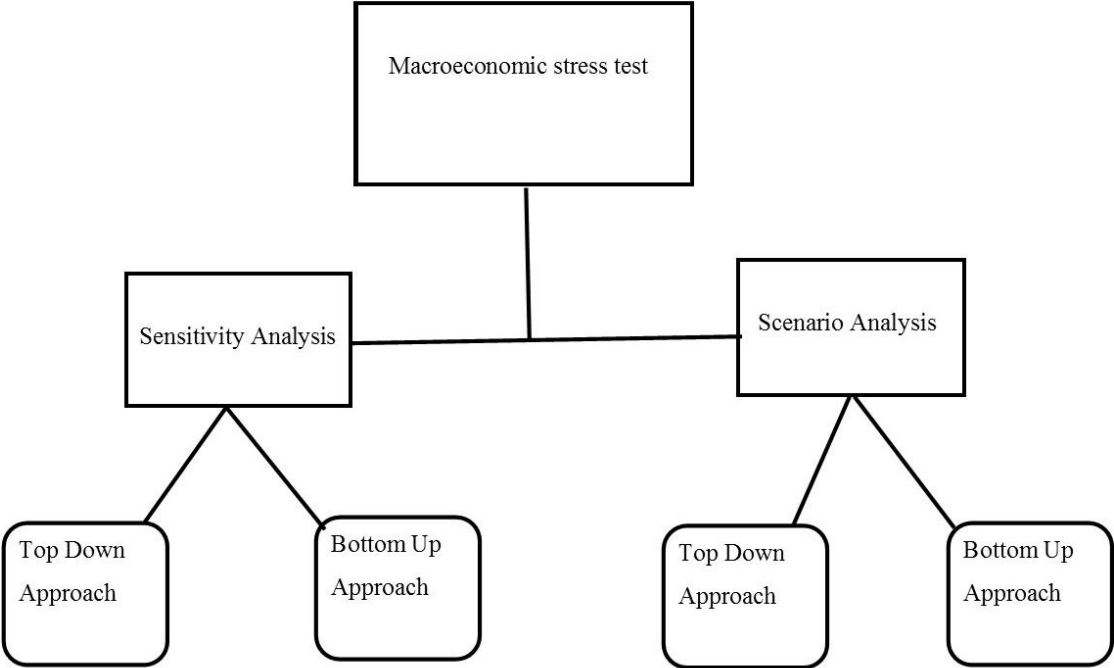


Figure 2.1. Classification of stress tests

Source: Quagliariello (2009)

2.5 Characteristics of Good Stress Tests

1. **Stress tests should be conducted regularly and timely:** One of the recipes to ensure a healthy performance of banks is to make stress testing regularly. Regular stress testing enables banks to early identify unexpected risks and they thus can better withstand them. The issue of stress testing is widely discussed especially in large international banks. Extra stress tests should be employed in periods when the economy struggles with abnormal conditions (Laubsch, 1999). However, Laubsch (1999) also remarks: “Stress testing should not be performed so frequently and extensively as to become overwhelming and loose meaning”. In general, stress testing should be run in monthly or quarterly time horizons (Haas, 2004)

2. **Stress tests should consider countries’ macroeconomic conditions:** It is important to know that there is not a common rule in specifying what stress test should be used for testing the resilience of particular banks. It is always necessary to have a good knowledge about the structure of the financial system and to be familiar with the overall macroeconomic performance in which the banks operate. This understanding helps to identify what variables are the most vulnerable and thus should be stressed. It also enables to formulate an appropriate stress scenario being applied (Cihak, 2007).

3. **Stress tests should include quantitative and qualitative criteria:** According to BCBS (1996), each stress test is expected to meet both quantitative and qualitative criteria. Quantitative aspects of stress testing determine the stress scenarios which could occur in a given banking sector. From a qualitative perspective, stress tests should be able to answer two basic questions:
 - 1) How much should be a bank’s capital to withstand losses due to an adverse shock?
 - 2) What action should be taken by a bank to reduce its risk exposure and to assure a further accumulation of capital?

- 4. Stress tests should be integrated into decision-making process:** Stress testing gives information about various risks that could have an adverse impact on a bank's portfolio. Such information shall be evaluated by managers as a part of their daily decision-making (Blaschke et al., 2001). The BCBS states recommendations for banks in the document Principles for sound stress testing practices and supervision (BCBS, 2009): Stress testing should form an integral part of the overall governance and risk management culture of the bank. Board and senior management involvement in the stress testing program is essential for its effective operation". The BCBS further suggests that "to promote risk identification and risk control, stress testing should be included in risk management activities at various levels" (BCBS, 2009).

- 5. Stress tests results should be reported periodically:** Stress tests produce meaningful information on the state of the banking sector in a case of marked deterioration in economic conditions. Therefore, stress tests are expected to be properly documented and discussed by the managing authorities who should report stress testing results periodically. They should also take them into account when setting policies and controls (BCBS, 1996).

2.6 Components of a Stress Test

Jones et al. (2004) describe macroeconomic stress-testing as a complex multi-step process that can be seen as the interaction of different skills: it is 'part investigative, part diagnostic, part numerical, and part interpretative. As such the process of stress testing has several components. First of all, the set of intermediaries that are of systemic importance is to be selected. After that, the major risks to the financial system and the underlying vulnerabilities are determined. Furthermore, some assumptions are to be made on the severity and plausibility of the shocks. Another relevant step is the choice and the development of the statistical methodologies to analyze how the changing macroeconomic environment will affect banks' portfolios. Finally, stress testing results are assessed for use in decision making (Quagliariello, 2009).

Quagliariello (2009) describes the steps of the stress testing exercise as follows:

1. **Selecting Coverage:** While considering entire banking sector would give a more accurate picture of the stress scenario, this approach may be impractical. It is best to choose a sample of core institutions that are considered particularly important for the stability of the financial system and are likely to be affected by common risk factors. As such, the coverage of the stress testing exercise should represent the banking sector but should be practical as well.

2. **Identification of Major Risks:** the next step is identifying the risks that may endanger the financial system and exposures to those risks. This part of the stress-testing process allows the tailoring of the stress testing process to the specific country, determining the weakest points of its banking system, making the whole process more effective and avoiding the misuse of time and resources (Jones et al., 2004). For a country like Uganda, the business of most banks is loaning money. As such the major risks is credit risk and liquidity risk.

3. **Shock Calibration:** Once the major risks have been identified, it is necessary to investigate the events that trigger the shock and determine the level above which the magnitude of the shock leads to the materialization of the risk. The major question at this stage is, “Which event can trigger the vulnerabilities?” It could be drastic changes in variables such as the interest rate, the exchange rate or oil prices.

Table 2.1. Some examples of historical scenarios and crisis triggers

Year	Crisis Triggers
1973	First oil crisis – increase of oil prices by OPEC
1979	Second oil crisis – cut of Iranian oil supply
1987	Black Monday – stock market crash in the US
1991	Gulf war – oil price increase
1992	European Monetary System crisis – speculation against weaker currencies
1995	Tequila crisis – Mexican current account deficit

1997	East Asian crisis – US dollar peg cutting
1998	LTCM – LTCM collapse
2001	September 11 – terrorist attacks in the US
2007–08	Sub-prime mortgages crisis – rise in home foreclosures

Source: Quagliariello (2009)

4. **Implementing the scenario:** Stress scenarios are by design simplified representations of the economy and it is imperative that their implementation allows for coherent movements in key variables and risk factors (Haldane et al., 2007). Structural macro econometric models are the most appropriate tools for understanding how the economic system behaves when the assumed shock occurs. Once the risk factors have been identified and the shocks affecting such factors properly calibrated, the model uses such information as an input and returns the values of the macroeconomic variables under stress conditions.

5. **Mapping the scenario to bank losses:** Once the scenario has been run, the stressed figures of the key macroeconomic variables are used for determining the impact of the shock on banks. This generally requires ad hoc statistical methodologies that help quantify the link between macroeconomic variables and banking variables, typically some indicators of default, losses or value adjustments. The choice of the most suitable approach largely depends on the risk that is under analysis and the main objectives of the simulation as well as data availability. For instance, while the use of reduced form regression methods is very common for credit risk.

6. **Interpreting results:** The resulting figures for bank losses under stress conditions are compared to some indicators of financial soundness in order to assess the capacity of the banking system to withstand the given shocks. It is very common to compare the magnitude of losses with pretax profits of banks (i.e. the income that is available for absorbing the extra losses arising from the stress scenario) and the level of regulatory

capital above the minimum requirements (i.e., the buffer against losses that go beyond banks' income). Even if macroeconomic stress tests aim at assessing the aggregate impact of the shock, the interpretation of their results requires a clear understanding of the actual distribution of losses.

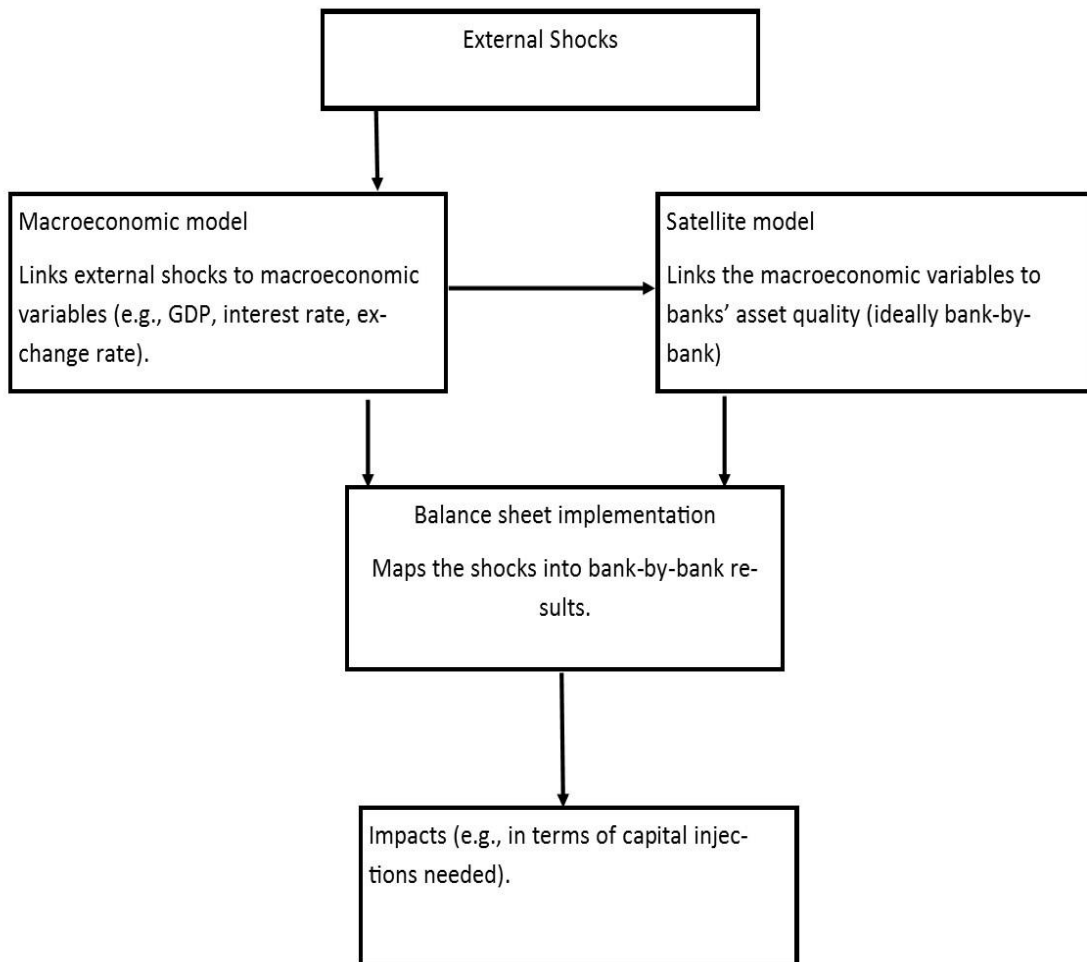


Figure 2.2. Stress Testing Framework

Source: Cihak (2007)

2.7. Credit Risk Models

2.7.1. Model Based on Loan Performance Data

Regarding this approach there are several possibilities for the dependent variable: non-performing loans, loan loss provisions and historical default frequencies. Depending Regarding this approach there are several possibilities for the dependent variable: non-performing loans, loan loss provisions and historical default frequencies. Depending on the availability of the data the exercise can be done on the aggregated type of data, on the industry level and on the individual bank data. The credit-risk models of Lehmann and Manz (2006) and the German Bundesbank use the LLP ratio to measure credit quality at the individual bank level, with static or dynamic panel data estimation.

2.7.2 Model Based on Data on Individual Borrowers

The credit risk model can also be based on the individual borrower data. The model may and should also include macroeconomic variables which would take into account some of the macroeconomic environment. The probability of default can be related to the borrowers' characteristics like Eklund, Larsen, and Bernhardsen (2001) have done it and then compared default with the characteristics such as firm size, age, industry and accounting variables. The forecasted macroeconomic variables are used to estimate the future income statement and with that information individual probabilities of default were calculated. Further, this data is aggregated to generate total loan loss.

2.8 Modeling Liquidity tests

Testing for liquidity risks is less common in central banks' stability reports (Cihak, 2007). This mostly reflects the fact that modeling liquidity risks is more complex. First, to properly model liquidity fluctuations in banks, one needs to have very detailed, high frequency data, such that are typically used by commercial banks themselves in their liquidity management models.

Second, to model the impact of large liquidity shocks, one needs to consider the broader liquidity management framework, in particular the lender- of- last- resort function of many central banks. Much of the attention in risk management and prudential supervision was on capital, partly in

relation to the efforts to standardize capital adequacy requirements across countries. In the process, relatively less attention has been paid to cash flows and analysis of liquidity (Goodhart et al., 2006). Analyzing the response of liquidity to stress is an important undertaking, because liquidity is how a stressful situation often manifests itself in the short run. In liquidity stress testing, the impact is shown for each bank in terms of the number of days it would be able to survive a liquidity drain without resorting to liquidity from outside.

2.9 Some Technical Aspects

2.9.1. Capital and Capital Adequacy

Capital adequacy (CA) forms one of the most important instruments of banking regulation. The essence of CA lies in the fact that the banks are obliged to maintain a certain amount of capital in order to absorb potential losses and thus prevent their insolvency (Prochazcova, 2011). With this respect, the level of CA gives a good indication of how resilient the banks are and whether they are able to withstand stressful events. Knowing of CA helps to answer two important questions (Cihak, 2007):

1. Which banks are resilient enough to withstand assumed shocks and which banks will fail?
2. What are the potential governmental costs associated with the failure of banks in stressful times?

2.9.3. Capital Adequacy Ratio

Typically, Capital Adequacy Ratio (CAR) is used for answering the first question defined above. The CAR can be computed as the proportion of bank's capital to risk weighted assets (RWA). According to the 1988 Basel Accord, a regulatory requirement for holding a minimum CAR was set at 8 % (BCBS, 1996). This regulatory minimum was confirmed in the more recent revised document issued by the BCBS in 2006, it states: "The Committee is also retaining key elements of the 1988 capital adequacy framework, including the general requirement for banks to hold total capital equivalent to at least 8% of their risk-weighted assets" (BCBS, 2006). Hence, it must hold true that:

$$\text{CAR} = \frac{C}{\text{RWA}} \geq 8\%$$

Where C is bank capital, and RWA is the bank's risk-weighted assets (BCBS, 1996). If the effects of stress scenarios cause the decline in CAR of a bank below the minimum of 8%, then the owners' initiative is in place and they need to inject capital into the bank in order to remain in operation. In case the CAR falls below zero, the bank becomes insolvent and leaves the business (Cihak, 2007).

2.10. Bank of Uganda's Regulatory Framework

Bank of Uganda is focused on strengthening its regulation and monitoring of the financial system. To ensure financial stability, the central bank set the minimum paid up capital for all commercial banks to US\$ 25 billion and published statutory instruments to introduce the Basel III capital and liquidity measures to enhance banking sector resilience. The pilot phase for the liquidity coverage ratio (LCR) was finalized with the aim of enhancing liquidity management at commercial banks. Bank of Uganda is also diligent in strengthening efforts to collecting macroeconomic data in collaboration with other public institutions such as the Uganda Bureau of Statistics (UBOS) and the Ministry of Finance, Planning and Economic Development in order to be in a stronger position while assessing financial stability. (Bank of Uganda, June 2012).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

As it is indicated in the title, this chapter includes the research methodology of the dissertation. In more details, in this part the researcher outlines the research strategy, the research design, the research approach, the methods of data collection, the selection of the sample, the research process, the type of data analysis, the ethical considerations and the limitations of the study. It includes detailed procedures that are followed to realize the research objectives.

In this research, the main objective was to explore the concepts and techniques of stress testing employed by Uganda's banking sector regulator, Bank of Uganda to determine the banking system's resilience to different shocks. The specific objectives were; to examine Bank of Uganda's regulatory policy in line with ensuring macroeconomic stability, to examine the ability of Uganda's banking industry to remain resilient in the face of various economic shocks, to analyze the concept of stress testing and to determine how various factors impact financial stability in the Ugandan banking system.

3.2 Research Strategy

The research held with respect to this dissertation was an applied one, but not new. While there exists previously published academic literature about stress testing from other countries, the author was not able to find academic publications on the subject from Uganda. As such, the research took the form of a new research but on an existing research subject.

3.3 Research Design

The research design is the overall plan for connecting the conceptual framework with the achievable empirical research. In the current study, the researcher sought to make a study of the different techniques used to stress test the Ugandan banking system

In order to satisfy the objectives of the dissertation, a research that was qualitative in nature was held. The main characteristic of qualitative research is that it is mostly appropriate for small samples, while its outcomes are not measurable and quantifiable. Its basic advantage, which also

constitutes its basic difference with quantitative research, is that it offers a complete description and analysis of a research subject, without limiting the scope of the research and the nature of participant's responses (Collis & Hussey, 2003).

However, the effectiveness of qualitative research is heavily based on the skills and abilities of researchers, while the outcomes may not be perceived as reliable, because they mostly come from researcher's personal judgments and interpretations. Since it is more appropriate for small samples, it is also risky for the results of qualitative research to be perceived as reflecting the opinions of a wider population (Bell, 2005).

Table 3.1. Features of qualitative and quantitative research

Qualitative Research	Quantitative Research
The aim is complete detailed description	The aim is to classify features, count them and construct statistical models in an attempt to explain what is observed
Researcher may only know roughly in advance what he/she is looking for.	Researcher knows clearly in advance what he/she is looking for.
Recommended during earlier phases of research projects.	Recommended during latter phases of research projects.
The design emerges as the study unfolds.	All aspects of the study are carefully designed before data is collected.
Researcher is the data gathering instrument.	Researcher uses tools, such as questionnaires or equipment to collect numerical data
Data is in the form of words, pictures or objects.	Data is in the form of numbers and statistics.
Qualitative data is more 'rich', time consuming, and less able to be generalized.	Quantitative data is more efficient, able to test hypotheses, but may miss contextual detail.
Researcher tends to become subjectively immersed in the subject matter.	Researcher tends to remain objectively separated from the subject matter.

Source: Miles & Huberman (1994). Qualitative Data Analysis

3.4. Research Approach

The research approach that was followed for the purposes of this research was the inductive one. According to this approach, researchers begin with specific observation, which are used to produce generalized theories and conclusions drawn from the research. The reasons for using the inductive approach was that it takes into account the context where research effort is active, while it is also most appropriate for small samples that produce qualitative data. However, the main weakness of the inductive approach is that it produces generalized theories and conclusions based only on a small number of observations, thereby the reliability of research results being under question (Denzin & Lincoln, 2005).

3.5. Data Collection Method and Tools

For the purposes of this research, in-depth interviews were used. In-depth interviews are personal and unstructured interviews, whose aim is to identify participant's emotions, feelings, and opinions regarding a particular research subject. The main advantage of personal interviews is that they involve personal and direct contact between interviewers and interviewees, as well as eliminate non-response rates, but interviewers need to have developed the necessary skills to successfully carry an interview (Fisher, 2005, Wilson, 2003). What is more, unstructured interviews offer flexibility in terms of the flow of the interview, thereby leaving room for the generation of conclusions that were not initially meant to be derived regarding a research subject. However, there is the risk that the interview may deviate from the pre-specified research aims and objectives (Gill & Johnson, 2002).

As far as data collection tools were concerned, the conduction of the research involved the use of semi-structured questionnaire, which was used as an interview guide by the researcher. Some questions were prepared, so as for the researcher to guide the interview towards the satisfaction of research objectives, but additional questions were made encountered during the interviews. A detailed form of the interview guide is presented in the Appendix.

3.6. Population and Sample

A population is the aggregate or totality of objects or individuals, having one or more characteristics in common that are of interest to the researcher and where inferences are to be made

A sample is part of the target (accessible) population that has been procedurally selected to represent it Oso et al. (2008). For this study, there was no need to sample since the data used is aggregated data for the entire banking system of Uganda as compiled by the central bank. In other words the data used in this study was secondary data encompassing the entire Ugandan banking sector.

3.7. Research Process

Meetings were held during the month of May of 2017 with employees from Bank of Uganda's Financial Stability department and the Research department. First, it was necessary for the researcher to identify himself as a student of Uganda Martyrs University so as to gain acceptance of their participation in the research. More specifically, the researcher came in touch with them and asked them to participate in the research after explaining the nature and the scope of the study. In general terms the respondents were willing to participate in the research and the interviews were conducted. The discussions took place at the offices and lasted about 40 minutes. During the interviews, the respondents were brief in their responses as they are usually very busy people and where necessary they referred the researcher to useful documents. Brief notes were taken.

During the conduction of the interview, respondents were free to express their views even in topics which were not included. Finally, it should be noted that the conversations flowed smoothly and pleasantly and the respondents even gave the researcher advice on how to successfully go about completing the dissertation in the most effective way.

3.8. Data Analysis

Content analysis was used to analyze the data which was gathered from personal interviews. According to Moore & McCabe (2005), this is the type of research analysis whereby data gathered is categorized in themes and sub-themes, so as to be able to be comparable. A main advantage of content analysis is that it helps in data collected being reduced and simplified, while at the same time producing results that may then be measured using quantitative techniques. Moreover, content analysis gives the ability to researchers to structure the qualitative data collected in a way that satisfies the accomplishment of research objectives. However, human error is highly involved in content analysis, since there is the risk for researchers to misinterpret the data gathered, thereby generating false and unreliable conclusions (Krippendorff & Bock, 2008).

For the current research, responses obtained during the interviews were analyzed by the researcher to draw meaningful information. Bank performance data was also analyzed and tabulated and graphs were generated in order to establish and explain the relationship between the variables involved in the study.

3.9. Ethical Considerations

The current study was subject to certain ethical issues. The researcher discovered that bank of Uganda employees were not authorized to freely give out bank specific data on loan performance. The interviewees informed the researcher that such data is of a sensitive nature and can cause misunderstanding and panic in case it enters into the public domain. As such, the interviewees referred the researcher to data that is publically available on Bank of Uganda's website and in their annual financial stability reports.

Additionally, participants were concerned about the legitimacy of the study and whether their identities would remain anonymous. In this regard the researcher had to make sure that interviewees were fully informed regarding the objectives of the study, and they were also reassured that their answers would be treated as confidential and used only for academic purposes and only for the purposes of the particular research.

Participants were not harmed or abused, both physically and psychologically, during the conduction of the research. In contrast, the researcher attempted to create and maintain a climate of comfort.

3.10. Research Limitations

As it is for every study, this study had the following limitations:

The size of the data set available for analysis was relatively small. The data that was publically available for analysis by the researcher was for the period between 2011 and 2016 and this small data set may have not captured fully the situation on the ground. A bigger data set would probably have enhanced the reliability of the research.

Another limitation to the research was the fact that the demanding workload of Financial Mathematics during the semester meant that the researcher had to be very diligent in juggling several demands. As such, time constraints may have affected the quality of the research. The time

allocated for the study may have limited the researcher's ability to conduct a comprehensive study to fully exhaust the study variables.

The complexities and intricacies of risk management and stress testing were relatively new to the researcher which may have hampered the extent to which the researcher could make a reliable analysis.

The researcher was also quick to note the limitation that much of the available literature on stress testing is in the context of developed economies and there is hardly any available prior research about stress testing in emerging economies such as Uganda. Hopefully, in time to come, more and more Ugandan researchers will take upon this subject and research it at different academic levels.

CHAPTER FOUR

PRESENTATION AND INTERPRETATION OF FINDINGS

4.1. Introduction

In this chapter, the researcher presents, and analyses the findings of the study. The findings are based on data collected from the central bank by means of interview guide. Due to the confidentiality issues, Bank of Uganda does not provide bank specific information on sectoral loan performance for specific commercial banks. The researcher found out that the central bank follows the stress testing framework put forth in the IMF working paper No.WP/09/59 by Cihak, M (2007) titled ‘Introduction to applied stress testing’. Bank of Uganda carries out stress tests for credit risk and liquidity risk

4.2. Bank of Uganda’s Stress Testing Framework

To assess the resilience of the banking sector, Bank of Uganda carries out quarterly basis stress tests using a framework based on Cihak (2007) to identify the breaking point for each risk. This is achieved by applying shocks to selected variables until the banks fail to meet minimum requirements (Bank of Uganda, 2012) The breaking points defined for each type of shock are as follows:

Table 4.1. Summary of stress test shocks and breaking points

Risk Type	Shock	Breaking point
Credit	Assess the effect of a decline in banks’ existing total and sectoral performing loans	The first large bank fails following a gradual increase in NPLs
Liquidity	A simulated bank run which models the number of days banks would be able to survive a systemic liquidity drain without resorting to liquidity from external sources	The first bank’s liquid assets are depleted following a sudden withdrawal of deposits

Source: Bank of Uganda (2012)

4.2.1. Stress Testing Credit Risk

BOU carries out quarterly stress tests to assess the resilience of the banking sector to systemic risks. The Commercial Banking Department of BOU uses sensitivity stress tests based on Cihak's model to assess credit risk, interest rate risk, and foreign exchange risk. The shocks included in these sensitivity stress tests are: increase in non-performing loans; 100 percent loan loss of each bank's largest borrower; decline in net interest margin; decrease in interest income on government securities; and depreciation of the Ugandan Shilling against the US dollar. Applying incremental magnitude of shocks to selected variables until banks fail to meet minimum requirements is used in these sensitivity stress tests.

Since July 2013, BOU introduced, through its Financial Stability Department, a macro-financial stress testing framework that can be used for both micro- and macro-prudential purposes. This stress testing framework is modular, and comprises three-pillars: the first pillar is the scenario design, which involves the design of the macro-financial scenario to be imposed on the Ugandan banking sector; the second pillar is the credit risk satellite model, which translates the scenarios designed on the first pillar into variable affecting the banks' loss absorption capacity; the third pillar is the balance sheet module, which applies the projected losses derived from the satellite model to individual bank balance sheets with the objective of calculating the resulting impact on each bank's solvency position (BOU, 2013). The description below focus on the BOU's macro-financial stress testing framework for credit risk.

(i) Pillar 1 - Designing a Macro-Financial Scenario and Shock Calibration

The first part of the BOU's framework is the design of a macro-financial scenario, which serves as a basis for defining a set of adverse macroeconomic shocks to apply to the banks. In its paper on macro stress testing, BOU (2013) considered a "price shock", where effects of an increase in international prices on food and energy are assessed in terms of direct impact on economic output through increased commodity prices and production costs, which in turn triggers domestic inflation to rise above the policy target, causing interest rates to increase, and as a consequence of the rising interest rates credit defaults soar, generating a severe credit tightening, as supply falls far below demand.

After mapping external shocks to systemic risks, BOU uses random shifts in the relevant economic or financial variable to calibrate shock sizes. Using the calibrated shocks as inputs, BOU generates

the macro financial scenario using the Economic Research Department’s macroeconomic models. The output of these models is a link between the external shocks and a range of country-specific macro-financial variables.

(ii) Pillar 2 – Estimating a Satellite Model

The BOU’s satellite model is a set of equations that translates the generated macroeconomic scenario into an impact on banks’ risks, focusing on those developments that can adversely affect the banking sector, and on credit growth.

The set of equations of the BOU’s satellite model consists of a small macro model and a micro data-base model for banks, which uses outputs from macro models built for Ugandan monetary policy forecasting purposes. Quarterly banking sector data series, which spans a period from first quarter of 2000 to the reporting quarter, is employed. The analysis focuses on the following variables: private credit, deposits, real GDP growth, inflation, banks’ average lending rate, the 91-day treasury bill rate (as a proxy for the monetary condition), and the NPL ratio. The target forecast variables are the aggregate profitability and solvency of the banking sector. The model measures profits by the aggregate after-tax earnings of the banking sector, and solvency in terms of capital adequacy and buffers against losses.

The Credit Model:

BOU’s credit satellite model has two key equations: *real credit growth* and *aggregate credit risk*. The equation used to model *real credit growth* considers both the demand and the supply sides of the credit market. In estimating the credit growth model, BOU puts emphasis on obtaining the relationship between credit risk, represented by the NPL ratio, and selected domestic macroeconomic indicators in an effort to link the model to the results of BOU’s macroeconomic forecast. Specifically, credit growth rate cg is explained by real GDP annual growth $rgdp$, the NPL ratio npl , the average lending rate lr , annual growth rate on deposits $depg$, and the quarterly change in annual inflation $\Delta\pi$.

$$cg_t = b_0 + b_1rgdp_{t-4} + b_2npl_{t-3} + b_3lr_{t-3} + b_4\Delta\pi_t + b_5depg_t + \varepsilon_t \quad (4.0)$$

On the demand side, BOU uses GDP growth, since it assumes that higher GDP growth translates into higher credit growth. The use of lagged GDP growth in the regression is to avoid the problem of reverse causality, namely higher credit growth leading to higher GDP growth.

On the supply side, BOU considers deposit growth, inflation, NPL ratio and the average lending rate. Expectation is that higher deposit growth would lead to more credit availability as banks would have more funds. Moreover, inflation is expected to be detrimental to real credit growth. Average lending rate is expected to lower credit growth should monetary policy stance be tight. BOU uses a lagged 91-day Treasury bill rate because there usually will be a lag for monetary policy decisions to take effect and there may also be reverse causality problem.

The equation BOU uses to model aggregate credit risk takes NPL ratio as the dependent variable. The NPL ratio is then expressed as a function of a linear combination of lagged real GDP growth and nominal interest rates. The model assumes that a decline in economic activity and a rise in nominal interest rates would lead to a rise in credit defaults.

$$npl_t = c_1 npl_{t-1} + c_2 r gdp_{t-1} + c_3 lr_{t-1} + \varepsilon_t \quad (4.1)$$

BOU defines the banks' lending rate lr as a function of the interest rate on the 91-day treasury bill i_t and the lending margin. The lending rate in a given period depends on contemporaneous changes in the policy rate and one period lag of the same, and also on its deviation from observed changes in the lending margin.

$$lr_t = a_0 + a_i i_t + a_2 i_{t-1} + a_3 (lr_{t-1} - i_{t-1}) + \varepsilon_t \quad (4.2)$$

(iii) Pillar 3 – Analysing Banks' Solvency Using Balance Sheet Implementation

After scenarios have been fed through the satellite model, BOU calculates individual bank solvency positions using granular information about the balance sheets and income statements of the banks included in the analysis using the Cihak model. Key balance sheet items projected include cash and balances with central bank, holdings of government securities, loans and deposits. In the basic Cihak model the balance sheets are static, so BOU does not take into account the effect of any expected future capital injection.

However, it takes into account previous interest income on NPL when calculating the NII. End-horizon solvency ratio is calculated as the summation of the existing capital stock and earnings accumulated over the stress test period in relation to the end-horizon risk-weighted assets.

Bank of Uganda, in modeling credit risk as part of stress tests follows approaches based on loan performance data i.e. losses given default, nonperforming loans, and provisions. The following is a summary of stress test results carried out for credit risk

	CAR (%)	Tier 1 capital in U.Shs. billion	NPL Ratio (%)	Number of undercapitalized banks
BASELINE SCENERIO for June 2012	18.3	1,868.9	3.9	1

Table 4.2. Baseline scenario for stress tests carried out in June 2012

Source: Bank of Uganda

Shock	Key Indicators	June 2012	March 2012	December 2012
Reduction in performing loans that fails the first large bank	Change in NPL ratio that breaks the first bank (%)	4.7	3.8	3.4
	CAR (%)	12.7	14.4	13.6
	NPL Ratio	8.6	7.2	5.6
Default by the largest borrower	Number of undercapitalized banks	7	8	7
	CAR (%)	12.3	12.7	10.8
	NPL ratio	10.4	10.0	8.3
	Number of undercapitalized banks	8	11	10

Table 4.3. Stress test results for June 2012

Source: Bank of Uganda

The results in the table above are of stress tests carried out by Bank of Uganda to assess the effect of a deterioration in asset quality would have on bank capital. The ratio of non-performing loans to total loans is the measure of credit risk. The first test applied is a uniform shock to the baseline level of performing loans so that a proportion become non-performing loans (NPLs).

Results: The level of NPLs as a share of the total loan portfolio would have to increase to 8.6% from the baseline of 3.9% for the first large bank to fall below the regulatory minimum capital requirement along with 6 other banks.

Also included in the table above are the results of a second test carried out to establish the effect of a simultaneous single default by the single largest borrower for each bank within the banking sector. The results showed that eight banks would not meet the minimum capital adequacy requirement.

4.2.2. Stress Tests for Sectoral Shocks

Bank of Uganda also carries out stress tests for credit risk that involve shocks pertaining to the performing loans for various business sector such as agriculture, manufacturing, trade and commerce, building and construction and personal and household loans. These shocks aims to determine how each bank will be affected by ad-hoc adverse events in different economic sectors where it has exposures. Shocks on specific economic sectors using loans by sector and by bank are simulated. The shock is a proportion of loans for each sector going bad. For each sector a specific impact factor, so that new provisions have to be made to cover new NPLs, is considered. Results are measured in the form of stressed CARs. The following formulas are used:

$$NPL_{i,s}^{stressed} = loans_{i,s} * shockfactor_s + NPL_{i,s} \quad (4.3)$$

$$NPL_i^{stressed} = \sum_{s=1}^n NPL_{i,s}^{stressed} \quad (4.4)$$

$$CAR_i^{stressed} = \frac{capital_i - \max(NPL_i^{stressed} - specific\ provisions_{i,0}, 0)}{RWA_i - \max(NPL_i^{stressed} - specific\ provisions_{i,0}, 0)} \quad (4.5)$$

Where **i** is the individual bank

s is the sector

n is the number of sectors in the test

In this way, the central bank can be able to determine the sectors that are most sensitive to loan losses i.e. the sectors for which smaller deterioration in loan performance can result in financial instability. Losses in these sensitive sectors have more adverse impacts on bank capital. Table 4.4 shows stress test results for sectoral shocks in June 2012.

Table 4.4. Stress results for sectoral shocks

	Breaking point (%)	CAR (%)	NPL Ratio (%)	No. of undercapitalized banks
Baseline Scenario		18.3	3.9	1
Agriculture	84.1	13.9	8.9	5
Manufacturing	33.6	14.2	8.5	4
Trade & commerce	19.7	14.8	7.9	6
Building/construction	18.0	14.9	7.8	6
Households	30.2	14.3	8.4	5

Source: Bank of Uganda

The stress testing results above show that the building and construction sector was the most sensitive to loan losses for the period of June 2012. If 18% of the loans to this sector became non-performing, six banks would become undercapitalized. The trade and commerce sector is also of systemic importance because loan deterioration of just 19.7% would also cause 6 banks to become undercapitalized. Sectors such manufacturing and households are also fairly sensitive to loan losses breaking points of 33.6% and 30.3% leaving 4 banks and 5 banks undercapitalized respectively. The agriculture sector was seen to be more resilient loan losses, requiring 84% of loans to go bad for 5 banks to be undercapitalized.

4.3. Analysis of the Relationship between Dependent Variables and Loan Performance

4.3.1. Relationship between GDP Growth and Loan Performance

Table 4.5. GDP growth and NPLs/Total loans between June 2014 and June 2016

Period	GDP Growth (%)	NPLs/Total loans (%)
Jun-14	0.7	5.8
Sep-14	-4.3	5.3
Dec-14	5.5	4.1
Mar-15	-2.3	4.3
Jun-15	-0.1	4.0
Sep-15	-1.5	3.8
Dec-15	-1.4	5.3
Mar-16	-0.7	6.9
Jun-16	-1.1	8.3

Source: Bank of Uganda

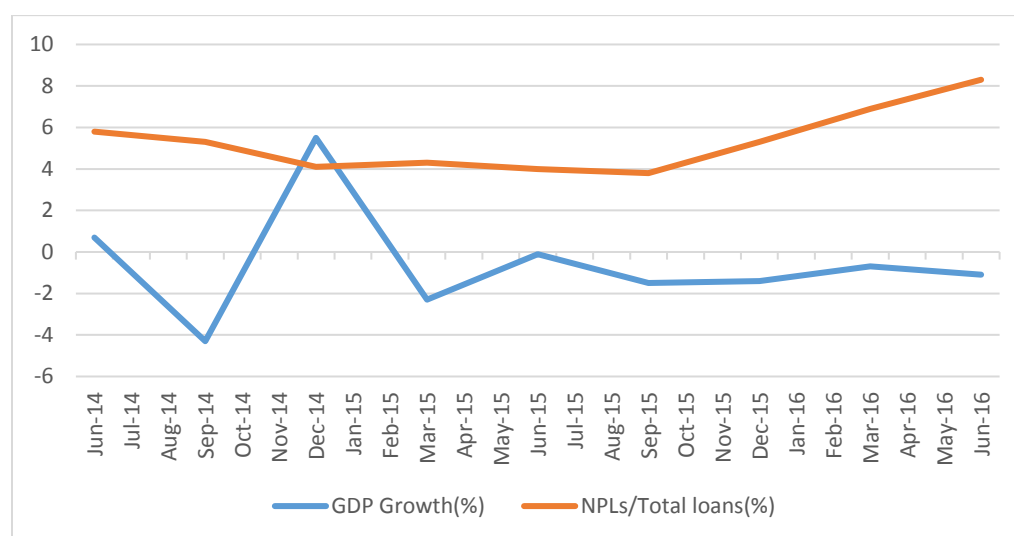


Figure 4.1. Movements in GDP growth and NPLs/Total loans between June 2014 and June 2016

From the data between June 2014 and June 2016, there was a significant decline in GDP growth especially between June 2014 and September 2014. This was accompanied by a drop in NPLs/Total Loans. A sharp increase in GDP between September 2014 and December 2014 was accompanied by further reduction in the NPLs/Total Loans. This is generally reflective of the trend between June 2014 and June 2015 whereby GDP growth did not seem to have a direct impact on NPLs. This is a possible reflection of the fact that variations in the GDP do not quickly translate to the actual economic situation in the short run.

4.3.2. Relationship between the Interest Rate and Loan Performance

Table 4.6. Interest rate and NPL/Total loans between June 2014 and June 2016

Period	Interest Rate	NPLs/Total loans (%)
Jun-14	15.5	5.8
Sep-14	15	5.3
Dec-14	15	4.1
Mar-15	15	4.3
Jun-15	17	4.0
Sep-15	21	3.8
Dec-15	22	5.3
Mar-16	22	6.9
Jun-16	20	8.3

Source: Bank of Uganda

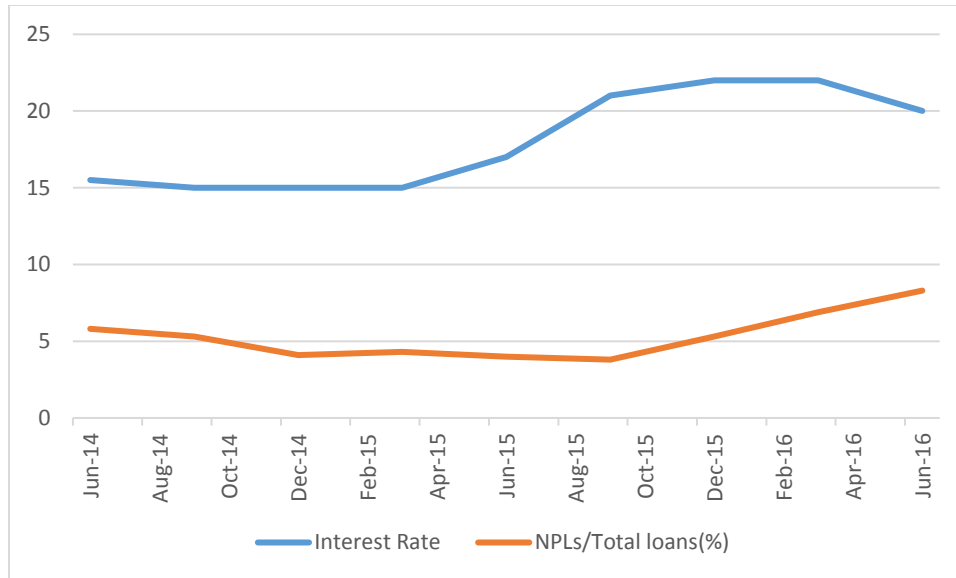


Figure 4.2. Movements in GDP growth and NPLs/Total loans between June 2014 and June 2016

In the period between June 2014 and April 2014, there was a general decrease in NPLs/Total Loans that seemed to be in agreement with an accompanying decrease in the interest rates. Between August 2015 and June 2016, the general trend was that a growth in the interest rates was accompanied by an expected increase in the ratio of NPLs to total loans. As such, there are few surprises as far as the impact of interest rates on NPLs is concerned for the data.

4.3.3. Relationship between GDP Growth and Loan Performance

Table 4.7. The exchange rate and NPL/Total loans between June 2014 and June 2016

Period	Exchange Rate (Shillings)	NPLs/Total Loans (%)	Growth in Exchange Rate (%)
Jun-14	2580.862	5.8	
Sep-14	2618.796	5.3	1.47
Dec-14	2768.795	4.1	5.73
Mar-15	2951.737	4.3	6.61
Jun-15	3199.903	4	8.41
Sep-15	3667.505	3.8	14.61

Dec-15	3362.493	5.3	-8.32
Mar-16	3365.497	6.9	0.09
Jun-16	3367.993	8.3	0.07

Source: Bank of Uganda

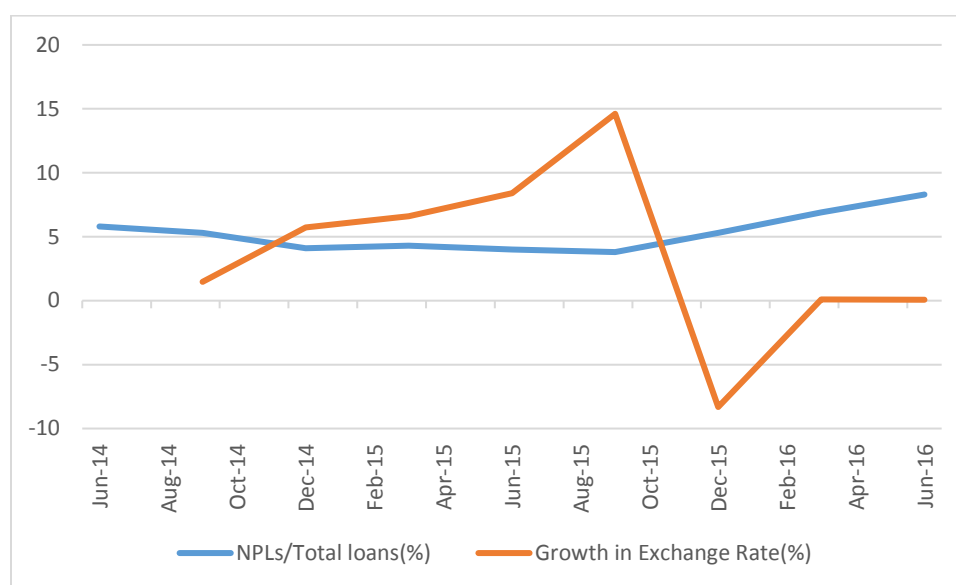


Figure 4.3. Movements the exchange rate and NPLs/Total loans between June 2014 and June 2016

Uganda is largely an import economy with most of its goods coming from foreign markets such as China. As such, the economy relies heavily on the US dollar which is by and large the most internationally accepted currency. The expected trend is therefore that a fall in the value of the shilling would generally cause price levels to shoot up leading to a reduction in consumption and therefore to an increase in the ratio of NPLs to total loans. Between June 2014 and June 2016, the trend was as follows.

NPLs to total loans continued to fall between June 2014 and October 2015 despite a marked increase in the dollar exchange rate. Even between October 2015 and June 2016, there was a trend in NPLs that did not seem reflective of market trends in the exchange rate. This might be explained by the fact that loans cleared within this period were from earlier periods and so the NPL to total loans ratio did not suffer significantly.

4.3.4. Relationship between Composite CPI and Loan Performance

Table 4.8. Composite CPI and NPL/Total loans between June 2014 and June 2016

Period	Composite CPI	NPLs/Total loans (%)	Change in CPI (%)
Jun-14	214.3	5.8	
Sep-14	217.3	5.3	1.405
Dec-14	217.0	4.1	-0.112
Mar-15	220.4	4.3	1.554
Jun-15	224.7	4.0	1.972
Sep-15	232.8	3.8	3.598
Dec-15	237.1	5.3	1.845
Mar-16	239.8	6.9	1.122
Jun-16	240.9	8.3	0.459

Source: Bank of Uganda

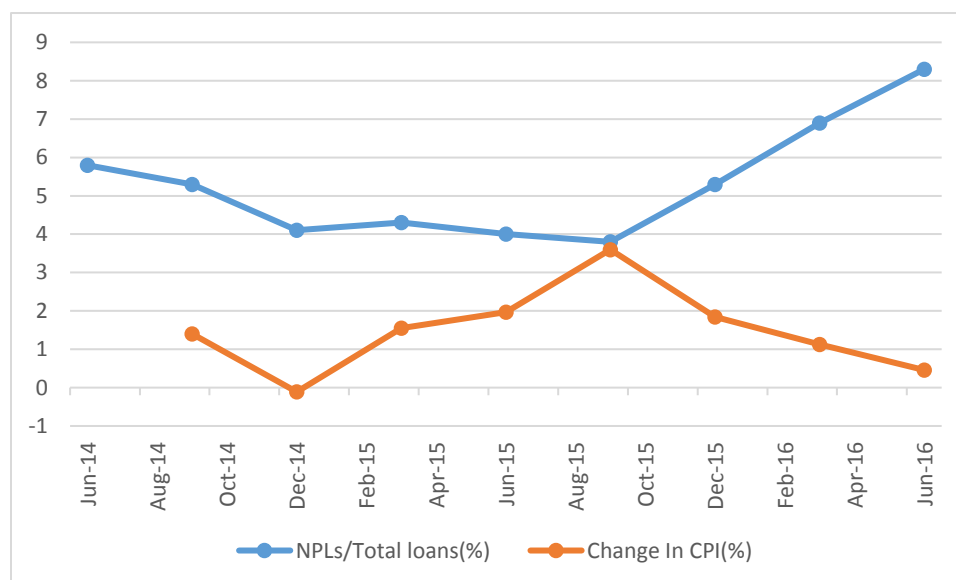


Figure 4.4. Movements in composite CPI and NPLs/Total loans between June 2014 and June 2016

The composite consumer price index (CPI) is generally reflective of the general price level within the economy and reflects the level of consumption. CPI is the core indicator of inflationary trends within the economy. The expectation is therefore that a growth in the CPI is an implication that prices are increasing and therefore businesses are finding it harder to sell commodities and services and thus also spending more and finding it more difficult to meet their loan obligations. In the period between June 2015 and June 2016, trends the CPI and NPLs were not reflective of this. Between June 2014 and October 2015, NPLs to total loans generally decreased while the price level was generally on the rise. This could be due to the fact that the increase in price level was generally mild over this period and therefore served as an incentive rather than an obstacle for businesses. Between October 2015 and June 2016, there was a general increase in NPLs to total loans alongside a general decline in the price level. This might be explained by the possibility that the economy was moving into a recession and so the fall in prices was not having a significant impact on consumption.

4.3.5. Relationship between 7-Day Interbank Rate and Loan Performance

Table 4.9. 7-day interbank rate and NPL/Total loans between June 2014 and June 2016

Period	7-day Interbank Rate (%)	NPLs/Total loans (%)
Jun-14	11.00	5.8
Sep-14	10.92	5.3
Dec-14	8.71	4.1
Mar-15	11.54	4.3
Jun-15	14.9	4.0
Sep-15	16.71	3.8
Dec-15	17.67	5.3
Mar-16	17.32	6.9
Jun-16	16.67	8.3

Source: Bank of Uganda

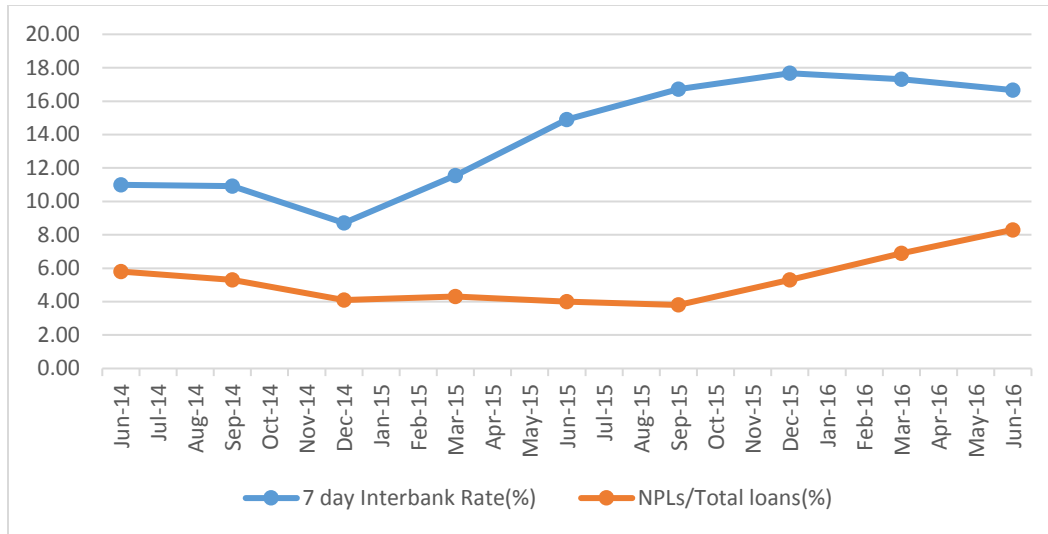


Figure 4.5. Movements in the 7-day interbank rate and NPLs/Total loans between June 2014 and June 2016

The seven day interbank rate is the interest rate at which commercial banks within the Ugandan banking sector lend each other funds in the short term to make up for deficits in liquidity. Banks must make up for these deficits in order to ensure that they are in position to meet client demands for withdrawals and also to ensure that they meet minimum liquidity requirements set by the central bank. It is expected that an increase in the 7-day interbank rate means that banks would also have to lend at a higher interest rate to customers, something which is expected to increase the ratio of NPLs to total loans. Between June 2014 and October 2015, the general fall in NPLs was accompanied by a period of reduction in the interbank rate between June 2014 and December 2014 followed by an increase up to October 2015. Between October 2015 and June 2016, an increase in the interbank rate was matched by an increase in NPLs to total loans. In general, the observed trend is that as the interbank rate increases, there is an increase in NPLs to total loans.

4.4. Liquidity Testing Framework

Liquidity Stress Tests (LST) aim to produce information for the analysis of liquidity risks arising from foreign currency cash flows, non-resident customers' cash flows, and a proxy for the stress scenario for the Liquidity Coverage Ratio (LCR) established in the Basel III liquidity paper, "Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools", issued in January 2013. The tests are applied to balance sheet data and to data on main foreign positions (by currency and

by customer's country of origin) monthly received from the banks. These stress tests are run in Excel spreadsheets in the Stress Tester 3.0.xls Microsoft Excel file and cover Currency Stress Scenario, Non-Resident Stress Scenario and LCR Stress Scenario.

The tests measure the banks' capacity to withstand specific scenarios of stressed cash flows over the following 30 days period in all scenarios, in order to allow comparative analysis among results. The metrics consist of comparing the amount of unencumbered liquid assets with the stressed cash flow. "Liquidity Shortfall" and "Liquidity Surplus", expressed in Meticais units, are the amount of liquidity under or above the amount of resources needed to settle the 30-day stressed cash flow, respectively. "Liquidity Ratio" is the ratio between the unencumbered liquid assets and the stressed cash flow. Ratios under 100 percent indicate lack of liquidity to face the adverse situations hypothesized in the scenario.

Most Ugandan banks are subsidiaries of foreign banks hence the exposure to foreign currency funding is substantial, mainly from their parent banks. Also, not only do banks accept deposits but give credit in domestic and foreign currencies, to residents and non-residents. In the case of LST, liquidity risk is assessed by currency and by customer's country of origin. Additionally, the LST tool offers a proxy for the calculation of the Basel III LCR, as a means of comparing the results among the scenarios. The objective and the premises of each scenario are:

- **Currency Stress Scenario** – this test estimates the bank's capacity to settle its obligations in foreign currency under adverse circumstances that involve (a) partial loss of foreign currency capacity; (b) early settlement of non-maturing obligations in foreign currency; (c) unexpected withdrawal of credit and liquidity lines in foreign currency; (d) difficulties in attaining foreign currency inflows (maturing assets and loans payment); and (v) difficulties in performing foreign currency exchange operations.
- **Non-Resident Stress Scenario** – this test estimates the bank's capacity to settle its obligations with foreign counterparties under adverse circumstances that involve (a) partial loss of foreign customer funding capacity; (b) difficulties in attaining assets issued by foreign entities or in receiving loan payments from foreign customers; (c) early settlement of non-maturing obligations with foreign counterparties; (d) unexpected withdrawal in irrevocable credit and liquidity lines to foreign customers

- **LCR Stress Scenario** – based on BCBS (2013) this test estimates the banks capacity to “survive under a significantly severe liquidity stress scenario, which entails a combined idiosyncratic and market-wide shock that would result in (a) the run-off of a proportion of retail deposits, including the run-off of one to a hundred of the top 100 deposits; (b) a partial loss of unsecured wholesale funding capacity; (c) a partial loss of secured, short-term financing with certain collateral and counterparties; (d) additional contractual outflows that would arise from a downgrade in the bank’s public credit rating by up to and including three notches, including collateral posting requirements; (e) increases in market volatilities that impact the quality of collateral and thus require larger collateral haircuts or additional collateral, or lead to other liquidity needs; (f) unscheduled draws on committed but unused credit and liquidity facilities that the bank has provided to its clients; and (g) the potential need for the bank to buy back debt or honor non-contractual obligations in the interest of mitigating reputational risk.”.

Table 4.10. Summary of stress tests results for liquidity risk

Shock	Key Indicators	Jun 2012	Mar 2012	Dec 2011
Simulated Bank Run	Liquid Assets to total Assets (%)	15.4	12.6	12.7
	Reduction in Total Deposits (%)	39.9	28.5	28.5
	No. of days to depleted liquid assets	7	5	5
	No. of banks failing test	4	4	4

A stress test was conducted for liquidity, in which a simple bank run was simulated to determine the impact of adverse uniform shocks to banks’ liquidity brought about by a sudden withdrawal of customer deposits. The resilience of banks to liquidity risk is judged by the number of days banking institutions would be able to withstand a liquidity drain without resorting to external support. The shocks applied for the respective periods were liquidity drains of 28.5%, 28.5% and 39.9% respectively.

Taking results for June 2012, the tests revealed that liquid assets of four banks would be depleted over a 7-day period of distress assuming a daily withdrawal rate of 5.7% of total deposits. This result is an improvement from March 2012 as the banking system can withstand a bank run for two days.

4.5 Summary

BOU carries out quarterly stress tests on liquidity and credit risk to evaluate the health of the Ugandan banking sector. The credit risk stress testing framework includes tests that involve shocks on loan performance while the central bank's liquidity stress testing framework includes scenarios for currency stress, non-resident stress and LCR stress. The stress test results in this chapter showed the banking sector to be resilient to macroeconomic shocks. The researcher however could not find very direct correlations between different variables and loan performance.

CHAPTER FIVE

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

5.0 Introduction

The study was meant to look at how Uganda's central Bank, Bank of Uganda carries out stress tests in order to determine the resilience of the financial system in the face of adverse conditions. In this chapter, the following sections are looked at: Discussion of the findings, Conclusions, Recommendations and Areas of further study.

5.1. Discussion of the Findings

5.1.1. The Nature of Stress Tests

The research established that Bank of Uganda follows the International Monetary Fund's stress testing framework that is based on the work of Martin Cihak (2007) while this framework contains stress tests for credit risk, interest rate risk, foreign exchange risk, interbank risk and liquidity risk, BoU's stress tests are majorly carried out on credit risk and liquidity risk. Bank of Uganda carries out these stress tests on a quarterly basis and follows both a bottom up approach where balance sheet and income statement data from the various commercial banks is analyzed as well as aggregated data for the entire banking sector. The stress tests are carried out by the central bank's financial stability department.

In carrying out stress tests for credit risk, the central bank models a general decline in asset quality, affecting all banks proportionately. It is assumed that nonperforming loans (NPLs) increase by a certain percentage and then the capital adequacy ratio is calculated to ascertain whether a particular bank is undercapitalized due to the shock or not.

The central bank also carries out stress tests for credit risk by shocking non-performing loans to selected business sectors namely agriculture, manufacturing, trade and commerce, building and construction and household loans. Stress test results have shown that the building and construction sector has the highest sensitivity to loan losses whereby in June 2012, stress test results showed that if 18% of loans in this sector became non-performing, 6 banks would become undercapitalized. This is in stark contrast to the resilience of banks to poor loan performance in other sectors. For example, according to the same stress test results, it would require 84% of agriculture sector loans to go bad for 5 banks to become undercapitalized. This goes to show that

banks must apply greater scrutiny in giving loans to the building and construction sector as these loans can have systemic implications in case they go bad.

As far as liquidity stress testing is concerned, Bank of Uganda simulates a bank run whereby a sudden withdrawal of customer deposits is used to shock the various commercial banks and then resilience of a bank is judged by the number of days a banking institution can withstand a liquidity drain without resorting to assistance from the central bank and/or other commercial banks. The tests measure the banks' capacity to withstand specific scenarios of stressed cash flows over the following 30 days period in all scenarios, in order to allow comparative analysis among results. The metrics consist of comparing the amount of unencumbered liquid assets with the stressed cash flow

Generally, the stress tests carried out by Bank of Uganda show the Ugandan banking sector to be resilient to shocks both in terms of credit risk and liquidity risk.

5.1.2. Relationship between the Various Independent Variables and NPLs

The major independent variables in this study were GDP growth, the composite consumer price index, the interest rate, the real effective exchange rate (REER) and the 7-day interbank rate. The dependent variable is the ratio of NPLs to total loans. In accordance with the specific objectives, the following is a discussion on the findings for each of these independent variables in relation to the dependent variable

1. **GDP Growth:** It would be expected that a growth in GDP would lead the higher growth in total output would increase real salaries, lessen unemployment, thus, leading to greater loan repayment rates. However for data within this study the ratio of NPLs to total loans was GDP inelastic for the period between June 2014 and June 2016. The explanation for this might be that changes in GDP within the Ugandan economy do not trickle down easily to affect the wellbeing of people and businesses in the short run.
2. **Composite Consumer Price Index (CPI):** The general expectation would be that an increase in consumer prices would erode a part of the individual/corporate budget, thus, limiting the loan repayment ability thus leading to an increase in the ratio of NPLs to total loans. However, the trends in the data do not seem to reflect this. The possible explanation

can be the limited data or the fact that the changes in price level occurred within a boom whereby increases in prices might not affect consumption.

3. **The Interest Rate:** Higher interest rates mean higher interest payments on loans for borrowers, therefore, they should be positively related with NPLs. This was generally visible for the data between June 2014 and June 2016. In periods when the interest rate fell, the ratio of NPLs to total loans followed the same trend and vice versa. Though the data only covered a period of two years, it might be safe to say that loan performance in the Ugandan banking system is interest rate elastic.
4. **Real Effective Exchange Rate (REER):** A strengthening of a country's currency means an increase in a country's competitiveness, implying higher loan quality of the banking system. The most important FOREX rate in Uganda is the US dollar – Shilling exchange rate. This is because most of Uganda's imports are purchased in dollars. For some time now, the shilling has been depreciating against the dollar which means that the cost of imports should be on the rise. In addition to that businesses that make use of dollar denominated loans and yet earn in shillings are expected to find it difficult to repay bank loans. However the depreciation of the Uganda shilling against the US dollar between June 2014 and June 2016 does not seem to be reflected in the ratio of NPLs to total loans for the same period. Again this might be explained by the nature of the business cycle where increase in price levels does not affect consumption for an expanding economy. It might also be the data set used in the study was narrow and did not therefore reflect the actual situation in the banking industry.
5. **The 7-day Interbank Rate:** For the data analyzed, there was a positive correlation between the 7-day interbank rate and the ratio of NPLs to total loans. This is the expected trend as any change in the interbank rate is expected to trickle down to the borrowers in form of higher interest rates.

5.2 Conclusion

The theoretical section of this dissertation was designed to introduce a reader the concept of stress testing and to explain its general methodological principles. Stress testing represents a general term for a set of risk measurement techniques employed for the assessment of the condition of the financial systems and the detection of potential vulnerabilities adverse macroeconomic events. Stress tests usually focus on the banking sectors which reflects the key role of banks in most financial systems. Either the risk exposures of individual entities or the systemic risk posing a threat to the entire system may be the subject of stress testing. In order for the running stress tests to be effective and working reliably as a detector of financial disruptions, there are several requirements on stress testing which need to be satisfied as put forth by the BCBS which have been looked at in the literature review.

The process of stress testing is a multi-stage procedure in which each stage has its significant position. The most important phase is a proper direction of stress testing requiring the identification of main vulnerabilities. This step is followed by a specification of a number of risk factors involved in stress scenario and then by simulating shocks. The size of shock is usually determined based on the most extreme changes in risk factors historically observed or even a new plausible stress scenario can be defined. The process of stress testing is completed by measuring the impacts of plausible shocks on the financial position of banks. Reference can be made to the literature review on this

After composing theoretical background on stress testing, the author made a qualitative analysis of the methods Bank of Uganda uses to carry out stress tests for liquidity and credit risk. Empirical analysis was not carried out using statistical models as the data available from the central bank was limited hence the use of qualitative analysis.

5.3. Recommendation

There is a need to make loan performance data more available to academics. Had data been readily available, it would have been possible to carry out an empirical analysis focused on the estimation of credit risk in the Ugandan banking sector using statistical models such as the vector autoregression (VAR) model to try to examine the development of credit portfolio of the Ugandan banking sector in relation to adverse economic conditions.

A central point of the empirical analysis would have been a testing the hypothesis that there is any empirical dependence between the measure of credit risk and the selected macroeconomic variables. The dependent variable in this case would still have been the ratio of non NPLs to total loans. The outcome achieved from the VAR model would then hopefully confirm some expectations about the interdependencies between the credit portfolio and macroeconomic variables. From selected macroeconomic variables and the model, it would then be determined which variables are statistically significant towards credit risk in the Ugandan banking sector thus creating a broader understanding.

5.4. Areas of Further Research

A possible area of further research can be the relationship between corporate management practices in commercial banks and financial stability.

Further detailed research can also be carried out for stress testing specific to the particular types of risk e.g. credit risk, liquidity risk and exchange rate risk.

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APPENDIX: Interview Guide

Dear respondent, I am doing research as I work on my final year dissertation titled ‘**An Analysis of the Stress Testing Techniques Used by Bank of Uganda**’ I am a third year student of Uganda Martyrs University pursuing a Bachelor’s Degree in Financial Mathematics. Your kind assistance in helping me obtain the answers to these questions is highly appreciated.

Thank you for your cooperation.

Yours faithfully,

.....
Atuhaire Philip

Bachelor of Science in Financial Mathematics

Faculty of Science

Uganda Martyrs University

QUESTIONS

1. In carrying out stress tests, a bottom-up approach may be employed where the central bank defines the macroeconomic shock and lets institutions evaluate the impact on their balance sheet. The results are then aggregated to evaluate the impact on the system as a whole. Alternatively, a top down approach may be employed where authorities apply the shock to the aggregated banking portfolio. What is Bank of Uganda’s stress testing approach and what are the details of the processes involved?
2. How does the central bank go about identifying the risks specific to particular institutions and carrying out shock calibration i.e. defining the events which will trigger the shock and the level to which the shocks will materialize into a stress scenario?
3. In designing a macroeconomic stress scenario, the macro econometric model can be done in three ways: a structural econometric model, vector autoregressive method (VAR) and a pure statistical approach. Which of these is employed by the central bank and how do they go about it?
4. In building credit risk models, a model based on loan performance data or/and a model based on data on individual borrowers may be applied. How does Bank of Uganda go about the credit risk models it uses?

5. In carrying out liquidity stress testing, how does the central bank overcome the obstacle of data limitation? What stress liquidity indicators are used?
6. What is the state of Uganda's banking system in terms of loan to deposit ratio, liquidity, credit growth, and non-performing loans? What are the challenges to financial stability in Uganda?
7. In carrying out an empirical analysis based on aggregated data, several variables maybe used to simulate an adverse macroeconomic scenario such as GDP growth, unemployment, the interest rate and domestic consumption among others. What variables does Bank of Uganda use?
8. With these variables, how does the central bank arrive at the capital adequacy ratio (CAR) that is used to determine how stressed a variable of interest is?
9. In carrying out empirical analysis based on bank specific data, how does the central bank make use of bank specific variables such as Return on Assets, Return on Equity, Solvency Ratio and Loans to Deposit ratio among others to assess the occurrence of Non-Performing Loans (NPLs)?
10. What is bank of Uganda's Liquidity stress testing framework?